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The interplay of a biology teacher's beliefs, teaching practices and gender-based student–teacher classroom interaction

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Summary

Cross-relationships among a Taiwanese seventh-grade biology teacher's beliefs, practices and classroom interaction with either male or female students were qualitatively and quantitatively analysed. Results show that the teacher's classroom practices reflect her teaching philosophy, which she described in interviews held before and throughout the class observation period. Gender-based characteristics clearly play an important role in establishing and maintaining differences in interactions between male or female students and their teacher in this particular classroom. Data collected from classroom observations show that the subject teacher's beliefs concerning boy/girl differences in learning style and classroom participation are reinforced or sustained by her behaviour, which includes unequal distribution of direct questions, unbalanced feedback and encouragement, and a lack of restrictive controls on calling out answers.

Keywords: teacher's beliefs, teaching practices, gender, student–teacher interactions, middle school biology class

Introduction

On a typical day, secondary school teachers interact with up to 150 individual students. As Good and Brophy (1991) point out, the majority of interactions entail complex exchanges of information at speeds which do not allow teachers to monitor or study their own behaviour. As a result, most teachers are unable to describe the dynamics of their classroom interactions. Investigating classroom behaviour from a communications system perspective, several Dutch researchers (Wubbels, Creton and Holvast, 1988; Wubbels, Creton and Hooymayers, 1992; Wubbels and Levy, 1993) observed and described a process of mutual influence between instructors and their students. Their 'system approach' assumes the inability to communicate effectively in the presence of interference from a third (fourth, etc.) party. Therefore, teachers occasionally overlook student questions for the simple reason that they don't hear them in the din of an active classroom.

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Unfortunately, students may infer that the teacher is too busy to pay attention to them, that the teacher considers the questions irrelevant or that the teacher is biased against them.

Numerous studies on teacher beliefs and how they influence in-class practices have been conducted during the past two decades. Shavelson and Stern (1981) are two of many researchers who have suggested that such behaviour is directly influenced by teacher thoughts, judgements and prior decisions. Clark and Peterson (1986) have argued that teachers' beliefs influence both their thinking and teaching performance. Brickhouse (1990), Gallagher (1991) and Rowell and Gustafson (1993) have all looked at the specific field of science education and found that teachers' beliefs and attitudes towards science tend to be congruent with their teaching strategies.

According to what is now called the Vygotskian perspective, teachers play a key role in mediating and 'passing on' existing public knowledge to their students (Vygotsky, 1978). In considering the question of how students develop 'new' understanding or meanings in science classrooms, the Vygotskian perspective employs an analytical approach which recognizes the importance of interactions on an interpsychological plane – in particular, the nature of teacher–student discourse in the classroom. She and Fisher (1999; in press) are the most recent researchers to reconfirm that students who answer more challenging questions achieve greater cognitive (and therefore academic) outcomes in the science classroom.

Greenfield (1997), Jones and Wheatley (1990), Sadker and Sadker (1994), Tobin (1990), She and Barrow (1997) and She (1998; 1999) have all researched gender-based student–teacher interactions in general science classrooms and reported that boys receive more attention than girls, are more frequently directed to answer questions, given greater freedom to call out answers and receive more feedback. For the most part, the results are the same as those from studies conducted in the 1960s. These researchers failed to identify or examine in detail the reasons for the gender bias they observed.

The goal of the present study was to qualitatively and quantitatively analyse and describe relationships between teacher beliefs, teaching practices and gender-based student–teacher interaction in a seventh-grade biology classroom in Taiwan. The primary research questions were: (1) What is the relationship between a teacher's beliefs, a teacher's practices and his/her classroom interaction with students? (2) Which beliefs most affect a teacher's pedagogical approach and interactions with either male or female students? and (3) What factors affect gender-based student–teacher interactions in these particular seventh-grade biology classrooms?

Methodology

Subjects

Ninety-four seventh-grade biology students (23 male, 25 female in class A and 23 male, 23 female in class B) from a middle school in Taiwan were observed for this study. The average age for seventh-grade students is 13. Their teacher, Diane (her chosen English name), has an undergraduate degree in biology and a graduate degree in science education. The subjects' academic achievement level is considered average for their school students. Each student subject was assigned a number for identification.

