The Development of a Questionnaire to Describe Science Teacher Communication Behavior in Taiwan and Australia

HSIAO-CHING SHE
Center for Teacher Education, National Chiao Tung University, Taiwan, R.O.C.

DARRELL FISHER
National Key Centre for School Science and Mathematics, Curtin University of Technology, Australia

ABSTRACT: Teachers contribute enormously to a positive social climate in science classes, particularly through their communication with students. This article describes the development and validation of a questionnaire, the Teacher Communication Behavior Questionnaire (TCBQ) (see pp. 723–726), which assesses student perceptions of the following five important teacher behaviors: Challenging, Encouragement and Praise, Non-Verbal Support, Understanding and Friendly, and Controlling. The TCBQ was administered to 1202 students from 30 classes in Taiwan and to 301 students from 12 classes in Australia. The reliability and factorial validity of the TCBQ were found to be satisfactory for both the Taiwanese and Australian data. To further validate the questionnaire and understand the differences in teacher behavior according to the perceptions of students from the two countries, a qualitative approach was used. Students were interviewed (two from each of five classes) in both Taiwan and Australia. The interview questions focused on these students' responses to selected questionnaire items. The results obtained from the interviews supported and helped explain the quantitative results. In an application of the TCBQ in both countries, students' perceptions on four of the scales of the TCBQ were associated with their attitudes to their science classes.   © 2000 John Wiley & Sons, Inc. *Sci Ed* **84**:706–726, 2000.

INTRODUCTION

International research efforts involving the conceptualization, assessment, and investigation of perceptions of aspects of the classroom environment have firmly established classroom environment as a thriving field of study (Fraser, 1994, 1998a; Fraser & Walberg, 1991). For example, recent classroom environment research has focused on constructivist classroom environments (Taylor, Fraser, & Fisher, 1997), computer-based tertiary class-

rooms (Newby & Fisher, 1997), science laboratory classroom environments (Fraser, Giddings, & McRobbie, 1995), and teacher interpersonal behavior in the classroom (Fisher & Kent, 1998; Wubbels & Levy, 1993).

In the past three decades, much attention has been given to the development and use of instruments to assess the qualities of the classroom learning environment from the perspective of the student (Fraser, 1998a, 1998b; Fraser & Walberg, 1991). The association between learning environment variables and student outcomes has provided a particular focus for the use of learning environment instruments. In a meta-analysis that examined 823 classes in eight subject areas and represented the perceptions of 17,805 students in four nations, Haertel, Walberg, and Haertel (1981) found enhanced student achievement in classes which students felt had greater cohesiveness, satisfaction, and goal direction and less disorganization and friction. Other literature reviews since then have supported the existence of associations between classroom environment variables and student affective and cognitive outcomes (Fraser, 1998a).

This paper describes the development and validation of an instrument that assesses student perceptions of their teachers' communication behaviors in the classroom environment. Both quantitative and qualitative methods have been used in the validation of the questionnaire. Data were gathered from a sample of Taiwanese and Australian students in science classrooms. In keeping with traditional approaches in classroom environment research, factor analyses, internal consistency, discriminant validity, and the ability to differentiate between classes were used in a quantitative validation of the questionnaire. To further validate the questionnaire and explain the perceptions of students from the two countries, a qualitative approach was used and students were interviewed.

When classroom environment perceptions have been used as predictor variables, associations between student cognitive and affective outcomes and learning environment have been found. Fraser (1994) provides a broad overview of these results, which indicate that classroom environment perceptions can influence students' outcomes. In keeping with this previous research, associations between students' perceptions of their teachers' communication behaviors in the classroom environment and their attitudes toward their science class were investigated in this study.

BACKGROUND

As discussed in the introduction, past research has confirmed the important contribution made by teachers in creating a classroom environment or atmosphere conducive to science learning (Fraser, 1998a, 1998b). Teachers make a major contribution toward creating a positive learning environment in science classes, particularly through their interaction or communication with students (Wubbels & Levy, 1993). Appropriate teacher–student interactions are important to prevent discipline problems and to foster professional development (Rosenholtz, Bassler, & Hoover-Dempsey, 1986). Student–teacher interactions also have been shown to be particularly important in a "constructivist" classroom, where relationships play a prominent role (e.g., Watts & Bentley, 1987). Other research has indicated that positive relationships between teachers and students promote student interest and outcomes in science (Wubbels & Levy, 1993).

Classroom interactions occur rapidly in a classroom and teachers are usually not aware, or not able to describe or remember, what happens in their interactions with students. For example, Good and Brophy (1974) interviewed teachers and confirmed that teachers usually were not aware of how many questions they asked students and what kind of feedback they provided. Cuban (1984) found that the basic structure of classrooms (heavy reliance on teacher–student recitation) has remained unaltered for decades. Good and Brophy

(1991) indicated that teachers in secondary schools may have interactions with 150 different students a day. Unless we can help teachers identify their own behaviors in teaching, and make them aware of what happens in class, it is difficult to promote positive science classroom environments.

Three common approaches to studying teachers and their classrooms involve systematic observation, descriptive case studies, and using student and teacher perceptions. Systematic observation and case studies have been used frequently in the past; however, perceptual measures now are used often, particularly when investigating a large sample of classes.

