 Vol. 25 No. 1 (Special Issue), pp. 26~40 (2005)

A Descriptive Study on Students' Talk During the Presentation of Their Science Projects

Phil Seok Oh

(Ewha Womans University)

ABSTRACT

Based on the Vygotskian perspective that a learner's thinking is constituted in his or her talk and the assumption that student talk in the classroom may occur in more than one way, this study examined discursive practices of students in Korean high school science classrooms. Data came from 11th grade earth science classrooms where the Group Investigation (GI) method was implemented. Data source included verbatim transcripts developed from video recordings of class sessions in which students presented their science projects to the whole class and exchanged questions and answers during the presentations. The analysis of the videotape transcripts revealed five different modes of student talk, including 1) retrieving information, 2) reformulating information, 3) building on one's own experience, 4) elaborating current understanding, and 5) negotiating meanings with others. Considering that each of the five modes had different value for learning science, it was recommended that the teacher should engage students in more active modes of discourse and guide them into more sophisticated understanding of science.

Key words: student talk, Vygotskian perspective, Group Investigation, Korean earth science classroom

Ⅰ. Introduction

Recently, science education researchers have paid much attention to discursive practices in the teaching and learning of science in classrooms (Bianchini, 1997; Herrnkohl *et al.*, 1999; Hogan *et al.*, 2000; Kaartinen & Kumpulainen, 2002; Oh *et al.*, 2003; Scott, 1998; Wallace, 2004). This trend has been influenced by constructivism, which claims that students develop their own knowledge and understanding out of the activities in which they participate. Especially, Vygotsky's idea that a learner's thinking is constituted in his or her talk (Vygotsky, 1981, 1987) contributed to the increased recognition of the role of language in learning. Following this line of research, this study examined how Korean high school students used language to talk, as they learned science through the Group Investigation (GI) method. The study dealt in particular with student talk when the learners presented their science projects to the whole class and exchanged questions and answers during the presentations. Although descriptive in nature, this study distinguished different modes of student talk to suggest more valuable ones for better educational practice in science classrooms.

*Received on 29 December 2004

**Phil Seok Oh (philoh@ewha.ac.kr)

Ⅱ. Background

1. Vygotskian perspectives

The notion of the importance of language in learning is often attributed to Vygotsky's view on the relationship between thinking and speech. Traditionally language has been regarded as a vehicle for thoughts and feelings. However, for human thinking and learning, language plays a more significant role. "Thought is not expressed but completed in word," Vygotsky contends; "Speech does not merely serve as the expression of developed thought. Thought is restructured as it is transformed into speech" (Vygotsky, 1987, pp. 250-251). Thus, in the Vygotskian framework, thinking cannot be appreciated properly if separated from talking, but rather, a learner's thinking is constituted in talking. Vygotsky's explanation of egocentric and inner speech provides an elaboration on this idea. Egocentric speech is talk intended for oneself. It can be heard when an individual plans and regulates his or her actions for resolving some difficulty he or she is now facing. For example:

> When the child encountered a problem, he attempted to assess the situation: "Where is the pencil? I need a blue pencil now. Nothing. Instead of that I will color it red and put water on it – that will make it darker and more like blue." The child conducted this entire discourse with himself (Vygotsky, 1987, p. 70).

Thus, the egocentric speech is the child's attempt to understand the situation and functions as a component of his goal-directed action and thinking. According to Vygotsky, egocentric speech evolves into inner speech in accordance with the learner's intellectual development. Inner speech is purely internal talk and inaudible to others. But, the structure of inner speech is similar to that of egocentric speech, and inner speech serves the same function as egocentric speech. In other words, inner speech is a unique type of internal collaboration, comprising one's own cognitive effort for solving problems and making sense of the world (Vygotsky, 1981, 1987; Wertsch, 1980, 1985).

Certainly people speak to themselves through self-addressed talk. It should be noted, however, that egocentric and inner speech are reflections of social processes in which one interacts with others. From the Vygotskian perspective, egocentric and inner speech are proceeded by social speech - i.e., talk with others. Social speech appears first in an interactive setting and provides forms and content that would be internalized into egocentric and inner speech of an individual learner. The internalization process involves constructing new speech, rather than simply copying the external talk, which enables the learner to use the self-directed talk to assist with his or her own cognitive tasks. Thus, the social interactional process offers a foundation for an individual learner to develop dialogues with him or herself, which represents the thinking process per se (Vygotsky, 1981, 1987; Wretch, 1980, 1985).