Instruments and procedures

The author conducted two formal (semi-structured) and numerous informal (unstructured) interviews throughout the study period. The initial interview with Diane, which was conducted prior to classroom observation, focused on her beliefs on science pedagogy, science/biology education and the learning characteristics of boys and girls in biology classes. The second formal interview conducted at the end of the observation period focused on Diane's views on differences between male and female students' learning styles and participation modes in her biology classes, as well as her own behaviour towards male and female students. Unstructured, informal interviews were conducted after class sessions whenever the researcher required an explanation of the teacher's practices or specific classroom interactions. Interviews were tape recorded and transcribed for further analysis.

Classes were observed twice a week for one semester, with each 50-minute class period video taped for later transcription. Transcripts were coded according to the *Teacher-Initiated Teacher–Student Interaction* (TITSI) and *Student-Initiated Teacher–Student Interaction* (SITSI) systems. Each is a modification of the Brophy–Good *Dyadic Interaction System* (Good and Brophy, 1991), designed to systematically categorize teacher–student interactions. To ensure coding consistency, a single, experienced observer was used throughout the project. All collected data were analysed using the SAS statistical package.

The TITSI system categorizes four types of teacher-initiated questions, four types of student responses, three types of student answers and 15 types of teacher feedback. Teacher-initiated questions are labelled according to complexity as follows: procedure questions requiring a description of how to approach a task; product questions requiring brief factual answers; process questions requiring the integration of prior knowledge; and choice questions requiring students to choose one correct answer from several choices. Student responses are categorized according to how they respond: open questions are those directed to students with their hands up; direct questions are directed to specific students identified by students' names or ID numbers; call-out questions are directed to the entire class and therefore answered without the teacher calling on a specific student; and drawn-lot questions are answered by students whose names or ID numbers are drawn at random. Student answers are categorized in terms of accuracy: correct, partly correct and incorrect. Teacher feedback is analysed in terms of extent, complexity and encouragement or discouragement for further interaction – including praise, expansion, hints and further questions for the former; and negation, negative comments, redirected questions to other students and absence of feedback for the latter. Finally, several categories of teacher feedback expressed simple confirmation, including affirmation and restating the answer.

The SITSI coding system includes four types of student-initiated questions, four types of student responses and 13 types of teacher feedback. The student-initiated question and response categories are identical to those of the TITSI system, while teacher feedback categories differ only slightly. Interaction reinforcement items include praising questions, asking new questions, providing answers, giving hints or giving explanations; interaction termination items include negation, no response, negative comment and not giving an answer; and interaction confirmation items include restating the answer and affirmation.

One limitation of both coding systems is the inability to code simultaneous responses from many students. Any questions which were answered by many students simultaneously were not counted in the statistic results. For this reason, the total number of questions reported in this study is far less than the actual number asked.

Results

Qualitative analysis of teacher interviews

1 Science/biology education beliefs

Diane believes the purpose of science education is to create science-literate citizens – in other words, to enable students to understand the science knowledge they learn in class, to use that knowledge to think independently and to make everyday decisions based on scientific principles. She told me that the primary source of this belief was her undergraduate scientific methods class. In addition, Diane believes the purpose of biology education is to develop students' understanding of the environment by means of observation, analysis and personal experience with the natural world. It is her wish that, through biology education, students might come to love natural biological and ecological processes and respect them, and therefore act to preserve and protect them. In her words:

> 'I was surprised when I was directly taught as an undergraduate that the goal of middle school science education is to cultivate all students to become science-literate citizens. However, at that moment, I realized how science education could develop students' abilities to read, write and understand science-related issues around them; moreover, to enhance their ability to think, judge and make proper decisions based on knowledge they learn in their science classes. I really feel this is what we need in our middle school science education.
>
> 'Focusing on biology education, I hope my students will be able to observe things in their environment, to recognize there are many other living organisms in this world besides human beings, and to respect all life. According to my teaching experience at a summer camp, students will naturally love and care for other forms of life, and have a natural desire to protect this earth, the only one we have, without any prodding from me.'

