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Patterns of Teacher Questioning Discourse in Korean Science Classrooms

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Abstract : This is a descriptive study to identify patterns of teacher questioning discourse. Transcripts from Korean secondary science classrooms were examined while extensive review of literature on classroom discourse was carried out. When it is assumed that teacher questioning discourse can be categorized into different patterns by considering together the apparent exchange structures and pedagogical functions, various patterns of teacher questioning discourse were revealed. Although most patterns found illustrate the centrality of the teacher, a few of them are considered alternatives to the typical IRE discourse. A framework for classifying teacher questioning discourse is suggested and its implications for science teacher education and future research discussed.

Keywords : classroom discourse, teacher questioning, discourse pattern, IRE, genuine dialogue, Korean secondary science classroom

Introduction

The use of teacher questions in the classroom has been widely investigated. Although some of these studies have shown conflicting results (Samson *et al.*, 1987; Winne, 1979), most of the findings indicate that appropriately employed teacher questions enhance student learning (Brualdi, 1998; Ellis, 1993; Gall, 1984). When synthesizing research findings on the effects of teacher questions, Ellis (1993) concluded that each type of question was effective for a particular instructional goal. Therefore, teachers need to clarify learning objectives for a particular lesson, analyze student abilities, and then plan appropriate types of questions. Brualdi (1998) also suggested that to foster student achievement teachers must be sure that they have a clear purpose for their questions.

The crucial role of teacher questions in teaching and learning lies in the fact that teacher questions do not occur alone (Dillon, 1978; 1982a, b; Durham, 1997). In the classroom, teacher questioning discourse takes place with teacher questions and student responses. When asking a question, the teacher usually solicits information and anticipates student answers. The question, however, does no more than request a response. Students may or may not answer the question that the teacher asked. They may or may not provide the information that the teacher wants to hear from them. Furthermore, teacher questions cannot guarantee the quality of student responses (Dillon, 1978; 1982a, b). It is often said that certain types of questions (e.g., higher-cognitive types of questions) stimulate higher-level thinking and elicit more thoughtful response. "But whether the response has a certain quality is a matter not of definition but of inspection and not of the question but of response" (Dillon, 1978, p. 53). Therefore, it is necessary to look at the behavior of the respondent to see what the question causes.

Costa and Lowery (1989) properly pointed out that it was the teacher's manner of reacting to students' responses (i.e., feedback) that greatly influenced their learning. The teacher may terminate or close down student thinking by simply providing a judgment of whether or not the student answered correctly. Contrarily, he or she can maintain, open up, or extend thinking by employing wait time, accepting the student response and asking for elaboration, or presenting additional information. Thus, teacher questioning discourse should be inquired in

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a broad context of verbal interactions so that the responses and reactions which the teacher and students have to questions and answers can be addressed in an integrated manner (Carlsen, 1991; Roth, 1996).

Teacher questioning discourse is often built in the three-part exchange structure in which a teacher initiates a question, a student replies usually by giving an answer, and then the teacher evaluates the student answer. This teacher initiation–student reply–teacher evaluation sequence has been called the IRE pattern (Cazden, 1988; Edwards & Westgate, 1987; Lemke, 1990; Mehan, 1979). While engaging in the IRE pattern, the teacher tends to formulate a question to which there is presumably one right answer and decides which student will answer which question. Consequently, the IRE discourse allows the teacher to set a topic and control the direction in which the topic develops. Indeed, the IRE is the most obvious pattern in teacher-led classroom discourse. However, there is a variety of classroom talk and it is necessary to determine other patterns of discourse to understand what is actually happening in the classroom and to identify more effective ways of classroom communication (Edwards & Westgate, 1987). For example, teacher questioning IRE discourse can be differentiated as either evaluative or elaborative according to how the teacher reacts to a student reply (Mortimer & Machado, 2000).

Given the discussion above, this study analyzed communication episodes in Korean science classrooms to identify patterns of teacher questioning discourse. Sixteen Korean secondary science teachers provided video recordings of their own classrooms. The types of classroom activities were varied, including lectures, science laboratories, student group presentations, and seatwork. Also, the recorded lessons were in a wide range of quality in terms of the teachers' self-reports regarding their own and/or their students' practices. Such diversity was conducive to recognizing a variety of classroom talk and provided motivation for devising a tentative framework for classifying teacher questioning discourse in science classrooms. This study proposes the framework for science teacher education and research concerning science classroom discourse.