The following advantages of using student perceptions as indicators of the quality of the classroom environment have been elucidated in a number of studies (e.g., Fraser, 1998a; Rosenshine, 1971; Stodolsky, 1984; Walberg & Haertel, 1980):

- Students are directly involved in classroom activities and observe more of the teacher's typical behavior than does an outside observer. A teacher's behavior is context-based and one teacher can exhibit different behaviors in different subject areas.
- Students are more familiar with their teacher's idiosyncrasies that can be interpreted differently by an observer.
- Students are in a better position to judge certain aspects of a teacher's behavior (e.g., clarity of expression).
- Students could observe aspects of the teacher's behavior that the observer does not.
- Students' perceptions of the classroom have been shown to account for a greater proportion of the variance in student outcomes than have directly-observed low-inference variables.
- The use of trained observers over a period of time is more expensive and time consuming than is the duplication, administration, and scoring of questionnaires.
- The presence of observers could alter what generally occurs in the classroom.

It is possible to ask teachers for their perceptions of their classrooms; however, these usually differ in some respects from those of students (Cooper & Good, 1983; Fraser, 1998a; Wubbels & Levy, 1993). In this study, it was decided to focus on student perceptions. Therefore, the purpose of this study was to establish a questionnaire that would allow a study of student perceptions of teacher behavior in a large number of science classes at the same time. In the longer term, it is hoped to develop a better understanding of teacher behavior occurring in science classrooms in both Taiwan and Australia.

Until about 20 years ago, research involving science students' outcomes focused primarily on educational objectives in the cognitive domain; but in more recent times, attention has been paid to outcomes in the affective domain, and the study of student attitudes has formed a primary component of this research (Weinburgh, 1995). The promotion of positive attitudes toward science is seen as a major aim of science education. Mager (1968) outlined three reasons for promoting positive attitudes in students. First, research has indicated associations between positive attitudes and enhanced academic achievement. Second, a positive attitude is more likely to sustain interest in the field of study in the future. Third, peers are influenced by the attitudes of others. Shulman and Tamir (1972) suggested that affective outcomes in education are at least as important as cognitive outcomes; acknowledgment of the importance of affective outcomes is reflected in their increasing emphasis in curricula (Gardner & Gauld, 1990; Hough & Piper, 1982; Mathews, 1974).

When classroom environment perceptions have been used as predictor variables, associations between student cognitive and affective outcomes and learning environment have been found. Fraser (1994) provides a broad overview of these results, which indicates that

classroom environment perceptions can influence students' outcomes. In a study in secondary science classes in Korea, students' attitude scores were higher in classrooms in which students perceived greater leadership, helping/friendly, and understanding behaviors in their teachers (Kim, Fisher, & Fraser, in press a). In a second study in Korea, results indicated that favorable student attitudes could be promoted in classes where students perceived more personal relevance, shared control with their teachers, and negotiated their learning (Kim, Fisher, & Fraser, in press b). These results were the same as those of the past research of Brekelmans, Wubbels, and Levy (1993) and Fisher, Rickards, Goh, and Wong (1997). Wubbels, Brekelmans, and Hooymayers (1991) found that the communication style of physics teachers is the most important variable in explaining differences in the students' appreciation of the lessons and the subject being taught at the class level.

Therefore, in keeping with this previous research, and because of the importance of affective outcomes in education, associations between students' perceptions of their teacher's interpersonal communication behavior in the learning environments and their attitudes toward their science class were investigated in this study.

DEVELOPMENT OF THE QUESTIONNAIRE

Researchers in the Netherlands (Wubbels, Creton, & Holvast, 1988; Wubbels, Creton, & Hooymayers, 1992; Wubbels & Levy, 1993) investigated teacher behavior in a classroom from a systems perspective, adapting a theory on communications processes developed by Waltzlawick, Beavin, and Jackson (1967). Within the systems perspective of communication, it is assumed that the behaviors of participants mutually influence each other. The behavior of the teacher is influenced by the behavior of the students and in turn influences the student behavior. Thus, a circular communication process develops. This "systems approach" assumes that one cannot not communicate when in the presence of someone else. For example, if a teacher ignores students' questions because he or she does not hear them, then the students might infer that the teacher is too busy, that the teacher thinks that the students are too dull to understand, or that the teacher considers the questions irrelevant. Another assumption within this approach is that every form of behavior involves the communication of both a relationship message and a content message. Research into interpersonal teacher behavior has focused on the relationship messages of teacher behavior. Based on this systems approach, the Questionnaire on Teacher Interaction (QTI) (Wubbels & Levy, 1993) was developed.

Research with the QTI in the Netherlands, America, and Australia clearly indicated that helping, friendly, and understanding teacher behavior was associated with higher cognitive outcomes scores and positive student attitudes (Fisher, Henderson, & Fraser, 1995; Fisher & Rickards, 1997; Wubbels & Levy, 1993). Furthermore, it was demonstrated in these research studies that the teacher's strict or controlling behavior was associated quite strongly with student cognitive gains, but not so strongly with their attitudes. It was thus decided to include in the questionnaire one scale to assess student perception of the teacher's understanding and friendly behavior, and one scale to assess controlling behavior.

To gather data about teachers' non-verbal behavior, van Tartwijk (1993) developed an observation instrument. He found that non-verbal teacher behavior explained 63% of the perceived influence teachers have on what happens in the class. For example, the teacher's facial expression, as perceived by students, was an important aspect of non-verbal behavior for determining the level of the teacher's cooperative interpersonal behavior. Van Tartwijk concluded that the non-verbal behavior of the teacher was related to students' perceptions of the interpersonal behavior of their teacher. It was decided to include a scale that assessed the teacher's non-verbal support for the students in their classrooms.