2 Science pedagogy beliefs

• *Science teaching* Diane's teaching philosophy entails making students independent thinkers by facilitating opportunities for active involvement in their own learning. Her approach is to constantly question and present problems for students to solve. Throughout the semester, she asked an average of 26 questions per period in class A and 22 per period in class B (again, not counting questions answered simultaneously by many students). She emphatically stated her belief that this approach is the best means of developing her students' higher-order thinking, learning, problem-solving and decision-making skills:

> 'I think that good science education is teaching students how to fish instead of simply giving them fish. I hope to teach them logical ways of thinking and problem-solving in order to help them construct their own knowledge. In order to reach this goal, I use questions to make students think. The questions that I initiate, sometimes I don't have the answer myself. Once

students find out there is no right or wrong answer, they're surprised at first, then they laugh . . . Biology is not just a discipline or textbook knowledge, it is closely related to our daily lives. Once you start thinking about it, you will find it is very interesting. It is life.'

• *Student learning* Diane believes biology should be interesting and its relationship to students' daily lives made clear. She emphasized that biology study should involve active participation in classroom activities and discussions. In her mind, the ideal student is willing to think, learn and solve problems rather than passively receive knowledge. One of her primary goals is to teach her students that even though they might make mistakes during the learning process, they will eventually arrive at a correct answer if they persist. In her words:

> 'Memorizing concepts is the easiest way to learn things. However, I expect my students to be able to do more in-depth thinking than just memorizing things. I hope my students will become active learners, to think, look for information from books, and come up with ways to solve problems. Once they finish and if they're not sure of their answers or results, when they come to me I think I'm much more satisfied seeing them learn things this way . . . You know, if they're actively involved in the learning process, it doesn't matter whether they're right or wrong because eventually they'll find the answers. I also believe it's important to prepare students to take an appropriate science attitude with them, for instance, respect scientific principles, life, the environment and cooperation with others.'

Diane also views herself as an agent who promotes and disseminates innovative thinking. Since she also believes that no one can force unwilling students to learn, she must make her biology class as interesting as possible, and provide opportunities for students to actively engage in thinking and learning:

> 'I hope my students enjoy their biology classes and are willing to spend time learning biology. I motivate them by asking interesting and challenging questions. When I ask a question such as "Do chickens have menstrual cycles?" I can tell from eye contact whether or not they're interested. In fact, I frequently use questions for the purpose of checking their level of understanding.'

3 Male/female student learning styles

Diane believes that boys, more so than girls, tend to focus on major concepts instead of memorizing facts and figures from lectures or textbooks; that boys are more flexible and creative than girls; and that boys grasp scientific concepts more quickly than girls. Of course, another way to state her beliefs is that girls are more focused on details, or, as she told me during an interview, they are limited in thinking and learning approaches in ways that are gender-specific:

> 'Because boys tend to focus much more on learning key concepts rather than details, they rarely get 100 on tests, with the best ones consistently around 90 . . . In addition, they're more creative and flexible, and grasp new concepts quickly. I feel girls tend to learn things passively and spend their time on learning and memorizing all of the details. If I search for creative answers

to my questions, usually it will come from boys. However, there are a few girls who are taking on new learning styles and becoming much more like boys in the way they learn information.'

4 Class participation

Diane's opinions were confirmed in her classroom. Boys were much more active in discussions and participated much more compared to their female classmates. Boys answered a greater number of questions, and gave more creative answers to unusual or challenging questions. Most of the girl students I observed were passive, 'participating' through eye contact or nodding their heads in agreement. In order to create equal opportunities for classroom participation, Diane designed a system of drawing lots to choose which student should answer a question. However, she frequently forgot to use it, leading to a situation where students called out answers to most of her questions:

> '. . . I can see girls participating in class through their eyes [but] boys answer more questions. There are a few boys in particular who answer questions simply to get my attention, but answer quality is a problem. Overall, however, boys' responses are much better than girls' . . . I've tried drawing lots to decide which student should answer my question, but it's still possible that some students never get the chance to answer a question for an entire semester, although others have a better chance to be called on when I draw lots.'