Method

Collection of video recordings

The samples of science classrooms used in this study came from Korean science teachers who participated in the Iowa Chautauqua summer workshop. The Iowa Chautauqua Program (ICP) is a professional development model for inservice science teachers, which has served Korean teachers since 1995 (Lee, 2001; Shin, 2000). The ICP teachers are asked on several occasions to share their teaching practices, normally in the form of videotapes, with other participants and the central staff. The video recordings are used to establish common understanding of classroom situations, to find problems to be resolved, and to implement collaborative action research projects focusing on science classroom improvement.

During the summer, 2000 through the spring, 2002, 16 Korean secondary science teachers provided videotapes comprising 28 science lessons. They taught general science, physics, chemistry, or earth science in either junior or senior high schools. Their teaching careers ranged from 4 to 21 years with 14 years as the average; 14 of them had either M.S. or M.Ed. degrees. There were 10 male and 6 female teachers.

Analysis of the transcripts

The ICP research staff first examined the video-recorded lessons and eliminated those with little teacher talk from the list of lessons to be analyzed. For example, a lesson dominated by student group discussion was not considered for the next step of analysis. Twenty-six lessons were selected, and those were repeatedly examined so that the staff could understand the whole context of class activi-

ties and roughly transcribe teacher questioning communication episodes. Meanwhile, extensive review of literature on classroom discourse was carried out. Such repeated examination of the lessons and extensive review of literature yielded a prototype framework for classifying teacher questioning discourse in science classrooms. The framework was continuously revised as more accurate transcripts were made and new discourse patterns revealed.

Researchers have suggested that questions can be categorized in terms of their semantic meaning as well as pragmatic reasons, namely social, personal, or communicative motives for asking questions (Clark & Lang, 1988; Graesser *et al.*, 1988). Similarly, it was assumed in this study that teacher questioning discourse can be classified into different patterns by considering together the apparent exchange structure of the discourse and the pedagogical function that it serves. Thus, the framework developed in this study categories teacher questioning discourse into three major patterns –monologues, dialogues, and IREs–according to the exchange structures. Each of these three patterns was classified one step further into subordinate forms of discourse which are distinguished by their functions.

The reliability of the framework was established through the process of social negotiation within the research staff. When the framework was applied to other communication episodes which were not included in this study, two of the staff classified teacher questioning discourse with 81.8 % agreement in terms of discourse patterns. Staff meetings followed to resolve the difference until consensus was achieved among the members. The framework was re-examined with the episodes included in this study and instances of each discourse pattern to be reported were selected.

In this article, communication episodes are presented before the framework to illustrate that there is a variety of teacher questioning discourse depending upon the nature of verbal behaviors and interactions between the teacher and students. The transcripts which had been originally in Korean were translated into English with pseudonyms used to indicate particular students. When necessary, brief explanation is presented at the end of each utterance. Also, the classroom teacher and lesson number are recorded at the bottom of each transcript. The final framework shows patterns of teacher questioning discourse in a summative way. However, since this study is a descriptive one with a view of identifying patterns of teacher questioning discourse, the emphasis is not on the frequency of each pattern. For the same reason, the framework developed is deemed to be tentative so that it can be used with modifications for future research on science classroom discourse.

Findings

Teacher questions in monologues

Questions are basically utterances which request answers. However, a teacher sometimes uses questions when engaging in a rather long monologue. For example:

> Teacher (T): This frictional electricity, is it visible to our eyes, or not? It isnt, is it? So we may detect indirectly whether [it is] charged or not. That is what Im talking about. Okay? What do we need, then? Frictional electricity, I mean, what is it that helps us to detect if an object is charged or not charged? Its an electroscope. Okay? What is a simple method we can use? If you rub [an object] and then try to get your hair or a piece of paper stick on, then you can decide whether [it is] charged or not, cant you? That is what Im talking about.
> (Lesson No. 13, Teacher No. 13)

Questions in a teacher monologue are not intended to elicit responses from students. Rather, they are used to give students information about what they are supposed to learn or do in class. According to Carlsen (1992), questions in a teacher

monologue are rhetorical or procedural in nature. Therefore, teacher use of questions in a monologue is likely to happen most frequently at the beginning of a lesson, which allows the teacher to formulate the lesson topic. Students occasionally join in a teacher monologue by participating in fill-in-the-blank questions (Yerrick *et al.*, 1998). However, student participation in fill-in-the-blank questions does not change the teacher-dominant nature of the discourse. In the above example, the teacher uses a speech event to introduce important concepts about the topic while employing several rhetorical questions and providing no opportunity for students to speak. He neither pauses to listen to the students nor reacts to their responses, if any.