The Vygotskian perception of the role of language in thinking provides great implications for talk in classrooms. In traditional classrooms, the discursive practices of students were often limited to listening to teacher lectures and to responding to test questions by the teacher (Tobin, 1987; Tobin & Gallagher, 1987). Research has consistently revealed that about 80% of classroom interaction is taken up by teacher-initiated talk. It was also reported that students ask two questions per hour while teachers ask one or two questions per minute (Dillon, 1988; Susskind, 1979; Wertsch & Toma, 1995). But, in order to facilitate the thinking process for students to learn, lessons should be designed in ways that students have opportunities to talk in social-dialogic environments (Barnes & Todd, 1995; Lemke, 1990; Wells, 1999; Wertsch & Toma, 1995). This principle can be realized by engaging students in conversing with one another in the course of their own learning. Monologic forms of student talk should be encouraged as well because, as Gee *et al.* (1992) point out, all language uses involve social activities and therefore, by nature, are dialogic.

> Even when a person is engaged in a monologue of some type, … his or her language, thoughts, and actions are still saturated with and fully influenced by the audience to which the monologue is directed. The monologue would take different forms in different contexts. Furthermore, it is influenced by how the audience behaves, how they sit, look, and respond (Gee *et al.*, 1992, p. 235).

Hence, it is obvious that talking in a social setting, whether it is in the form of monologue or dialogue, influences the speaker's thinking to learn some subject matter by allowing the learner to construct his or her understanding in words, and in turn, reconstruct it in his or her mind (Chang & Wells, 1993).

2. Relevant research

Student talk in science classrooms has been studied mainly in the context of small group interactions, either with the teacher present or not (Bianchini, 1997; Kaartinen & Kumpulainen, 2002; Meyer & Woodruff, 1997; Richmond & Striley, 1996; Roychoudhury & Roth, 1996). The goals of such studies included finding the ways the learners construct their knowledge and understanding of science. For example, Richmond and Striley (1996) analyzed student talk in groups during laboratory investigations and found that the learners' knowledge-construction occurred along with the development of scientifically appropriate arguments under an inclusive social situation. Meyer and Woodruff's (1997) work also indicated that social interactions concerning consensus-building were essential for students to develop more powerful insights for explaining the phenomena being studied. Thus, previous studies suggest that social-dialogic procedures are crucial to achieving robust knowledge of science, since individual learners build idiosyncratic understanding through different links and paths (Schuh, 2003). Indeed, when students are engaged in conversational interactions, speakers formulate linguistic representations of their unique understanding, and listeners construct their own interpretations of the meanings of the speakers' utterances. However, both participants can modify their knowledge in the light of the observable and/or non-observable feedback from the other participants (Chang & Wells, 1993). It is argued, therefore, that talking in social setting is necessary for the development of personal knowledge, as well as for the establishment of shared meanings within participants (Kaartinen & Kumpulainen, 2002; Meyer & Woodruff, 1997; Roychoudhury & Roth, 1996).

Among a few studies conducted in the context of student presentation, Crawford *et al.*'s (1997) work provides an empirical support for the view that people's talk is constructed differently according to the social situation on which it is based. As part of three-year long ethnographic research, they explored how high school students presented their science projects to multiple audiences, including teachers and 5th grade students. The influences of the audience on student talk were different: when speaking to teachers, the students' explanations were relatively short, and their discourse strategies were limited. Contrarily, the presentation to 5^{th} graders was accomplished with expanded explanations and a variety of communication skills. This result implies that providing opportunities for students to speak to audiences different from the teacher, such as their peers, can lead them into a process in which they develop meanings through multiple ways of talking.

Bleicher (1994) argues that presenting science is an authentic activity of practicing formal scientific discourse. He also contends that when students communicate their research projects and interact through questions and answers, they are enabled to display their own understanding of science. This study agrees with Bleicher's idea that student presentations provide a great opportunity for the learners to internalize the scientific ways of communication into their own. But, the assumption underpinning the present study is beyond the assertion that speaking is a means to display student mastery of scientific concepts. Inspired by the Vygotskian perspectives, this study presupposes that student talk in a presentation setting mediates the speaker's thinking, which in turn influences his or her learning. In other words, it is assumed in this study that while talking in a social context, students encounter the knowledge that is externalized in discourse by either themselves or others, discover its significance through using it in the social situation, and (re)construct the corresponding forms of knowledge in their minds (Chang & Wells, 1993).