Qualitative analysis of teacher–student discourse

The following discourse, a discussion on how plants react to stimuli, serves as a descriptive introduction to Diane's teaching technique (T = teacher, Sm = many students simultaneously responding, Sb = boy, Sg = girl):

T: Do you know the plant called the Venus flytrap? Which part of the plant catches insects? The root, stem, leaf, flower, fruit or seed?
Sm: Leaf!
T: Did you learn that from the textbook? What does the flytrap do after catching an insect?
Sb1: Digests it.
T: What happens after the insect is caught?
Sm: Death.
Sb1: Catabolism and digestion.
Sb2: Catabolism and digestion.
T: What does the flytrap do after catching an insect?
Sb1: Secretion.
Sb3: Secrete something.
T: What types of substances does it secrete?
Sb1: Acid?
T: Is it necessarily an acid?
Sm: No, it's not necessary.
Sb4: A base?
T: What do we call it?
Sm: Enzyme.
T: Enzyme. Are the leaves of the Venus flytrap responsible for catching an insect?

Sm: Yes, right.
T: You know leaves are capable of photosynthesis. How about the leaves of the flytrap?
Sm: Yes, they can.
T: How do you know?
Sm: Because they have chlorophyll.
T: How do you know they have chlorophyll?
Sm: Because they're green.
T: Okay! We need to clarify something here. Tell me, if the flytrap can do photosynthesis, when does it need to catch an insect?
Sb1: When an insect comes.
T: When an insect comes? Happy New Year? (*Diane uses this metaphor of something that only happens once a year to show students their answer is incorrect*) And?
Sg1: Happy New Year? (*This girl is not certain why her teacher just made that metaphorical statement*)
T: To get dessert! (*Much laughter*)
Sb5: When they feel hungry.
T: When would they feel hungry?
Sg2: When the sun doesn't show up.
T: When the sun doesn't show up. Actually, the flytrap catches insects when available sunlight isn't strong enough for them to efficiently perform photosynthesis. Why do you think a flytrap feels hungry? What does hungry mean to a Venus flytrap?
Sg3: Lack of nutrition.
T: Lack of nutrition. This means they can't do photosynthesis when sunlight isn't strong enough, so they need to catch a fly to provide nutrition. That's why we name this plant the flytrap.
Sg1: What if the sunlight is strong enough?
T: In that case, the flytrap doesn't need to catch insects. What if you put your hand into the flytrap?
Sm: Then we'll be caught and wrapped up.
T: And then?
Sm: The flytrap will secrete a toxin.
T: Then your hand will be digested and absorbed, and finally nothing will be left.
Sm: It wouldn't happen!
T: Well, you can wait there for a couple of days to see what happens. (*Everyone laughs*)
Sb1: It has specification.
T: It's very interesting! The flytrap's digestive enzyme does have specification, and it cannot digest your hand, you're right. But would you be so stupid as to stay there and shout, 'I'm trapped!'? (*Everyone laughs*)

Diane taught the concept of plant reaction by asking a series of questions meant to make students integrate what they already knew and construct their own understanding. She provided students with correct answers and clarifications whenever necessary, and provided a scenario (putting their hand into a Venus flytrap) to make the information more realistic to their daily lives (digestion). This type of discourse, which is very typical of Diane's biology classes, confirms what she told me about her pedagogical approach during our initial interviews. It also shows how the majority of student answers in her classes are called out, and illustrates how she provides feedback to their responses. A simple count shows that more boys than girls answered questions in cases where an individual student gave a response (Sb1–Sb5 vs Sg1–Sg3), resulting in more feedback being given to boys.

Quantitative analysis of classroom observations

Teacher-initiated teacher–student interactions

Significant differences were found in teacher-initiated question types for males and females in both classes. Of 355 questions asked of class A students, 283 and 72 were answered by boys and girls respectively (79.7 vs 21.3 per cent). Of 581 questions asked of class B students, the numbers were 456 responses from boys and 125 from girls (78.5 vs 21.5 per cent). In all, boys answered nearly four times as many questions as girls. Mean frequencies for teacher–student interaction categories are presented in Table 1 (average frequency per 50-minute class period). The results show that boys answered a mean of 20.21 teacher-initiated questions per 50-minute period in class A, while girls answered a mean of 5.15. The means for class B were 17.55 and 4.81 respectively. In general, the male student subjects in both classes answered many more questions regardless of types of questions (process, product, procedure or choice).