When students do not respond to a teacher question

(1) The teacher answers his or her own question

Teacher questions are not always followed by student answers even when those are designed to encourage students to speak. Students more often hesitate than not and eventually fail to respond to what a teacher has asked. In such a case, the teacher may answer his or her own question. When the teacher answers his or her own question, the teacher questioning discourse leads to a teacher monologue, rather than producing a conversation between the teacher and students. The following episode came from the same class as the previous one and happened prior to the teacher informative presented above.

T: What is frictional electricity?
Students (Ss): (no response)
T: It is what generates electricity by rubbing [objects with] each other.
(Lesson 13, Teacher 13)

(2) The teacher rephrases, redirects, or paraphrases the question

Many authors have suggested that teachers should provide enough time for student responses after asking a question, believing that such wait time provides students with the opportunity to think about the question and prepare an answer (Ellis, 1993; Gall, 1984; Rowe, 1986). Other strategies that teachers use more practically to help students arrive at an answer include rephrasing, redirecting, or paraphrasing the original question (Cazden, 1988; Edwards & Westgate, 1987; Mehan, 1979). Rephrasing and redirecting strategies are realized when a teacher does not remark on student failure to respond and repeats the initial question to the same or different students. Paraphrasing is such a strategy as simplifying the original question so that the students can easily answer. In the following example, the teacher changes his initial question into an easier one to get a response from students.

T: As we go down under the ground, as we go down inside the earth, how does the temperature change?
Ss: (no response)
T: Does it get warmer or colder as we come closer to the interior of the Earth?
{Paraphrasing the initial question}
Ss: Warmer.
(Lesson 22, Teacher 9)

When students answer correctly

(1) The teacher provides positive evaluation

The most common pattern for teacher questioning discourse, the IRE pattern is completed when a teacher hears an answer from students and then provides immediate evaluation. Teacher evaluation is realized by a judgment of whether the student answer is right (i.e., positive evaluation) or wrong (i.e., negative evaluation). Not surprisingly, student correct answers are likely to draw positive evaluation from the teacher. In the example below, the teacher evaluates the student answer positively by repeating what they said.

T: Into what major types do we classify rocks?
{Initiation}
Ss: Sedimentary, igneous, and metamorphic

rocks. **{Reply}**
T: Igneous, sedimentary, and metamorphic rocks. **{Evaluation}**
(Lesson 3, Teacher 3)

Despite its effectiveness for particular purposes such as monitoring student understanding and developing a shared meaning among class members (for example, see Driver, 1989), the IRE pattern has been criticized in that it is a discourse pattern embedded in a teacher-led lesson or recitation. In lessons, the teacher asks questions to which he or she almost invariably knows the answers and evaluates student answers. Whereas, the students have few opportunities for initiation or for controlling the direction of talk (Cazden, 1988). Thus, although apparently dialogic, the IRE pattern fits a closed-loop discourse as long as the teacher thinks he or she knows the answer and the feedback from the teacher is limited to evaluation (Lemke, 1990; Mortimer and Machado, 2000).

Teacher evaluation is sometimes omitted, which makes the exchange structure just IR, not full IRE (Cazden, 1988; Mehan, 1979). The two-part IR pattern may occur when a teacher asks a set of questions on a single topic. The teacher in the following episode does not provide any form of feedback regarding the first two student answers, which functions as positive evaluation and enables the teacher himself to ask more questions until he can present ostensive evaluation at the end of the whole series of questions. In consequence, the discursive episode is constructed in three IRE sequences two of which have unspoken teacher evaluation.