Other research has shown that two teacher behaviors have had a considerable effect on students' achievement (e.g., Good & Brophy, 1974; Walberg, 1984). According to these research studies, questioning and the teachers' reactions to the students' answers are key factors in the interactions that occur between teachers and their students. Questions have been shown to be an important and integral part of learning, and questions asked by teachers may be used as indicators of the quality of teaching (Carlsen, 1991; Smith, Blakeslee, & Anderson, 1993). Deal and Sterling (1997) suggested that effective classroom questions promote relevance, encourage ownership, help students interpret their observations, and link new learning to what students already know. Systematic classroom observation research in Taiwan involving the use of questioning, verbal reinforcement, and non-verbal reinforcement in the teachers' behavior toward students (She, 1997, 1998, 2000; She & Barrow, 1997) supported the importance of these three teacher behaviors. It was thus decided to include two scales related to the teacher's questioning and reinforcement behaviors in the questionnaire.

Thus, the development of this questionnaire was based on She's (1997, 1998, 1999, 2000) studies of teacher–student interactions in science classrooms in Taiwan and on previous research with the QTI. The initial version of the questionnaire, named the Teacher Communication Behavior Questionnaire (TCBQ), contained a total of 60 items, with 12 items belonging to each of the five scales. Each item is responded to on a 5-point scale with the alternatives of almost never, seldom, sometimes, often, and very often. Table 1 contains a description of the meaning of each of the five scales and a sample item for each scale.

Items for the TCBQ were written originally in Chinese and then translated into English. A back translation of the English version into Chinese, by people not involved in the original translation, was then completed. This resulted in the modification of both the original Chinese and English version.

TABLE 1
Description of Scales and a Sample Item for Each Scale of the TCBQ

Scale Name	Description of Scale	Sample Item
Challenging	Extent to which the teacher uses higher-order questions to challenge students in their learning	This teacher asks questions that require me to apply what I have learned in class in order to answer.
Encouragement and Praise	Extent to which the teacher praises and encourages students	This teacher praises me for asking a good question.
Non-Verbal Support	Extent to which the teacher uses non-verbal communication to interact positively with students.	This teacher smiles at me to show support while I am trying to solve a problem.
Understanding and Friendly	Extent to which the teacher is understanding and friendly towards the students	This teacher understands when I doubt something.
Controlling	Extent to which the teacher controls and manages student behavior in the classroom.	This teacher requires us to be quiet in his/her class.

Students respond on a 5-point scale from Almost Never to Almost Always.

Item Analysis

The original 60-item version of the questionnaire was administered to a sample of 1202 students from 30 grades 7 to 9 science classes in Taiwan and 301 students from 12 grades 7 to 9 science classes in Australia. Sixty items were written for this first version so that statistical analyses could be used to eliminate items to about 40. This reduced number was desirable in order to ultimately have a questionnaire that is economical in time for students to respond to and teachers to score.

The first step in refining and validating the instrument was an item analysis procedure, the purpose of which was to identify those items that, if removed, would enhance each scale's internal consistency and discriminant validity. This involved removing items with a low correlation with the remainder of the items in its own scale and items whose correlation with its *a priori* assigned scale was lower than its correlation with any of the other scales in the original version of the TCBQ. In addition, because of the desire to establish the cross-national validity and applicability of the TCBQ, the item analyses were performed separately for each of the two countries. In fact, an item was omitted if it displayed unsatisfactory statistical characteristics in either country. After all, it was important to develop an instrument in which all items were suitable in each country. These item analyses led to the successive deletion of three of the original 60 items that had very low or negative correlations with the rest of the items in their assigned scale, to produce a 57-item version of the instrument whose scales had satisfactory internal consistency reliability and an acceptable level of scale independence. The item analyses formed the starting point for the series of factor analyses described in the following section.

Method

Initially, the Chinese version of the TCBQ was administered to several grades 7 to 9 science classes in Taiwan, and this was followed by the researchers interviewing students about the readability and comprehensibility of items in order to check whether students were responding to the items on the basis intended by the developers. A similar process, plus the use of interviews, was conducted in Australia. This led to modifications to questionnaire items. The extensive field testing and instrument validation procedures in both countries, described later, led to a final version consisting of 40 items altogether, with eight items in each of the five scales.

At the same time, students' attitudes toward their class were assessed with a 7-item Attitude to This Class scale based on selected items from the Test of Science-Related Attitudes [TOSRA] (Fraser, 1981). This scale has been used in several previous studies involving students in science classes and has been shown to have satisfactory internal consistency (e.g., Fisher, Fraser, & Rickards, 1997; Henderson, Fisher, & Fraser, 1998). The reported Cronbach alpha reliability coefficients for this attitude scale were 0.85 and 0.78, respectively, when using the individual student as the unit of analysis.

Having developed the five scales of the TCBQ, we wanted to determine their practical viability for use with students. We were interested in examining what perceptions students had of the scales and the items. How did they interpret each scale? What did they think an item meant? Were the students viewing the concepts behind each scale in a similar manner to that of the original developers?

Schools to be involved in the interview component of the study were selected according to the students' responses to the questionnaire. This was particularly important as the quantitative analyses of data suggested that in some classes a diverse range of students' views existed.

TABLE 2
Factor Loading of Items in the TCBQ

Old Item Number	Challenging		Encouragement & Praise		Non-Verbal Support		Understanding & Friendly		Controlling	
	Taiwan	Aust.	Taiwan	Aust.	Taiwan	Aust.	Taiwan	Aust.	Taiwan	Aust.
1	0.51	0.59								
2	0.67	0.57								
3	0.70	0.62								
4	0.72	0.46								
5	0.66	0.75								
6	0.70	0.73								
7	0.72	0.62								
9	0.49	0.41								
13			0.60	0.55						
14			0.55	0.56						
15			0.62	0.60						
16			0.59	0.77						
17			0.67	0.47						
19			0.67	0.42						
20			0.61	0.52						
22			0.65	0.40						
25					0.46	0.42				
29					0.57	0.52				
30					0.70	0.77				

31	0.73	0.74				
32	0.71	0.63				
33	0.75	0.76				
34	0.75	0.73				
35	0.68	0.64				
39			0.53	0.67		
40			0.61	0.68		
41			0.55	0.71		
43			0.45	0.59		
44			0.71	0.82		
45			0.75	0.86		
46			0.75	0.79		
47			0.71	0.72		
49					0.51	0.43
52					0.62	0.62
53					0.79	0.81
54					0.80	0.81
55					0.80	0.80
56					0.72	0.54
57					0.46	0.58
59					0.62	0.62

All loadings smaller than 0.3 have been omitted.