Despite the view above, however, the study does not assume that all students use language in the same manner to fulfill the same function, but rather expects that there are different modes of student talk. Concerning the assumption of multiple modes of student talk, Wretsch and Toma's (1995) view is worth noting. Adapting Lotman's (1988) idea of the functional dualism of text, Wretsch and Toma argued that classroom discourse served univocal or dialogical functions. "The univocal function focuses on how it is possible 'to convey meanings adequately', and the dialogic function is concerned with how it is possible 'to generate new meanings'" (p. 165). However, these two functions are not determined by the apparent form of discourse such as monologues or dialogues. Rather, they are likely to be distinguished according to whether the speaker takes an active or passive stance toward the discourse. For instance, the dialogic function will be evident when students use their own utterances and those of others to stimulate new thinking. Thus, Wretsch and Toma suggested that student talk in the classroom may occur in different modes, actively or passively, to serve different functions.

The primary goal of this study is to identify such various modes of student talk, particularly during class sessions in which students present their science investigations and exchange questions and answers with the audience. Just a few studies have focused on student presentation settings. But, research in diverse environments can contribute to better understanding of educational practices in classrooms. Although focusing on describing ways of student use of language to talk, the present study also includes the interpretation that each discursive mode has different educational value. This means that a certain mode is more desirable than others in terms of the learner's activeness in participating in and contributing to the process of learning science.

Ⅲ. Method

1. Classroom setting

Data for this study came from a two-year long action research conducted in a high school located in a suburban area in Korea. Participants in the action research were a science teacher and the students enrolled in his 11th grade earth science classes during the 2001-2002 (March, 2001 ~ February, 2002) and 2002-2003 (March, 2002 ~ February, 2003) academic years. Two classes with a total of 36 (male = 28, female = 8) and 35 (male = 26, female = 9) students, respectively, were taught earth science by the teacher in the first year, and two others with 33 (male = 27, female = 6) and 32 (male = 28, female = 4) students, respectively, during the second. These four classes were all selected as sites for the action research project and provided data for the present study.

In the action research classrooms, Group Investigation (GI, Sharan & Sharan, 1989, 1994) was implemented as a cooperative, inquiry-oriented learning method. When learning with GI, students were organized in small research groups of two to six members, and each group carried out an investigation concerning a topic emerging from group discussions. The inquiry topics selected by the students were drawn from a wide range of earth science and often moved beyond the scope of the national curriculum. Examples of the topics were: Experimenting the Foucault pendulum motion, Building a model for volcanic eruption, The Bermuda Triangle Mystery, Death of whales [ocean contamination], Observation of nebulae, and, Is there another solar system? This variety entailed multiple ways of conducting investigations, including experiments, observations, model building, multimedia production, and Internet survey.

The GI protocol also included in-class sessions in which students presented their science investigations to the class and interacted with their peers, as well as the teacher, by asking questions and providing answers. When presenting their science projects, students were asked to share with their peers how they had planned and carried out their inquiries as well as what they had learned from the investigations. Therefore, the content of student presentations was varied among research groups, depending on the inquiry topics and the nature of investigative methods. It was common that each student in a group took a part in a presentation. Typically, a group divided information they were presenting into pieces, and its members took turns for addressing the sub-divided content. Students at times made their presentations in such a way with some members explaining the sequentially organized information, while the others ran computer programs.

During the presentation session, students were also encouraged, when they served as the audience, to ask questions for the speakers and provide comments on the performance of their peers. Sometimes questions and comments were called for by the teacher or presenter at the end of a presentation. In most cases, however, a student with curiosity or puzzlement requested information spontaneously, normally by posing a question. It was typically the presenter who offered the information requested; but, the teacher or other students in the same group often participated in responding to a question. Such question-answer exchanges were public and all students in the class could hear the content and join in the interaction. Student discursive practices in the presentation and question-answer exchange sessions were the target of analysis for this study, where the goal was to identify different modes of student talk.

2. Data source and analysis method

Data sources for this study included videotapes of the GI classrooms and verbatim transcripts made from the video recordings. The GI method was implemented three times during the 2001-2002 academic year, and five times during the 2002-2003 one. Parts of the GI activities were videotaped for every period of the GI implementation. Although the videotapes contained interactions in both small group and whole class settings, the records of the presentation sessions were only considered relevant for this study. Two sets of video recordings, which had been created in April and July, 2001, respectively, were available for the first year, and three sets recorded in April, September, and November, 2002, were used for the second. The total length of the videotapes used for this study was 781.9 minutes with 156.4 minutes as the average per set.

Verbatim transcripts were made and analyzed, with viewing the video recordings repeatedly. The focus of the analysis was on discourse initiated by students, even though the teacher also triggered verbal interactions with students for his own pedagogical purposes. The student-initiated talk was first distinguished by its external structure (e.g., monologue or dialogue) to increase the readability of the transcripts. Then, the discourse was classified into different modes, according to the ways the speakers talked to fulfill different functions. That is, the classification of student talk was guided by the heuristic questions of why the speakers engaged in a particular verbal action, and how actively or passively they did so. Consequently, five discursive modes of student talk were identified. They were: 1) retrieving information, 2) reformulating information, 3) building on one's own experiences, 4) elaborating current understanding, and 5) negotiating meanings with others. The reliability of this classification scheme was established when two science education researchers blindly tried it out with three sample sets of transcripts and classified student talk with 92.0% consistency. The following section presents the five modes of student talk, with representative excerpts from the class sessions for students presenting their science projects.