Gender-based differences were also observed in terms of response patterns, with male students calling out answers much more frequently than female students per class period (means for class A boys and girls were 14.71 and 0.43; for class B 13.04 and 2.54). Overall, boys called out answers to 57 per cent of 355 and 60 per cent of 581 teacher-initiated questions in classes A and B respectively. In addition, Diane directed boys to answer more questions than girls in both classes (means for class A boys and girls were 5.07 and 4.14; for class B 3.19 and 0.96) (see Table 1). The number of boys called on after raising their hands was slightly higher than the number of girls. Male/female differences were much less prominent in terms of accuracy, with class A males giving correct answers to 199 of 279 questions (71.3 per cent), only slightly higher than the 48 of 72 (66.6 per cent) given by their female classmates. For class B students the numbers were 314 of 446 (70.4 per cent) for males and 69 of 110 (62.7 per cent) for females.

However, a significant difference was noted in the amount of feedback provided to boy or girl students in both classes (see Table 1). Respective instances of teacher feedback were 503 and 752 in classes A and B. In class A, 81 per cent of feedback was given to male responses, while for girls it was only 19 per cent; for class B the respective figures were 77 and 23 per cent. Class A boys received more praise than girls per class period (1.0 vs 0.29); also in that class, only male students received negative feedback. Diane gave class A boys eight times as much feedback in terms of clarification compared to class A girls (5.36: 2.64), and restated approximately five times as many male student answers (8.86: 1.79) per class period. Similar patterns were observed for class B students.

Student-initiated teacher–student interactions

Males asked all of the 19 student-initiated questions counted in class A. In class B, 30 of the 39 student-initiated questions were from males. Most of the nine questions asked by female students were product-type. Regardless of gender or

TABLE 1 Mean frequencies of teacher-initiated question types, student responses, response quality and teacher feedback, according to gender, in classes A and B per 50-minute class period

	Class A		*Class B*	
Variable	*M*	*F*	*M*	*F*
Teacher-initiated question type				
Procedure	3.07	0.57	1.27	0.46
Process	0.57	0.43	2.35	0.46
Product	14.07	3.86	11.62	3.54
Choice	2.50	0.29	2.31	0.35
Student response type				
Call out	14.71	0.43	13.04	2.54
Open	0.07	0.00	0.81	0.35
Direct	5.07	4.41	3.19	0.96
Draw lots	0.36	0.57	0.27	0.73
Response quality				
Correct	14.21	3.43	12.08	2.65
Partially correct	0.93	0.50	1.35	0.77
Incorrect	3.86	0.64	3.00	0.38
Did not know	0.36	0.21	0.19	0.23
No response	0.57	0.36	0.54	0.19
Teacher feedback				
Praise	1.00	0.29	0.77	0.50
Affirmation	1.64	1.57	1.08	0.58
Negation	0.50	0.00	0.42	0.19
Correction	1.79	1.43	0.92	0.19
Clarification	5.36	2.64	2.85	0.58
Expansion	0.93	0.57	0.85	0.15
Comment	0.36	0.07	0.38	0.08
Restate answer	8.86	1.79	5.08	1.77
Repeat question	0.79	0.21	0.23	0.04
Give hints	0.57	0.14	0.38	0.23
Further question	2.57	0.71	4.00	0.92
Challenge the answer	1.43	0.50	2.27	0.35
Ask others	0.57	0.57	0.69	0.46
No feedback	2.07	0.07	1.73	0.46
Give more information	0.64	0.29	0.62	0.12

class, all student-initiated questions were called out. For the most part, Diane responded positively to these questions, with a simple answer or a more detailed explanation.

Discussion and conclusion

The data collected from the TITSI and SITSI instruments show clearly that Diane's beliefs in science teaching and gender differences influence her in-class practices. An analysis of classroom discourse also shows that she tries to make her lessons more interesting by giving real-world examples and problems to her students. She initiates large numbers of questions to make students integrate information, problem-solve and laugh.

The collected data also show that Diane's male students answered teacher-initiated questions at a much higher frequency than girls – a ratio of approximately 4:1 – and that those same boys preferred calling out their answers (80 per cent) to all other means of question response – almost 14 and five times more than girls in classes A and B respectively. These figures reconfirm Brophy *et al.*'s (1981) assertion that boys call out in class much more than girls do. Overall, the data presented in Table 1 show that class A boys called out 57 per cent (14.71/13.04 boy/girl ratio) of responses to teacher-initiated questions and that class B boys called out 60 per cent (25.62/21.98). Again, these statistics fit with Brophy *et al.*'s arguments that sex differences determine in-class student behaviour and that teachers respond to these differences.