Ten students from each country were interviewed for a maximum of 15 min in a fully visible position where student confidentiality could be assured; for example, in an interview or counseling room, an open classroom, on school playground seating, or in a library annex. After assuring them of the confidentiality of their responses, their approval for audio-recording was obtained. A semi-structured interview was used during which students were asked to comment generally about the questionnaire. Secondly, the interview focused on the particular constructs assessed by the scales in the new questionnaire. Thirdly, it focused on their responses to individual items in those scales.

QUANTITATIVE ANALYSIS: VALIDATION OF THE QUESTIONNAIRE

The next step in the modification and cross-national validation of the TCBQ involved a series of factor analyses to examine further the internal structure of the set of 57 items that had survived the initial item analyses. Principal components analysis with varimax rotation was used to generate orthogonal factors. These factor analyses, which were completed separately in each country, led to a decision to delete 17 items, either because they were loaded at more than one factor, or because their loading was lower than 0.31.

Although the deletion of the items was mainly based on statistical analyses, the interview data described later in this article also assisted in determining which were the best items to include in the final version. For example, some items in the Encouragement and Praise scale appeared to be unsatisfactory because they referred to the questioning of the teacher rather than the reinforcement. The deleted item, "This teacher encourages me to answer questions by giving hints and examples," was such an item. It was also clear, particularly in early interviews, that negative items caused problems for the students when they had to provide a response on a scale from Almost Never to Almost Always. The deleted item, "This teacher ignores or criticizes my questions," was an example of this. In the Controlling scale, it was apparent that students had problems with the concise meaning of the word "strict" and this resulted in the deletion of an item like, "This teacher is strict with me." With the Non-Verbal Support scale, words like "without speaking" were important to emphasize the non-verbal support of the teacher.

The 40-item 5-factor instrument shown in Table 2 was decided upon as the optimal structure for the final version of the TCBQ and is provided at the end of this article. Every one of the 40 items in the final version is retained in exactly the same scale to which it was assigned when the instrument was original developed. The factor loadings of these 40 items are depicted in Table 2. Apart from the deletion of certain items, the factor analyses have confirmed the validity of the original structure of the questionnaire without the need to change the scale allocation of any item or the name of any scale. Taken together, all of this evidence lends considerable support to the factorial validity of the 40-item, 5-scale version of the TCBQ.

Estimates of the internal consistency of the five scales of the questionnaire, calculated using Cronbach's alpha coefficient and shown in Table 3, were found to be generally satisfactory for both the Australian and Taiwanese data. The alpha reliability coefficient for each scale, using the individual student as the unit of analysis, ranged between 0.86 and 0.93 in Taiwan and between 0.86 and 0.93 in Australia.

Another feature considered important in a classroom environment instrument is the discriminant validity of each scale of the instrument; that is, the extent to which the scale measures a dimension different from that measured by any other scale. In this study, the mean correlation of one scale with the other four scales ranged from 0.16 to 0.50 in Taiwan and from 0.06 to 0.45 in Australia. These values can be regarded as small enough to

TABLE 3
Internal Consistency (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with other Scales), and Ability to Differentiate Between Classrooms for the TCBQ

Scale	Alpha Reliability		Mean Correlation with Other Scales		ANOVA Results η^2	
	Taiwan	Aust.	Taiwan	Aust.	Taiwan	Aust.
Challenging	0.88	0.86	0.40	0.37	0.17**	0.11**
Encouragement & Praise	0.90	0.87	0.50	0.45	0.19**	0.15**
Non-Verbal Support	0.93	0.91	0.50	0.44	0.21**	0.09**
Understanding & Friendly	0.91	0.93	0.46	0.40	0.22**	0.14**
Controlling	0.86	0.86	0.16	0.06	0.21**	0.05*

* $p < .05$; ** $p < .001$; Taiwan, $n = 1202$; Australia, $n = 301$.

confirm the discriminant validity of the TCBQ, indicating that each scale measures a distinct, although somewhat overlapping, aspect of the teacher's communication behavior.

Also, the ability of a classroom environment instrument to differentiate between classes is important. Students within a class usually view the classroom learning environment similarly, but differently from students in other classes. The instrument's ability to differentiate in this way was measured using one-way analysis of variance (ANOVA) with class membership as the main effect. The results, depicted in Table 3, show that each of the scales did in fact significantly differentiate between classes ($p < .001$). The amount of variance explained by class membership is reflected in the η^2 scores which ranged from 0.17 to 0.22 in the Taiwanese sample and from 0.05 to 0.15 in the Australian sample.

QUALITATIVE ANALYSIS: STUDENT INTERVIEWS

Ten students from each country were interviewed for a maximum of 15 min. Initially, students were asked whether they could tell us what the questionnaire was about. Among student comments were:

> *Yes, they were about like the teachers' methods and how the teacher gets things through.*
>
> *Well it's about the classroom teacher and how you feel in the class.*
>
> *Just trying to work out how the teacher teaches and stuff.*
>
> *Yes, it was about the teacher and how she teaches.*
>
> *Oh the first few questions they were a bit, I don't know, I couldn't understand it at first but then it came to me what you were meaning.*

From the student comments and other questions that were asked, it was clear to the researchers that the students were able to read the TCBQ and had some idea what it was about.