Ⅳ. Findings and Interpretations

1. Retrieving information

In the presentation session, students were expected to communicate their science investigations in a manner that was understandable to their peers. Therefore, to support their speech, students often organized what they presented with such a computer tool as PowerPoint®. They also employed a variety of artifacts, including pictures, posters, physical models, computer simulations, movie clips, and experimental instruments. The use of tools and artifacts was helpful for the audience to make sense of what was being presented. It became problematic, however, when the presenter relied too much on the tools and artifacts. That is to say, there were some students who simply retrieved information written on the sheets of papers they had in their hands or PowerPoint® documents displayed on a screen. In this case, the presentation was dominated by student monologue in the same tone as book-reading discourse. For example, the student in the following excerpt was trying to read the explanations projected on the TV screen, while a slide show prepared with a computer program was playing. This inert attitude provoked the teacher's frequent interventions to coach the speaker to manage her talk more effectively.

Presenter (P): The amount of solar energy is so enormous that the six billion people of the earth may save some even after they consume for more than *** [inaudible] years.

Teacher (T): (intercedes) Would you talk, not read, about what you know to your friends?

P: (returns to read the text on the screen and continues her presentation) To explain how this huge energy was made … Eddington proposed that the collision of hydrogen atomic nuclei under the high-temperature and high-pressure condition inside of the sun yielded helium nuclei and released energy.

T: (intercedes) Hey. During presentation, you must talk while looking at those who are listening. (indicates a spot closer to the audience) Come forward up here. … Only if you understand [what you are talking], you can tell [it] to your friends.

(November, 2002)

Thus, retrieving information from some sources created previously was the most passive mode of student talk because it was at best the process in which the speaker transferred written text to oral expression, with little change in the form and content. However, this mode was not the case for student talk in the presentation sessions addressed in this study. The passiveness in talking in a social setting was characteristic of particular students who were, for example, low achievers and/or inert learners in science.

2. Reformulating information

The presentation was an opportunity for students to practice the language of science as they developed their own meanings of the subject matter content. The scientific language includes disciplinary terms, their relationships, and argument patterns which are used in the community of professional scientists. These entities are often found in sources of scientific information, such as books, Internet, and experts' lectures. However, they are usually alien to young science learners. Therefore, when engaging in presenting their projects, students made their efforts to appropriate the language of science into their own, and to reformulate scientific information in their speech. For instance, in the excerpt below, the presenter YP (name initial used to keep the student's identity anonymous) is developing his own explanation of the Foucault pendulum motion before describing how he conducted an experiment to calculate the rotational period of the swinging plane of a Foucault pendulum.

YP: The earth rotates anticlockwise on its own axis and this pendulum just comes and goes like this (lets the pendulum swing). But, when we observe the pendulum, this [the plane of its swing] would appear to rotate, because the earth rotates. Hum, because the direction of the earth's rotation is anticlockwise, the pendulum appears to rotate clockwise.

(April, 2001)

Although YP's explanation was very similar to that in science books and references, this mode of speech was not like that of retrieving information, in the sense that the speaker did not attempt to simply bring the information back out of a pre-made source. In fact, he kept his eye contact with the audience throughout his presentation, and even initiated interactions with the listeners by asking questions. As a result, the speaker's tone was far different from that of book-reading discourse which was evident in the mode of retrieving information, but rather similar to that of story-telling. More importantly, YP demonstrated, by means of the talk above, the connectedness of his experiment to the well-known scientific law, and used the connection as a basis for his ongoing presentation. Thus, the mode of reformulating information meant the effort of students to reconstruct, in their own speech, the scientific information already established by scientists. This mode was considered as valuable in that it offered a chance for a speaker to exercise scientific discourse, and appropriate it for his or her own use.

It was not surprising to find that not all students were successful in reformulating scientific information. For example, in another class involved with the 2001-2002 year project, a student was observed to misspeak concerning the same principle as YP explained. She said, "The Foucault pendulum rotates clockwise, doesn't it? Because this stuff [a Foucault pendulum] rotates clockwise but the earth rotates on its axis, an observer here …." It was obvious in her speech that she had difficulty in understanding the Foucault pendulum motion and completing her conception of the scientific law correctly in her words. In a positive sense, however, her utterance provoked a skeptical question from the audience, which in turn developed dialogues between the presenter and audience. Sometimes the information reformulated through student talk was not enough to cover all the important concepts related to the topic addressed. Such insufficient speech was followed by the teacher's pedagogical intervention in which he offered complementary information or elicited other student contributions.