T: (puts a weather map on the board) What season is this? **{Initiation}**
Ss: Summer. **{Reply}**

T: What is the evidence to decide that it is summer? **{Initiation}**
Student 1 (S1): The distribution of air pressure, I mean, it is high in the south and low in the north. Besides, the distances between isobars are wide and irregular. **{Reply}**

T: And, what is here? **{Initiation}**
S2: Cyclone. **{Reply}**
T: Of course, it is a cyclone. **{Evaluation}**
(Lesson 4, Teacher 4)

Instead of evaluating alone, a teacher sometimes invites students into the evaluation move where the teacher and students jointly evaluate the given answer. The following transcript was extracted from the lesson in which the students had conducted an experiment comparing the reactivities of different metals. After writing the results of the experiment down on the board, the teacher began to ask students to rank the metals according to their relative reactivities. Now he nominates students to ask what metallic element should be ranked third and, as an answer is given, calls for evaluation by others in the class. Although the IRE pattern here is slightly extended with the teacher and students' joint evaluation, its closed-looped nature still remains unchanged.

T: Who is going to say which one has the next-highest reactivity? What is the next, *Sarah*, are you going to say? **{Initiation}**
Sarah: It is Zinc. **{Reply}**
T: Zinc, is that it? **{Call for evaluation}**
Ss: Yes. **{Evaluation}**
(Lesson 9, Teacher 9)

(2) The teacher provides motivation

Wells (1993) pointed out that evaluation was not the only verbal act occurring in the third move of the IRE pattern. In practice, teacher evaluation is sometimes substituted or supplemented with other forms of feedback, so that the third move functions as an opportunity to encourage students, extend student answers, draw out their significance, or make connections with other parts of the unit (Wells, 1993). Here is an example of an IRE sequence in which teacher evaluation is supplemented with her motivation to the student who

answers correctly. As shown below, teacher motivation is often realized by praise such as "excellent" and "great" (Costa & Lowery, 1989, p.35).

T: In low latitudes, why is the energy, I mean, why is the seawater warm?
S: Because here (indicating the tropics of a globe) is the most protuberant part and the sunlight directly, comes straight in.
T: Yes, it is. Good for you.
{Evaluation with motivation}
(Lesson 25, Teacher 16).

(3) The teacher provides elaboration

Another example of an IRE sequence being complemented by other forms of feedback is a teacher providing elaboration on a student answer. Teacher elaboration is basically a verbal act to add more information to a student answer and it often results in supporting the answer with evidence, expanding the meaning, or developing more scientific student terminology (Cazden, 1988; Costa & Lowery, 1989; Lemke, 1990). The following example shows that a teacher, when evaluating the student answer positively, provides students with associated subject matter information as the form of elaboration.

T: Who discovered buoyancy?
Ss: Archimedes.
T: Yes, Archimedes did. That is why the law about buoyancy is called Archimedes' principle.
{Evaluation with elaboration}
(Lesson 11, Teacher 11)

According to Mortimer and Machado (2000), elaborative IREs can contribute to changing the nature of classroom discourse from authoritative to persuasive. The elaborative IREs include an IRE sequence "in which the feedback from the teacher is not evaluative, but supplies elements for a further extension of the response by the students" (Mortimer & Machado, 2000, p. 436). Thus, the IRE pattern with teacher elaboration can help the teacher generate new meanings, rather than transmitting, consolidating, or reinforcing meanings already shared by the class.

(4) The teacher asks a new, but related question, which leads to an exploratory dialogue

The elaborative IREs that Mortimer and Machado (2000) propose also include IRE discourse where the teacher elicits new ideas and contributions related to the previously given answer. That is, when a student gives a correct answer, the teacher develops the discourse into a genuine dialogue by asking a new question to further probe the student's thinking process. The next episode illustrates how a teacher transforms a discourse pattern from the IRE to that of a genuine discourse which we would call an exploratory dialogue.