The questions then became more focused and we referred to student responses to various items to see if the scales were actually assessing what they were supposed to be assessing. We were also seeking questions about why students gave the responses they did. The

following student comments from both countries supported the content and construct validity of the scales of the TCBQ.

Challenging

Australia.   Could you see what this section was about?

> *About questions and how the teacher approaches us and asks us questions.*

So you told me the first group of items here were about questioning and for number 2 you circled almost never, 1. Can you tell me why 1? (2. This teacher asks me questions that make me think hard about things that I have learned in class.)

> *Because a lot of the questions require a real answer, not your opinion.*

So the questions make you think?

> *Yes. She gives us work and we just do it. I don't know, it just makes me think about solutions and stuff?*

Right, and that's good?

> *Yes.*

Again, in relation to number 2 another student said:

> *Because, well we haven't really done things about like thinking, except for when we did something like genetics and that sort of stuff.*

So that was mainly because of what the science was like?

> *Because of the curriculum.*

Taiwan.   Does your teacher ask questions very often?

> *Yes, the teacher asks a lot of questions.*

What types of questions does your teacher ask?

> *The teacher asks questions that will make us think a while. The teacher likes to ask us, "Why would it happen?" types of questions.*
> *The teacher rarely asks us yes or no questions.*

Why did you circle always or very often to these items?

> *Because the teacher always asks a lot of questions to all of us.*

Could you tell me why you circled 4 for number 6? (6. This teacher asks questions that require me to integrate information that I have learned.)

Because you need to understand the content you have learned in order to continue to answer the teacher's questions.

Encouragement and Praise

Australia.

Um, those ones they were like encouraging you to answer questions.

Here's another one with 5 circled, question 14, this teacher praises my answers?

Yes, even though it (the answer) is wrong she just still says good attempt.

And here's a 5 here at number 13, the teacher does that a lot does she? (13. This teacher praises me for asking a good question.)

Yes and it really boosts your confidence as well.

Yes, it's a good thing to do?

Yes. It is. And even if you don't get the answer right, they say yeah, like they know it's wrong but they like go on to correct it as well.

Yes, she often says yeah, that was good and stuff like that.

And does that feel good to you?

Yes.

Your answer to number 10 is a little different in that you have circled 1, the teacher encourages me to discuss the answers to questions. Can you tell me why you circled 1 for that item?

Well she doesn't actually ever say to me while you are joining in you should be discussing the answers, she never says that or anything like that.

Taiwan. How does your teacher respond when you answer a question?

She will say "it is very good."

Very often, the teacher will clarify my ideas and expand to deeper concepts instead of praising my answer or using my thoughts as part of the lesson.

(This student circled 3 to both the teacher praises my answer and the teacher uses my thoughts as part of the answer.) Does your teacher encourage you to answer questions?

Yes, the teacher usually will ask students who know the answer to raise their hands to answer the questions.

Does the teacher give you hints if you do not know how to answer the questions?

Yes, sometimes she will help you to think of an answer.

Non-Verbal Support

Australia.

Because I think she sort of like, she knows the correct manner to approach someone and rather than just sort of being a little machine which puts out answers and that she sort of like interacts and it just makes you feel a bit more important, if like she looks at you or comes around to your desk or something if you have got a problem.

Taiwan.   Does your teacher use some other ways to help you answer questions?

The teacher usually will nod her head or smile to us.

Why did you circle 5 for number 23? (23. Without speaking, this teacher shows his/her enthusiasm about my questions through his/her facial expression.)

It is always like this, while you are talking, the teacher will show her enthusiasm through her eyes or face to show that she is expecting a good question.

Another student who circled 2 for this item said:

Because I seldom ask the teacher questions.

Understanding and Friendly

Australia.   The students had little difficulty understanding the nature of the Understanding and Friendly scale and made such comments as:

Yes, because everything she says is clear and you can understand it.
Yes, there is freedom to ask questions and stuff like and she is clear and explains things.
Yes, she is kind and friendly and not that strict.

Taiwan.   Is your teacher friendly to you?

Yes, she is very friendly to us. She usually will not get angry unless we are too noisy.

(27. If I have something to say, this teacher will listen.) Why did you circle 5?

For instance, we went to National Science Museum and the teacher listened to our talking while on the bus.

(29. This teacher is patient with me.) Why did you circle 4?

Because this teacher is patient. If you have something you do not understand, the teacher will explain to you more than three times until you understand.

Controlling

Australia. The general responses to the items in this scale included:

> *Isn't it saying, um, like we have to obey her every instruction?*
>
> *She is not that strict and that's why people like her. She gets the job done.*

You say she is not strict with you, how do you understand the word strict?

> *Like disciplined and very disciplined.*

The teacher does not always expect you to do everything she tells you to do. Is that what you are saying here?

> *Oh, sometimes if it is too hard she will let us not do it and she will explain it to us later. If she sets homework, it's all right if we weren't able to do one if we really didn't understand it.*

I see, so that is a positive thing is it?

> *Yes.*
>
> *Well when people are mucking around the teacher deals with them like and then they will know what behavior is expected because they know she is not strict and they know that mucking around isn't good and know that she doesn't go over things more than twice. If they don't really know it then they will get it wrong in the test.*

Taiwan. Does your teacher have any expectations of you?

> *Yes, the teacher asks us to bring our books and other things to the class.*

Do you think the expectation is too high for you?

> *No, I do not think so. She just likes to ask us to study hard.*

Why did you circle 4 for this item? (34. This teacher expects me to obey his/her instructions.)