P: The principle of artificial precipitation, the most important thing to produce artificial rainfall is making ice crystals. … To make rain clouds, you can scatter something to serve as ice nuclei into clouds.

T: Wait a second. Well, now, it is known that there are two ways to produce artificial rainfall. … Would you explain what is the difference [between the two methods]?

(September, 2002)

In the episode above, the teacher indicated what was missing in the student's explanation about the mechanism of artificial rainfall and asked him to present supplementary information to the class. Likewise, in the presentation session, student talk often provided a ground for an extended speech activity which might lead to developing more robust knowledge in students.

3. Building on one's own experiences

The modes of retrieving and reformulating information are common in the sense that both emerge from the pre-determined knowledge of science, even though the latter is more active since it involves the learner's efforts for appropriating the scientific information into their own. In contrast, the third mode of student talk is based on the learner's own experiences. In the following example, the student is trying to make his classmates understand how he came to a conclusion concerning the plate tectonic movement of the earth through an experiment of his own design.

P: I filled one-third of a big pot with water, put some pieces of foam blocks for the lands of the earth, and then boiled the water. … Later, I heated it slowly. Then, [the pieces] moved slowly. Observing that, I said to myself, "Ah, [the lands are] moving." … When the water cooled, [the pieces] came back together. … So I concluded that most continents of the earth might re-gather to make a single land 5,000 years later.
(July, 2001)

The student first describes how he set up the experiment and what he observed through it. He then uses his observation as a basis to develop his conclusion about the future of the earth's surface. Thus, in the GI classrooms, students' knowledge was more often than not built on their own data and materials. Sometimes students' own experiences provided evidence which conflicted with their beliefs and expectations. This discrepancy became a challenge for the learners to develop new knowledge to resolve the conflict. The excerpts below illustrate this feature.

P: (His group has just completed demonstrations of the geological mechanism with clay models of folds and faults.) We did simulate [how folds and faults are made] like this, but many things didn't work very well. The reason is that, you know, our strength is far weaker than the forces which shape the earth's crust. We probably need such power that can move dozens of buildings.
(July, 2001)

P: My group actually observed [nebulae] on the roof [of our school]. We observed with the expectation that the nebulae would be viewed in red, but in fact, they were not seen in red. … We came to know the reason later. Since our eyes have a structure which is not suitable to see such colorful light, hum, if we observe with our eyes, they are seen gray, just like a gray shape. You must take a photo to gain these beautiful colors.
(November, 2002)

As described thus far, building new knowledge with using one's own experiences as bases was an active mode of student talk which could be found in an inquiry-oriented science learning environment. However, it is not guaranteed that the knowledge developed by the learners is always compatible with the canonical concepts in science, even though, as Hammer (1995) indicated, misleading statements and arguments are part of authentic inquiry. This is a reason science teachers need to pay careful attention to how student work, make timely interventions, and implement appropriate pedagogies to lead them into scientifically more valid understanding.

4. Elaborating current understanding

The presentation session afforded collective modes of discourse in which two or more participants cooperated verbally to develop new meanings. One of the most salient modes of this sort was elaborating current understanding through exchanges of questions and answers. Asking questions was a conscious endeavor for a learner to enrich his or her conception of some subject by gaining new information in the form of an answer. Students who were presenting their investigations as well as the teacher contributed to this process by providing the information asked for by the questioner.

It was evident from students' discursive practices that through the use of questions, the learners sought to not only make sense of the topic being addressed but also gain new knowledge related to it. The verbatim transcript of a student-student interaction below shows that the student is trying to extend his current understanding by integrating the new information with his existing knowledge about the properties of magma.

> S: The viscosity varies with temperature, doesn't it? The lava will accumulate more when cooled, when cooled [faster], won't it?
> P: Yes, it does. The viscosity is related to temperature as well.
> S: In the ocean, for example, it [magma] would be cooled as soon as it comes out.
> P: Yes. Well, to talk about the tholoide (i.e., a cone-shape volcano), the lava doesn't flow far and it forms a shape like this because it has high viscosity and also the temperature is low.
> (July, 2001)

The episode above was exemplary in that the presenter successfully provided answers relevant to the question asked. But, it was also observed that students at times failed to offer appropriate information, or responded to a question with an incomplete answer. This occurred mainly because students did not possess a strong knowledge base to answer all the questions asked, and because they had difficulty in reformulating scientific information into their own words. When a question was not answered properly by students, the teacher joined in the dialogue between presenters and the audience to provide answers or ask pedagogical questions additionally. However, it was typical that when the topics were relevant and of interest to students, the audience actively pursued elaboration of their current understanding by initiating interactions with the speakers.