During our pre-observation interviews, Diane admitted that her personality and academic experience set her apart from her female classmates because her learning style resembles that which she described as typical for boys. It is possible, but unprovable from the present data, that her learning style preference influences the unintentional bias she shows in the classroom. In both classes, she directed boys to answer more questions than girls – most likely, a reflection of her belief that boys are more creative and less detail orientated. The question remains of how much the in-class behaviour of her male students simply serves to reinforce this belief, cutting off opportunities for girls to show that they are also capable of abstract thinking, integration and giving creative answers. In an informal interview following one of her class sessions, Diane mentioned that occasionally boys gave answers that were clearly beyond her expectations; she never made the same comment for any of the girls in her two classes. When she wanted a response to a particularly challenging problem, Diane was much more likely to call on a boy student.

Diane, as with many other teachers, is still struggling with the issue of controlling classroom interaction and training students to raise their hands instead of automatically calling out answers. She does have a system in which lots are drawn to choose respondents to individual questions, but she tends to abandon the system whenever the energy level of in-class discussion intensifies; this observation is confirmed by the low mean frequency of drawing lots shown in the student-response section of Table 1. Her primary teaching method is therefore initiating questions, receiving called-out responses and providing feedback. Again, a possible explanation for this situation is that the boys' consistent calling-out behaviour confirms her belief that boys are more active participants, and so her passive acceptance of the situation sustains what she believes to be 'typical' classroom behaviour. Support for this explanation comes from Morse and Handley (1985), who argue that the higher number of responses by male students is usually perceived by teachers as indication of greater interest in a subject.

The aggressiveness of Diane's male students (they answered almost four times as many questions as girls in both classes) also resulted in their receiving more feedback and generally receiving more attention than girls. This, of course, includes negative feedback (in the form of negation and criticism) which her girl students rarely, if ever, received. Again, this observation supports the assertion which Diane made during her initial interview that she frequently uses negative feedback to adjust her male students' behaviour or to control those boys who ask questions simply to catch her attention. As she admitted, answer quality in many situations was very low, forcing her to react in a passive manner to her male students' behaviour. This observation supports Brophy and Good's (1974) belief that teacher behaviour, especially during interactions with individual students, is situationally determined and reactive rather than provocatively planned and systematic.

Conversely, boys in her classes also received much more positive feedback (praise, expansion, hints and further questions) than girls. Since positive feedback expresses teacher satisfaction with individual students' answers and provides new opportunities for participating, Diane (perhaps unknowingly) reinforces her male students' in-class behaviour. Both Dweck *et al.* (1978) and Brophy and Good (1974) have noted that teachers are the primary source of gender difference reinforcement via the different kinds of feedback they give to boy and girl students.

Based on the data collected through interviews and in-class observations, the following conclusions were drawn: (1) Diane's beliefs regarding science pedagogy influence her science teaching practices; (2) her question-oriented teaching approach allows for a higher frequency of student–teacher interaction (especially compared to what is considered the norm in Taiwanese science classrooms); (3) gender-based differences in student–teacher interactions exist in both of her biology classes; (4) male/female student–teacher interaction patterns were similar in both of her classes; (5) her beliefs regarding differences in male/female learning and class participation characteristics influence her interactions with male/female students; and (6) male/female student characteristics influenced gender-based student–teacher interactions.

The results suggest that gender-based characteristics play an important role in establishing and maintaining male-dominated classroom interaction – primarily the habit of calling out answers. They also suggest that a teacher's beliefs concerning gender-related characteristics reinforce and sustain gender differences when no action is taken to control the calling out of answers by more aggressive male students, as well as by a tendency to direct more questions towards boys and, consequently, give them more feedback. In short, the results add to the existing evidence that male/female characteristics serve to establish and maintain gender-based differences in classroom behaviour, and that teachers' preconceived beliefs concerning gender-based learning styles reinforce and sustain those differences.

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