> *You must follow the teacher's instructions during the laboratory or the teacher might be unhappy.*

Another student who circled 5 said:

> *Teacher would give us homework assignment, which must be done because it will be discussed in the next class.*

The interview data had assisted us with validation of the instrument. The quantitative analysis using factor analysis, reliability, the discriminant validity, and η^2 of each scale, had indicated that most of the scales were acceptable. However, the interviews described above provided verification of the content and construct validity of the scales. It is important to examine students' perceptions of items in each scale even though statistical

evidence suggests that the scale is valid. Students can interpret items or scales in ways that were not originally intended. Researchers need to examine the extent of this variation and to keep this in mind when describing the results of the TCBQ.

AN APPLICATION USING THE TCBQ

Having validated the TCBQ, it was then used in an investigation involving associations between students' perceptions of their teachers' communication behaviors and their attitudes toward their science classes. The responses to the Attitude to this Class scale were analyzed first to check the reliability of the scale using the Cronbach alpha coefficient. The Cronbach alpha reliability for the Attitude scale was 0.90 for the Taiwan sample and 0.85 for the Australian sample. These can be regarded as satisfactory (Nunnally, 1978, p. 245). These reliability measures also compare favorably with the use of the scale in previous studies involving students in science classes where the reliability coefficients ranged from 0.78 and 0.85 (e.g., Fisher, Fraser, & Rickards, 1997; Henderson, Fisher, & Fraser, 1998). The data then were analyzed using simple correlation analyses. Table 4 reports the simple correlation (r), which describes the bivariate association between students' attitude to science and each scale of the TCBQ.

The simple correlation (r) figures reported in Table 4 indicate, for both Taiwanese and Australian data, that there were statistically significant ($p < .001$) associations between students' attitude to class and four of the scales of the questionnaire; namely, Challenging, Encouragement and Praise, Non-Verbal Support, and Understanding and Friendly Behavior. That is, students' attitude scores were higher where students perceived their teacher as using more challenging questions, as giving more encouragement and praise, more verbal support, and as being more understanding and friendly.

CONCLUSIONS

The development and validation of the TCBQ has added to the range of instruments available to researchers and teachers which can be used to assess the learning environment of science classrooms. The TCBQ in particular has added teacher communication behaviors to the existing dimensions like individualization, teacher interpersonal behavior, and constructivism. In this original study, the instrument proved satisfactory for use in science classes from grades 7 to 9; however, with minor modifications to words, it may well be suitable for use from grades 6 through 12.

TABLE 4
Associations Between TCBQ Scales and Students' Attitudinal Outcome in Terms of Simple Correlations (r)

Scale	Strength of TCBQ Scale—Attitude Association	
	Taiwan	Australia
Challenging	0.38*	0.22*
Encouragement & Praise	0.37*	0.41*
Non-Verbal Support	0.38*	0.41*
Understanding & Friendly	0.48*	0.64*
Controlling	−0.06	−0.07

*$p < .001$; Taiwan, $n = 1202$; Australia, $n = 307$.

One of this study's major contributions is the development and validation of this new perception of teacher behavior instrument designed specifically for use in science classes. All five scales of the TCBQ were found to display satisfactory internal consistency reliability, discriminant validity, and factor validity. As well, further analyses supported the ability of the TCBQ to differentiate between the perceptions of students in different classrooms. In the validation process the researchers used a combination of quantitative and qualitative analyses. The quantitative data provided numerical descriptions of the reliability and validity of the TCBQ, while student interviews provided verification of the content and construct validity of the scales.

Four of the five aspects of science students' perceptions of their teacher's behavior measured in this study; namely, Challenging, Encouragement and Praise, Non-Verbal Support, and Understanding and Friendly were found to be associated with students' attitudinal outcomes. In other words, in classes where students perceive that their teacher exhibits higher levels of each of these qualities, the students are likely to have more positive attitudes about their science class.

One advantage from this study is that the TCBQ proved satisfactory in two countries. Therefore, researchers in other countries should be able to use the questionnaire in their situations. Some minor changes to words may be necessary and a method of back translation is recommended.

The TCBQ will continue to be used to study science classrooms in both Taiwan and Australia, in particular, in an investigation of mean scores and differences between the two countries. In the future, the development of a teacher version and a student preferred version of the questionnaire will allow other comparisons to be made. For example, teachers will be able to use this information to promote an atmosphere of positive interaction in their science classrooms and improve student learning.

REFERENCES

Brekelmans, M., Wubbels, T., & Levy, J. (1993) Student performance, attitudes, instructional strategies and teacher-communication style. In T. Wubbels & J. Levy (Eds.), Do you know what you look like? Interpersonal relationships in education (pp. 56–63). London: Falmer Press.

Carlsen, W. S. (1991). Questioning in classrooms: A sociolinguistic perspective. Review of Educational Research, 61, 157–178.

Cooper, H., & Good, T. (1983). Pygmalion grows up: Studies in the expectation communication process. New York: Longman.

Cuban, L. (1984). How teachers taught: Constancy and change in American classrooms 1890–1980. New York: Longman.

Deal, D., & Sterling, D. (1997). Kids ask the best questions. Educational Leadership, 54, 61–63.

Fisher, D., Fraser, B., & Rickards, T. (1997, March). Gender and cultural differences in teacher–student interpersonal behaviour. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, USA.

Fisher, D., Henderson, D., & Fraser, B. (1995). Interpersonal behaviour in senior high school biology classes. Research in Science Education, 25, 125–133.

Fisher, D., & Kent, H. (1999). Associations between teacher personality and classroom environment. Journal of Classroom Interaction, 33(1), 5–13.

Fisher, D., & Rickards, T. (1997, April). A way of assessing teacher–student interpersonal relationships in science classes. Paper presented at the National Science Teachers Association Annual National Convention, New Orleans, USA.