5. Negotiating meanings with others

The question-answer exchanges during the presentation sessions were also an opportunity for students to practice negotiating meanings while challenging and responding to each other. Typically, a challenge expressed a student's disagreement or dissatisfaction with what had been recently said, and indicated his or her own knowledge on the matter. A response usually occurred in a defensive manner, including justification, clarification, or modification of the respondent's idea. As a result of dialogic exchanges of challenge and response, the participants' initial ideas developed into new meanings to resolve a conflict in their knowledge and beliefs.

When student presentations included some forms of hands-on activities, such as experiments, model building, and simulations, the issues dealt with in challenge-response exchanges were mainly concerned with the consistency of those activities with corresponding natural phenomena or scientific theories. The conversational episode presented below provides an example. While a student JE was simulating a volcanic eruption by using a physical model, several students intervened in her presentation and asked skeptically about the differences between the model and real volcanoes.

Student 1 (S1): [I have a] question! When a volcano erupts, something like a basin is formed. But, this model doesn't make any shape like that. So, [I am wondering] how things are different between this [model] and that [real volcano eruption].

JE: Well, when I tried different amounts of liquid petroleum, ··· actually I experimented under various conditions, ··· it made that kind of shape.

S2: Hey, couldn't it blast all at once [like a real volcano erupting]?

JE: It could if you make a model in that way. ···

S3: It couldn't because the conditions don't fit.

S4: Well, the earth crust is solid, you know. Then, when a volcano erupts, the crust wouldn't look like this, does it?

JE: ··· When a real activity occurs on the crust, the pressure is just enough to do that. ··· Because this is a model with the size reduced, hum, it just looks like this. But, in a real situation, the pressure here should be stronger and other conditions also fit.

(July, 2001)

It should be noted that through the successive dialogues among students, JE's talk developed further to involve more articulated explanations of her model and real volcanic eruption. Thus, negotiating meanings with others was a way of collaborative knowledge-construction which characterized the social-dialogic learning environment addressed in this study. To be different from the mode of elaborating the questioner's understanding, however, in this discursive mode the questioner contributed to the development of new meaning in the other's talk by posing challenging questions or comments.

Another set of dialogues below illustrates how students talk together to negotiate new meanings. In particular, this example shows that student talk in an inquiry-oriented classroom has congruence with scientific discourse. The episode occurred while a group of students presented their inquiry about the Bermuda Triangle Mystery (i.e., high incidence of unexplained loss of ships, small boats, and air crafts). When one of the presenters proposed that the mysterious events in the Bermuda Triangle might result from an earthquake caused by a change in magnetic field in that area, a student in the audience initiated a dialogue.

S1: I say, all that you have told so far are hypotheses?

P: Yes. It is a hypothesis not proven yet.

S1: If so [If it is a scientific hypothesis], the earthquake, I mean, the hypothesis including a potential earthquake could be tested. Don't you think?

P: Well, it [an earthquake] is due to magnetic field, you know, a change in magnetic field, and so you couldn't test precisely.

S2: I am not convinced that an earthquake is due to a change in magnetic field: if the magnetic field changes, then it should have an affect all over the ocean.

P: No. What I am saying is that the change in magnetic field occurs temporarily in that limited area.

(September, 2002)

Obviously, as the interaction proceeded on, the meaning of the explanation presented previously became clearer in the participants' speech. The parallel between student talk and scientific discourse was also found in the dialogues. That is, a student (S1) qualified the given explanation as a scientific hypothesis which should be supported by an empirical test. The other student (S2) challenged the speaker to refine the explanation in light of the science knowledge that he believed was credible. In fact, this episode was followed by additional dialogues in which several other students in the audience and the teacher proposed alternative hypotheses about the cause of the Mystery. Some scientific alternatives included that particular ocean currents might cause the Mystery, that a change in magnetic field could result in malfunctions of ships and airplanes, and that topographical features might cause the disasters. Thus, the class sessions for presentation of students' science projects served as a genuine environment for learning science in which student practiced the ways scientists communicate and argue about their inquiries.