T: What does it suggest that the spilled oil was moved while we couldn't see the seawater flowing violently? **{Initiation}**
Ss: There is a current. **{Reply}**
T: There is a current. **{Evaluation}**
T: Then, what kinds of seawater movements have you seen on seashore? **{Exploratory question}**
S: The seawater splashing over rocks.
T: The seawater splashing over rocks. What is that? Do you mean that you have seen the seawater splashing over and then moving back, splashing over and then moving back again, rather than flowing continuously after splashing over?
S: Yes.
T: What else have you seen?
(Lesson 25, Teacher 16)

When students answer incorrectly or incompletely

(1) The teacher provides negative evaluation

The simplest way for a teacher to react to a student incorrect or incomplete answer is to provide negative evaluation. Negative evaluation may occur with disapproving words, such as "poor", "incorrect", or "wrong" and it sometimes takes the form

of ridicule or sarcasm, such as "You are not good enough" or "Where on earth did you get that idea?" (Costa & Lowery, 1989, pp. 34-35). In the following episode, the teacher presents negative evaluation by mildly disapproving what the student said.

T: What do you think the amount of electric charge means?
S: The amount of electricity that has a charged object. **{Incorrect answer}**
T: The amount of electricity that has a charged object, sounds strange. **{Negative evaluation}**
(Lesson 5, Teacher 5)

According to Costa and Lowery (1989), teacher negative evaluation tends to terminate student thinking about the task since it leaves the student with a feeling of failure and cognitive inadequecy and contributes to a poor self-concept. For this reason, a number of authors recommend that teachers not provide an immediate evaluation of whether a student answer is right or wrong but instead attempt to understand how the student came to the answer (Driver, 1989; Ellis, 1993). Following this recommendation, teachers can create classroom discourse in genuine dialogues even if making a start with a known-answer question. An exemplar of such teacher behavior is presented later.

(2) The teacher provides correction

In reality, teacher negative evaluation is often replaced or complemented in a similar way as the previous episodes where students answer correctly. In the case that students respond with answers that the teacher believes to be incorrect, the teacher may present the correct answer so that the students can realize what they should have said and what they must know. In the classroom below, the teacher, through asking a series of questions, is trying to make sure that the students are given all the materials for an experiment about static electricity. When a student produces a grammar error in his answer, she instantly corrects it and proceeds to the next question.

T: What are you all given?
S: Wool. **{Incorrect answer}**
T: A piece of wool. **{Correction}**
What else?
(Lesson 5, Teacher 5)

(3) The teacher provides elaboration

A teacher uses IRE discourse when seeking to transfer subject matter information to students. The information can be carried on the initiation move in which the teacher prepares a question with a long statement or on the reply move where students present the right answer. Teacher intention to transmit his or her knowledge is also obvious when he or she provides elaboration on a student incomplete answer in the evaluation move. In the following example, the teacher begins his explanation of plate tectonic movement by asking a review question. Instead of posing another question to the class, he provides additional information to have his initial question answered completely, which yields an IRE sequence with elaboration.

T: How are mountains made?
S: Orogenic movement. **{Incomplete answer}**
T: Orogenic movement. Mountains are made through orogenic movement and they are also made through epeirogenic movement.
{Elaboration}
(Lesson 19, Teacher 6)

(4) The teacher rephrases, redirects, or paraphrases the question

When a teacher expects a particular answer from students but they do not provide that answer, he or she may employ re-asking strategies until the expected answer is accomplished by the students. In such a case, the teacher reserves the right to correct or elaborate on student answers for the positive evaluation he can provide at last (Edwards & Westgate, 1987). The following two episodes illustrate teacher strategies of rephrasing and redirect-

ing the original question, respectively.

T: The Meteorological Administration receives satellite photos every four hours. What would appear on the satellite photos?
S1: Map. **{Incorrect answer}**
Ss: Weather map. **{Incorrect answer}**
T: What would appear on the satellite photos? {Rephrase}
S2: Clouds. **{Correct answer}**
T: That's it. Clouds appear. **{Positive evaluation}**
(Lesson 4, Teacher 4)

T: What do you think the amount of electric charge means?
S: The amount of electricity that has a charged object.
T: The amount of electricity that has a charged object, sounds strange....
T: *Jason*, what does the amount of electric charge mean? **{Redirect}**
Jason: The amount of electricity that a charged object has. **{Correct answer}**
T: It's the amount of electricity that a charged object has. **{Evaluation}**
(Lesson 5, Teacher 5)

(5) The teacher asks a new, but related question, which leads to a genuine dialogue

The following episode demonstrates that teachers can produce genuine dialogues even when they have already initiated a speech event with a factual-level, known-answer question. In the episode below, the teacher accepts a student incorrect answer in a neutral way and then challenge the students misconception about heat balance of the Earth.