Fisher, D., Rickards, T., Goh, S., & Wong, A. (1997). Perceptions of interpersonal teacher behaviour in secondary science classrooms: Comparisons between Australia and Singapore. In D. Fisher & T. Rickards (Eds.), Science, mathematics and technology education and national development. Proceedings of the International Conference on Science, Mathematics and Technology Education, Hanoi, Vietnam (pp. 136–143). Perth: Curtin University of Technology.

Fraser, B. J. (1981). Test of Science-Related Attitudes (TOSRA). Melbourne: Australian Council for Educational Research.

Fraser, B. J. (1994). Research on classroom and school climate. In D. Gabel (Ed.), Handbook of research on science teaching and learning (pp. 493–541). New York: Macmillan.

Fraser, B. J. (1998a). Science learning environments: Assessment, effects and determinants. In B. J. Fraser & K. G. Tobin (Eds.), The international handbook of science education (pp. 527–564). Dordrecht, The Netherlands: Kluwer.

Fraser, B. J. (1998b). Classroom environment instruments: Development, validity and applications. Learning Environments Research, 1, 7–33.

Fraser, B. J., Giddings, G. J., & McRobbie, C. R. (1995). Evolution and validation of a personal form of an instrument for assessing science laboratory classroom environments. Journal of Research in Science Teaching, 32, 399–422.

Fraser, B. J., & Walberg, H. J. (Eds.). (1991). Educational environments: Evaluation, antecedents and consequences. Oxford, England: Pergamon Press.

Gardner, P., & Gauld, C. (1990). Labwork and students' attitudes. In E. Hegarty-Hazel (Ed.), The student laboratory and the science curriculum (pp. 132–156). London, England: Routledge.

Good, T., & Brophy, J. (1974). Teacher–student relationships: Causes and consequences. New York: Holt.

Good, T., & Brophy, J. (1991). Looking in classrooms (5th ed.). New York: Harper Collins.

Haertel, G. D., Walberg, H. J., & Haertel, E. H. (1981). Socio-psychological environments and learning: A quantitative synthesis. British Educational Research Journal, 7, 27–36.

Henderson, D. G., Fisher, D. L., & Fraser, B. J. (1998, April). Learning environments and student attitudes in environmental science classrooms. Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Diego, CA.

Hough, L. W., & Piper, M. K. (1982). The relationship between attitudes toward science and science achievement. Journal of Research in Science Teaching, 19, 33–38.

Kim, H., Fisher, D., & Fraser, B. (in press a). Classroom environment and teacher interpersonal behaviour in secondary science classes in Korea. Evaluation and Research in Education.

Kim, H., Fisher, D., & Fraser, B. (in press b). Assessment and investigation of constructivist science learning environments in Korea. Research in Science and Technological Education.

Mager, R. F. (1968). Developing attitude toward learning. Belmont, CA: Fearon Publishers.

Mathews, J. C. (1974). The assessment of attitudes. In H. G. Macintosh (Ed.), Techniques and problems of assessment (pp. 172–185). London, England: Arnold.

Newby, M., & Fisher, D. (1997). An instrument for assessing the learning environment of a computer laboratory. Journal of Educational Computing Research, 16(2), 179–197.

Nunally, J. (1978). Psychometric theory. New York: McGraw Hill.

Rosenholtz, S. J., Bassler, O., & Hoover-Dempsey, K. (1986). Organizational conditions of teacher learning. Teaching and Teacher Education, 2, 91–104.

Rosenshine, B. (1971). Teaching behaviours and student achievement. Windsor, Berkshire: National Foundation for Educational Research in England and Wales.

She, H. C. (1997, April). Gender difference in teacher–student interaction in high and low achieving middle school biology classes. Paper presented at annual meeting of the National Association for Research in Science Teaching, Chicago, IL.

She, H. C. (1998). Interaction between different gender students and their teacher in junior high school biology classes. Journal of Proceedings of the National Science Council, Part D: Mathematics, Science, and Technology Education, 8, 16–21.

She, H. C. (1999). Students' knowledge construction in small groups in the 7th grade biology laboratory: Verbal communication and physical engagement. International Journal of Science Education, 21(10), 1051–1066.

She, H. C. (2000). The interplay of a biology teacher's beliefs, teaching practices and gender-based student-teacher classroom interaction. Educational Research, 42(1), 100–111.

She, H. C., & Barrow, L. H. (1997). Gifted elementary students' interactions with female and male scientists in a biochemistry enrichment program. Journal of Elementary Science Education, 9(2), 45–66.

Shulman, L. S., & Tamir, P. (1972). Research on teaching in the natural sciences. In R. M. W. Travers (Ed.), Second handbook of research on teaching (pp. 1098–1148). Chicago, IL: Rand McNally.

Smith, E. L., Blakeslee, T. D., & Anderson, C. W. (1993). Teaching strategies associated with conceptual change learning in science. Journal of Research in Science Teaching, 20, 111–126.

Stodolsky, S. (1984). Teacher evaluation: The limits of looking. Educational Researcher, 13, 11–18.

Taylor, P., Fraser, B., & Fisher, D. (1997). Monitoring constructivist classroom learning environments. International Journal of Educational Research, 27(4), 293–302.

van Tartwijk, J. (1993). Sketches of teacher behavior, in Dutch: *Docentgedrag in beeld.* Utrecht: W.C.C.

Walberg, H. J. (1984). Improving the productivity of American schools. Educational Leadership, 41, 19–27.

Walberg, H. J., & Haertel, G. D. (1980). Validity and use of educational environment assessments. Studies in Educational Evaluation, 6, 225–238.

Watts, M., & Bentley, D. (1987). Constructivism in the classroom: Enabling conceptual change by words and deeds. British Educational Research Journal, 13, 121–135.