V. Summary and Conclusion

In the traditional science classroom, teacher speech for delivering curriculum content was predominant over student talk. Discursive practices of students were limited to listening to teacher monologues and providing answers in responses to test questions by the teacher (Tobin, 1987; Tobin & Gallagher, 1987; Wertsch & Toma, 1995). Considering that the cognitive process of learners is embedded in their use of language (Vygotsky, 1981, 1987), this feature could be a significant obstacle to student learning of science. The GI method addressed in this study provided a possible solution to this problem in the sense that it allowed students to talk in a social-dialogic setting for learning science. Especially, student discourse in class sessions for the learners presenting their science investigations and exchanging questions and answers offered data through which various mode of student talk could be identified.

When students presented their science projects to the class, their discursive practices were in the modes of retrieving or reformulating scientific information. However, the mode of reformulating information was believed to be more active than the former since it required the speaker to appropriate the scientific knowledge established by scientists in their own speech. The students also engaged in the mode of building their own meanings with using their personal experiences, data, and materials as bases. This mode involved the learners' conscious efforts to construct words to communicate their knowledge more effectively to the classroom participants. The presentation sessions were also characterized by two collective modes in which students interacted discursively for developing new meanings. That is, students pursued elaboration of their current understanding through asking questions and receiving answers. The question-answer interaction also afforded the students the discursive mode of negotiating new meanings by challenging and responding to each other.

From the Vygotskian perspective that a learner's thinking is constituted in his or her talk (Vygotsky, 1981, 1987), a speaker develops his or her own knowledge out of the discursive practice in which he or she is currently engaging. Specifically, talking in social settings, whether it is in the form of monologue or dialogue, enables the learners to construct in words their understanding of some subject matter and reconstruct it in their minds (Chang & Wells, 1993). In this sense, the presentation and question-answer exchange sessions are considered an opportunity for students to participate in and contribute to the development of new knowledge and understanding for themselves as well as for others. The dynamic feature in this social learning environment was evident by various modes of student discourse as described in the preceding section. However, it was not true that all the discursive modes were equally valuable in terms of students' activeness in constructing their own meanings. There were some students who attempted to merely retrieve information from some sources and who had difficulty in reformulating scientific principles in their own words. Further, the knowledge constituted in student talk was not always valid as compared with the canonical knowledge of science. Such negative aspects provide an important suggestion for the teacher's acts in a student-centered science classroom. That is, teachers of science should attend carefully to students' performance in their learning processes and make appropriate interventions in order to engage the learners in more active modes of interaction, and to guide them into more sophisticated understanding of science. Specifically, these pedagogical roles ought to be implemented in ways that support student ownership of their learning and promote their participation in classroom discourse.

The analysis of student talk in a social-dialogic learning environment offered a new perspective of science learning. During the presentation of their science projects, students legitimately used the language of science as they explained their understanding of the science involved in their investigations. Student practice of the scientific discourse was also obvious when the learners challenged one another to bring their arguments into line with scientific theories and evidence. Thus, the findings of this study at least partially imply that science learning should not be viewed only as the individual learner's knowledge construction process and that it should also be conceptualized as an ongoing process of participating in scientific discourse (c.f., Sfard, 1998). When science learning is defined in such a broad way, it can provide a more solid rationale for science education reform which is based on the creation of science learning communities in schools and classrooms (National Research Council, 1996, 2000).

Language is unique to human beings. By using language, people are enabled to learn, develop communities, and create culture. Discourse analysis in various social and cultural settings can provide great implications for enhancing learning science in school and classroom environments (Gallimore & Tharp, 1990). Therefore, future studies should include those where the goal is to identify better forms of educational and scientific discourse, and to provide practical ideas for building a sustainable community of science learners.

References

Barnes, D., & Todd, F. (1995). *Communication and learning revisited: Making meaning through talk*. Portmouth, NH: Boynton/Cook Publishers.

Bianchini, J. A. (1997). Where knowledge construction, equity, and context intersect: Student learning of science in small groups. *Journal of Research in Science Teaching*, 34(10), 1039-1065.

Bleicher, R. (1994). High school students presenting science: An interactional sociolinguistic analysis. *Journal of Research in Science Teaching*, 31(7), 697-719.

Chang, G. L., & Wells, G. (1993). Dynamics of discourse: Literacy and the construction of knowledge. In E. A. Forman, N. Minick, & C. A. Stone (Eds.), *Contexts for learning: Sociocultural dynamics in children's development* (pp. 58-90). New York, NY: Oxford

University Press.

Crawford, T., Chen, C., & Kelly, G. (1997). Creating authentic opportunities for presenting science: The influence of audience on student talk. *Journal of Classroom Interaction*, 32(2), 1-13.

Dillon, J. T. (1988). *Questioning and teaching: A manual of practice*. New York, NY: Teachers College Press.