T: If the Earth didn't rotate and if it didn't revolve around the Sun, either, ... because it would be always day on one side and always night on the other side, ... things would be burned to death on the side where the sunlight continuously came in, for the temperature would keep going up. And things would be frozen to death on the other side. ... Can it be so?
S: Yes. **{Incorrect answer}**
T: Ah, you think so. **{Acknowledgement}**

T: Then, if I flash, flash light on his face for a year, would this guy be burned to death?
S: Because one year is too short, it couldn't. For a long period of time ...

T: Ah. If [I keep] flashing light for a hundred years, would he be burned to death, then? ... What do you think? What do you think?
Ss: (laughter)
S: A million years.
T: Ah. If I flash light on [him] for a million years, ... (inaudible because the class laughs).
(Lesson 28, Teacher 6)

The teacher's questioning behavior here is similar to that of Mortimer and Machado's (2000) second type of elabortive IRE. This strategy also resembles a *reflective toss* (van Zee & Minstrell, 1997a, b) by which a teacher takes the responsibility for thinking back to the student and other members of the class. Unfortunately, it is not easy to find such alternative discourse in classrooms since teachers adopt the IRE pattern by default unless there is a good reason to behave otherwise (Wells, 1993). Also, it is expensive in terms of time and effort to clearly understand unfamiliar forms of teacher-student talk (Edwards & Westgate, 1987). However, in order to overcome the demerits of the traditional IRE discourse, new patterns of teacher questioning discourse are to be uncovered and teachers and students need to engage in genuine dialogues (Cazden, 1988; Lemke, 1990; Skidmore, 2000). Considering this, the rest of this article is devoted to five patterns of genuine dialogues which were identified in the Korean secondary science classrooms.

Teacher questions in genuine dialogues

Genuine dialogues are portrayed as information-

seeking questions; information-seeking questions in turn have underlying assumptions which are different from those of the IRE discourse (van der Meij, 1987). The exchange structure of genuine questioning dialogues is basically that of question and response. Therefore, genuine questioning dialogues can be characterized by the questioner-respondent relationship (Dillon, 1978; 1982a). According to van der Meij (1987) and Dillon (1978; 1982a), those assumptions and characteristics include: (i) the questioner does not know the information for which he or she is searching. Therefore, the question expresses his or her interest, desire, or need to obtain the information; (ii) the questioner believes that the respondent possesses the information and uses the question in order to stimulate the respondent to supply the information; and (iii) the respondent is allowed to reply in many ways. The reply can be an indirect answer, a partial answer, incorrect information, a refusal to share the information, or any other forms of response, some of which may constitute the answer to satisfy the questioner.

Genuine teacher questioning dialogues presented below have these assumptions and characteristics in common whereas each dialogue is distinguished from the others according to the teacher's intention and the pedagogical function that it serves.

(1) Exploratory dialogue

As other genuine questioning dialogues do, an *exploratory dialogue* has the exchange structure of question and response. Although this question-response sequence is similar to the first two moves of the IRE pattern, a teacher-initiated exploratory dialogue is different from the IRE discourse in the sense that the teacher is not seeking a single, right answer, but interested in students ideas, conceptions, or experiences. In other words, teacher intention for employing an exploratory dialogue lies in helping students reflect on their own ideas, conceptions, and experiences. Therefore, the teacher is likely to listen to whatever is said and, when an answer is given, he or she does not evaluate it, but rather acknowledge it.

In the classroom below, the teacher and students are figuring out possible ways to estimate the number of stars in the sky. The teacher is now asking an analogy question to elicit student ideas about star counting methods. When a student gives an answer, he dose not provide evaluation but instead shows that the answer is received and understood by saying, "Okay" and "could be" (i.e., acknowledgement).

T: (drawing a rectangle on the board and making dots inside it) For example, let's say there is a cloud of people gathering in this big square. If each of these dots is a person, if this many people are scattered everywhere in the square, then how could you know the number of people?
S: You can figure out how many people are in a 1 m^2 square and then multiply.
T: Okay. It could be used. **{Acknowledgement}**
(Lesson 16, Teacher 1)

(2) Query & Response dialogue

A query and response dialogue is different from an exploratory dialogue in that the question generally comes from the questioner's desire for resolving his or her own problem or curiosity, not from the interest in others' thoughts and their thinking processes. Considering that a teacher rarely asks questions of students with his or her own problem or curiosity, the following episode is exceptional. Just a moment ago, the teacher began to ask an exploratory question of what nebulae the students already knew. When a student mentioned *North America Nebula* of which he was ignorant, the teacher turned the discourse into a series of query and response dialogues in order to gain new information. The query and response dialogues below continued till the teacher was satisfied with enough information about North America Nebula.