Watzlawick, P., Beavin, J., & Jackson, D. (1967). The pragmatics of human communication. New York: Norton.

Weinburgh, M. (1995). Sex differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991. Journal of Research in Science Teaching, 32, 387–398.

Wubbels, T., Brekelmans, M., & Hooymayers, H. P. (1991). Interpersonal teacher behavior in the classroom. In B. J. Fraser & H. J. Walberg (Eds.), Educational environments: Antecedents, consequences and evaluation (pp. 141–160). Oxford: Pergamon Press.

Wubbels, T., Creton, H. A., & Holvast, A. J. (1988). Undesirable classroom situations. Interchange, 19(2), 25–40.

Wubbels, T., Creton, H. A., & Hooymayers, H. P. (1992). Review of research on teacher communication styles with use of the Leary model. Journal of Classroom Interaction, 27, 1–12.

Wubbels, T., & Levy, J. (Eds.). (1993). Do you know what you look like? Interpersonal relationships in education. London, England: Falmer Press.

TEACHER COMMUNICATION BEHAVIOR
Student Questionnaire

Directions

This questionnaire contains statements about the interactions you have with your teacher in this class. You will be asked how often each interaction takes place.

There are no "right" or "wrong" answers. Your opinion is what is wanted.

Think about how well each statement describes what this class is like for you.

Draw a circle around

1	if the practice takes place	Almost Never
2	if the practice takes place	Seldom
3	if the practice takes place	Sometimes
4	if the practice takes place	Often
5	if the practice takes place	Almost Always

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Suppose that you were given the statement: "The teacher asks for my opinions during discussion." If you think your teacher almost never asks for your opinion you would circle 1, however, if your teacher almost always asks for your opinion you would circle 5. Or you can circle the numbers 2, 3, and 4, which are in between.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Your Name: Male ☐   Female ☐
Teacher's Name:
School:
Grade:

Challenging	Almost Never	Seldom	Some-times	Often	Almost Always
1. This teacher asks questions that require me to provide steps or ways of solving problems.	1	2	3	4	5
2. This teacher asks questions that make me think hard about things that I have learned in class.	1	2	3	4	5
3. This teacher asks questions that require me to carefully analyze information in order to answer.	1	2	3	4	5
4. This teacher asks questions that require me to use a judgment to answer.	1	2	3	4	5
5. This teacher asks questions that require me to apply what I have learned in class in order to answer.	1	2	3	4	5
6. This teacher asks questions that require me to integrate information that I have learned.	1	2	3	4	5
7. This teacher asks questions that require me to understand what I have learned in class in order to answer.	1	2	3	4	5
8. This teacher asks questions that require me to give explanations in my own words.	1	2	3	4	5

Encouragement and Praise	Almost Never	Seldom	Some-times	Often	Almost Always
9. This teacher asks for my opinions during discussions.	1	2	3	4	5
10. This teacher encourages me to discuss the answers to questions.	1	2	3	4	5

	Almost Never	Seldom	Some-times	Often	Almost Always
11. This teacher encourages me to discuss my ideas with other students.	1	2	3	4	5
12. This teacher encourages me to express my opinions about a topic.	1	2	3	4	5
13. This teacher praises me for asking a good question.	1	2	3	4	5
14. This teacher praises my answers.	1	2	3	4	5
15. This teacher uses my ideas as part of the lesson.	1	2	3	4	5
16. This teacher uses my answer as part of the explanation of the lesson.	1	2	3	4	5

Non-Verbal Support	Almost Never	Seldom	Some-times	Often	Almost Always
17. This teacher nods his/her head to show his/her understanding of my opinion.	1	2	3	4	5
18. This teacher nods his/her head to show support while I am struggling to answer a question.	1	2	3	4	5
19. Without speaking, this teacher indicates support for me through his/her facial expression.	1	2	3	4	5
20. Without speaking, this teacher supports me when I have a problem through his/her facial expression.	1	2	3	4	5
21. Without speaking, this teacher shows he/she understands my opinion through his/her facial expression.	1	2	3	4	5
22. Without speaking, this teacher shows his/her enthusiasm about my answer through his/her facial expression.	1	2	3	4	5
23. Without speaking, this teacher shows his/her enthusiasm about my question through his/her facial expression.	1	2	3	4	5
24. Without speaking, this teacher shows his/her support through his/her eyes.	1	2	3	4	5

Understanding and Friendly	Almost Never	Seldom	Some-times	Often	Almost Always
25. This teacher trusts me.	1	2	3	4	5
26. This teacher is willing to explain things to me again.	1	2	3	4	5

27. If I have something to say, this teacher will listen.	1	2	3	4	5
28. This teacher realizes when I do not understand.	1	2	3	4	5
29. This teacher is patient with me.	1	2	3	4	5
30. This teacher is friendly to me.	1	2	3	4	5
31. This teacher is someone I can depend on.	1	2	3	4	5
32. This teacher cares about me.	1	2	3	4	5

Controlling	**Almost Never**	**Seldom**	**Some-times**	**Often**	**Almost Always**
33. This teacher's standards of behavior are very high.	1	2	3	4	5
34. This teacher expects me to obey his/her instructions.	1	2	3	4	5
35. This teacher insists that I follow his/her rules.	1	2	3	4	5
36. This teacher insists that I do everything(s) he/she tells me to do.	1	2	3	4	5
37. This teacher demands that I do exactly as I am told.	1	2	3	4	5
38. This teacher does not allow me to do things differently from what he/she expect.	1	2	3	4	5
39. This teacher makes very clear to me the standard of behavior expected of all students in this class.	1	2	3	4	5
40. This teacher demands that I listen to instructions.	1	2	3	4	5