Gallimore, R., & Tharp, R. (1990). Teaching mind in society: Teaching, schooling, and literate discourse. In L. C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of sociohistorical psychology* (pp. 175-205). Cambridge, UK: Cambridge University Press.

Gee, J. P., Michaels, S., & O'Connor, M. C. (1992). Discourse analysis. In M. D. LeCompte, W. L. Millroy, & J. Preissle (Eds.), *The handbook of qualitative research in education* (pp. 227-291). San Diego, CA: Academic Press.

Hammer, D. (1995). Student inquiry in a physics class discussion. *Cognition and Instruction*, 13(3), 401-430.

Herrenkohl, L. R., Palincsar, A. S., DeWater, L. S., & Kawasaki, K. (1999). Developing scientific communities in classrooms: A sociocognitive approach. *The Journal of the Learning Sciences*, 8(3&4), 451-493.

Hogan, K., Nastasi, B. K., & Pressley, M. (2000). Discourse patterns and collaborative scientific reasoning in peer and teacher-guided discussions. *Cognition and Instruction*, 17(4), 379-432.

Kaartinen, S., & Kumpulainen, K. (2002). Collaborative inquiry and the construction of explanations in the learning of science. *Learning and Instruction*, 12, 189-212.

Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Norwood, NJ: Ablex.

Lotman, Y. M. (1988). Text within a text. *Soviet Psychology*, 26(3), 32-51.

Merrill, M. D. (1991). Constructivism and instructional design. *Educational Technology*, 31(5), 45-53.

Meyer, K., & Woodruff, E. (1997). Consensually driven explanation in science teaching. *Science Education*, 80, 173-192.

National Research Council (1996). *National Science Education Standards*. Washington, DC: National Academic Press.

National Research Council (2000). *Inquiry and the National Science Education Standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

Oh, P. S., Shin, M.-K., & Yager, R. E. (2003). Patterns of teacher questioning discourse in Korean science classrooms. *The Journal of the Korean Earth Science Society*, 24(2), 61-73.

Richmond, G., & Striley, J. (1996). Making meaning in classrooms: Social processes in small group discourse and scientific knowledge building. *Journal of Research in Science Teaching*, 33(8), 839-858.

Roychoudhury, A., & Roth, W. M. (1996). Interactions in an open inquiry physics laboratory. *International Journal of Science Education*, 18(4), 423-445.

Schuh, K. L. (2003). Knowledge construction in the learner-centered classroom. *Journal of Educational Psychology*, 95(2), 426-442.

Scott, P. (1998). Teacher talk and meaning making in science classrooms: A Vygotskian analysis and review. *Studies in Science Education*, 32, 45-80.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one.

Educational Researcher, 27(2), 4-13.

Sharan, Y., & Sharan, S. (1989). Group Investigation expands cooperative learning. *Educational Leadership*, 47(4), 17-21.

Sharan, Y., & Sharan, S. (1994). Group Investigation in the cooperative classroom. In S. Sharan (Ed.), *Handbook of cooperative learning methods* (pp. 97-114). Westport, CT: Greenwood Press.

Susskind, E. (1979). Encouraging teachers to encourage children's curiosity: A pivotal competence. *Journal of Clinical Child Psychology*, 8(2), 101-106.

Tobin, K. (1987). Forces which shape the implemented curriculum in high school science and mathematics. *Teaching and Teacher Education*, 3(4), 287-298.

Tobin, K., & Gallagher, J. J. (1987). What happens in high school science classrooms? *Journal of Curriculum Studies*, 19(6), 549-560.

Vygotsky, L. S. (1981). The genesis of higher mental functions. In J. V. Wertsch (Ed. and Trans.), *The concept of activity in soviet psychology* (pp. 144-188). Armonk, NY: M. E. Sharpe.

Vygotsky, L. S. (1987). Thinking and speech. In R. W. Rieber, & A. S. Carton (Eds.), *The collected works of L. S. Vygotsky: Volume 1: Problems of general psychology* (pp. 37-285, translated by N. Minick). New York, NY: Plenum.

Wallace, C. S. (2004). Framing new research in science literacy and language use: Authenticity, multiple discourses, and the "Third Space". *Science Education*, 88, 901-914.

Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education*. New York, NY: Cambridge University Press.

Wertsch, J. V. (1980). The significance of dialogue in Vygotsky's account of social, egocentric, and inner speech. *Contemporary Educational Psychology*, 5, 150-162.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University Press.

Wertsch, J. V., & Toma, C. (1995). Discourse and learning in the classroom: A sociocultural approach. In L. P. Steffe, & J. Gale (Eds.), *Constructivism in education* (pp. 159-174). Hillsdale, NJ: Lawrence Erlbaum Associates.