T: North America Nebula? Is there a North America Nebula?

S1: Yes.
T: What is it? Is it bright?
S1: Bright.

T: Why, of all names, North America?
S2: It looks like that.
T: Does it look like the North America?
S2: Yes.

T: How, I mean, can we see it with the naked eye?
S3: If very lucky, very lucky, you can see it with the naked eye.
(Lesson 21, Teacher 8)

(3) Consensual dialogue

While a query and response dialogue is about the questioner's problem or curiosity, a consensual dialogue focuses on matters of concern that the questioner and respondent have in common. In the classroom, such things include making a schedule for lessons or sequencing learning activities. The teacher in the example below is asking students to decide for themselves the order of presentation of their projects, rather than nominating the presenter by herself. When the students suggest a team for the first presentation, she accepts it and the dialogue is created as a consensual one.

T: Which team will go first?
Ss: *Kim*s team.
T: Okay. *Kim*, would you come forward and present?
(Lesson 11, Teacher 11)

A consensus between a teacher and students is also needed when they engage in assessment of learning. Here is a lesson in which a student science conference was held and the participants have been discussing which group is the winner. Although the teacher and students had a problem where two groups tied, they came to the final decision through a consensual dialogue. In the following transcript, it is the teacher who suggests an idea and a consensual dialogue is completed when the students simply agree with the teacher's suggestion.

T: Is it okay with all of you if we say that Team 2 wins the championship and Team 4 gets the greatest prize?
Ss: (laughter) Yes.
(Lesson 6, Teacher 6)

(4) Challenge & Response dialogue

According to Lemke (1990), teacher-student debate is embedded in a series of challenge and response dialogues. Students in class may pose a question to challenge something the teacher has recently said and then they get a teacher response normally in defensive nature. If the students do not accept the response at this point but keep things going on, then the discourse will be a full-fledged debate in which several challenge and response dialogues take place. This is also the case when the teacher takes the role of a challenger.

In the following episode, the teacher argues against the students who used the word 'typhoon' to mean both a violent tropical cyclone in general and a particular one occurring in the western Pacific and crossing Korea during the summer. The teacher wanted to employ different terms to distinguish the western Pacific typhoon from other severe tropical cyclones such as a hurricane. Whenever it was necessary to indicate the western Pacific typhoon in particular, the teacher purposely pronounced typhoon as *tai poon*, which is similar to the Chinese term of typhoon, *tai fung*. But, the students felt little confusion in using the same word to refer to different ones. Especially, S2 and S3, when presenting their project, did not use the term typhoon distinguishably. Their presentation brought about successive challenge and response dialogues as follows.

T: The typhoon here (meaning a violent tropical cyclone in general) is different from the typhoon here (meaning the western Pacific typhoon), isn't it? Then, don't you think this typhoon (meaning

the western Pacific typhoon) should be named differently?
S1: Because *tai poon* is a typhoon happening in our country, it may be called just a typhoon.
T: It may be called a typhoon in our country?
S1: Yeah.

T: Then, *tai poon* may be called a typhoon, and then, what do they call it there (meaning in other countries)? Do they call it a typhoon, too?
S2: They call it what they call it there. Isn't it that because we need our own language in Korea, we use a particular noun as common?

T: Do you mean this (indicating 'typhoon' written on the board) is not a particular noun to our country, Korea? Huh? ... If a typhoon is what happens in our country, that is, *tai poon* is called a typhoon, then what is a hurricane?
S3: A hurricane is what is occurring in the western North Atlantic, which is particular to that country.

T: Then, what is our particular name?
S2: A typhoon.

T: A typhoon? You are saying this typhoon (meaning the western Pacific typhoon) is a typhoon and that typhoon (meaning a violent tropical cyclone in general) is also a typhoon?
S4: That typhoon isn't; what those guys worked on is not.

T: Do you mean what these guys worked on is wrong?
S5: That is a tropical cyclone.
S4: Yeah. It includes all tropical cyclones.

T: (indicating 'typhoon' written on the board) This is a particular name, isn't it?
S3: I don't think it would be a problem.
(Lesson 8, Teacher 8)

(5) Check & Report dialogue

This dialogue often takes place when the teacher wants to confirm that the students are done with something he or she asked them to do before, such as assignments and worksheets. It also occurs when the teacher tries to make sure if the students remember or understand what they have been taught. Thus, a question in a *check and report dialogue* reveals the questioner's concern for information about a process of a lesson, and therefore a check and report dialogue helps the teacher determine whether he or she is going to proceed to a new lesson or new discourse. For instance:

T: We learned about igneous rocks in the last class, didnt we?
Ss: Yes.
T: Todays lesson is about metamorphic rocks, and I am going to explain the formation of metamorphic rocks.
(Lesson 10, Teacher 10)

A check and report dialogue can also be used by the teacher to ask for results of student experiment. In the following example, a student reports the experimental data of her group and the teacher merely receives the data without evaluating it.

T: Would you say the temperatures, from the lower level through the higher ones, in the beaker with ice at its bottom?
S: 23.5 degree.
T: (writing on the board) 23.5.

{Acknowledgement}

S: 25.
T: (writing on the board) 25.
S: 25.5.
T: (writing on the borad) 25.5.
(Lesson 2, Teacher 2)

Conclusion: A Framework and Implications

Guided by the research agenda that classroom communication should be analyzed in a broad context of verbal interaction between a teacher and students, this study investigated teacher question-

Table 1. A framework for classifying teacher questioning discourse.

	Discourse pattern	Number of teachers using the discourse pattern (n=16)
Monologues	Informative with rhetorical/fill-in-the-blank questions	15
	Informative by self-answering	11
Dialogues	Exploratory dialogue	10
	Query & Response dialogue	2
	Consensual dialogue	3
	Challenge & Response dialogue	2
	Check and Report dialogue	14
IREs	IR(E)*	14
	IR(E) with correction	2
	IR(E) with motivation	3
	IR(E) with elaboration	12

*(E): optional; can be omitted.

ing discourse to identify a variety of discourse patterns. Video recordings of Korean secondary science classrooms were examined while extensive review of literature on classroom discourse was carried out. These research efforts revealed various patterns of teacher questioning discourse in Korean science classrooms, some of which are considered alternative to the typical IRE pattern.

The findings are summarized in Table 1 where a framework for classifying teacher questioning discourse is presented. The framework first categorizes teacher questioning discourse into three major patterns: monologues, dialogues, and IREs. These three categories in turn have subordinate forms of discourse each of which has a unique exchange structure and particular pedagogical function. Table 1 also indicated in the right column the number of teachers who used each discourse pattern. It was evident that the IRE was the predominant pattern of teacher questioning discourse and that teacher questions often constituted monologue patterns through which the teacher attempted to deliver information to students. Teacher use of genuine dialogues was relatively rare while a check and report dialogue was popularly used by the teachers. Thus, the discourse patterns in the science classrooms analyzed mostly illustrated the centrality of teacher directions–even through questions.

The framework in Table 1 is hopefully useful to encourage science teachers to recognize alternative forms of questioning discourse and utilize them in appropriate situations. Such use of this framework could be included in a science teacher education program. For example, encouraging teachers to reflect on their own questioning behaviors could provide a starting point for a professional development opportunity (Westgate & Hughes, 1997). Furthermore, collaborative action research projects between teachers and research staff can be conducted with a view of improving discursive practices in classrooms.

Throughout the study, the framework has served as a heuristic device; it is still open to modification and further development. The present framework itself gives no preference to any particular pattern even though some drawbacks of the IRE pattern have been indicated. Rather, it is an ongoing research task to inquire into the ways different forms of classroom discourse fulfill particular teaching and learning purposes and to find out effective discursive strategies. It will be especially important to study the all-too-seldom student questions that may help teachers to encourage student questions in classrooms and use them to drive lessons. Further, such research could contribute to the request that science education researchers need to study classrooms, construct pictures of classroom life, and communicate such findings to others (Tobin & Gallager, 1987).

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