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An Exploratory Analysis of Constructivist Teaching Practices and Science Teaching Interactions in Earth Science Classes

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Abstract: This study aimed to explore how to characterize the earth science inquiry in schools in terms of science teaching interaction and constructivist teaching practice. The constructivist teaching practices were analyzed with Reformed Teaching Observation Protocol (RTOP) in three aspects including (1) student oriented class implementation, (2) subject knowledge and representation, and (3) classroom communication. Fourteen earth science classes were observed and scored with RTOP. The class was evaluated to be transitional stage in terms of constructivist teaching, e.g., moving toward student-centered teaching practice. Especially, Korean teachers tend to lean their classes more on propositional knowledge than procedural knowledge. To interpret science teaching interactions, an earth science teacher with a RTOP top rank was selected. Her class was then videotaped for detailed analysis. I adopted the analytical framework of communicative approaches and discourse patterns among the five aspects of interactions presented by Mortimer and Scott (2003). It was found that this earth science teacher used more authoritative patterns than the dialogic. In addition, she used IRE discourse pattern more frequently. Interestingly, teachers interacted with their students more frequently in the form of repeated (or IRE chain pattern), that is IRFRF (teacher initiation-student response-teacher feedback-student response-teacher feedback) in the context of dialogic communicative approaches, while simple IRE occurred in an authoritative approach. In earth science classrooms, typical interaction may well be constructed in the form of IRFRF chains to allow students free conjectures and abduction.

Keywords: science teaching practice, communicative approaches, discourse pattern

Introduction

Before characterizing earth science inquiry in real classrooms, it is desirable to define what is scientific inquiry. Probably, earth science inquiry should be included in the category of scientific inquiry. However there is a lack of agreement on the meaning of inquiry in the field of science education (Martin-Hauser, 2002; Minstrell and van Zee, 2000). Rather meaning and implementing of scientific inquiry has evolved (Barrow, 2006). For example, John Dewey, a former science teacher, encouraged K-12 teachers of science to use inquiry as a teaching strategy where the scientific method was rigid and consisted of the six steps: (1) sensing perplexing situations, (2) clarifying the problem, (3) formulating a tentative hypothesis, (4) testing the hypothesis, (5) revising with rigorous tests, and (6) acting on the solution (Barrow, 2006). These meaning of scientific inquiry moved into science process or doing science with focus on training scientific process skills affected by Gagne since 1960's.

Doing science was more like the skillful exercise of a repertoire of craft skills rather than the following of an algorithm (Polanyi, 1958; Ravets, 1971). The training of scientists involves the process of internalizing these tacit canons of procedure and judgement (Millar, 1989). Recently scientific inquiry is considered as practical work in the teaching and learning of science (Millar, 2004). Millar defined 'practical work' as any teaching and learning activity which involves at some point the target students for monitoring or manipulating real objects. This term is used preferentially over laboratory work (Millar, 2004). In order to do the practical work, he emphasized teaching scientific knowledge as communication and involving students in action and reflection (Millar, 2004). This study assumes that there will be more interactions in student-teacher and student-student relationships as

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well as frequent student-centered teaching strategies in implementing scientific inquiry.

Earth science has a unique practice compared to other subject areas. For example, it covers wide range of research areas including astronomy, oceanography, geophysics, geology, and meteorology. Its practice usually occurs in fields. Many issues and knowledge in earth science has been updated to date as well. How is earth science inquiry characterized in a real classroom? In order to answer this question, this study explored an earth science class in terms of its teaching practice and verbal interaction.

Research Background

Communicative approaches and discourse pattern of interactions

It is useful for implementing the meaning of scientific inquiry to characterize current practice of science teaching in terms of constructivist teaching practice and to verify interaction between teacher and students as well as among students in classes. There is much emphasis on studying teacher talk in the science classroom by engaging in the framework presented by Mortimer and Scott (2003). Even in planing classroom inquiry, it is important for teachers to plan social interaction on teacher talk from the view point of each particular learning situation.

Mortimer and Scott (2003) proposed the analytical framework for analyzing science teaching interactions. They consisted of five aspects; (1) teaching purposes, (2) content, (3) teacher interventions, (4) communicative approach and (5) patterns of discourse. Among these aspects, this study adopted communicative approach and discourse patterns for analyzing interactions.

According to Mortimer and Scott (2003), the concept of communicative approach focused on the ways in which the teacher works with the students to address different ideas in classes. It was defined by categorizing talks between student and teacher in two dimensions. The first one was a continuum between dialogic and authoritative talk, while the second between interactive and non-interactive talk.

Along with dividing talks in their communicative approaches, another aspect of interaction is discourse patterns. Discourse in classes were mostly driven by teacher questions (Oh et al., 2003). Therefore, most frequently identified patterns consisted of monologues, dialogues, and IREs; I stands for initiation through a teacher question; R for response from the student; and E for evaluation by the teacher. Simply discourse patterns focused on distinctive pattern of interactions emerging between teacher and students during classroom talks.

Constructivist teaching practice

Educators have argued that the insights gained from a constructivist perspective on learning has significant implications on how science should be taught (Anderson et al., 1994; Saunders, 1992). Saunders (1992) cited four instructional features which emerged from constructivist theory that research indicates were successful in creating meaningful learning situations:

> Hands-on laboratory activities provide opportunities for pupils to experience phenomena in first-hand which can stimulate cognitive conflicts.
> The active cognitive involvement of learners is enhanced through the use of activities and exercises that promote scientific ways of thinking.
> Students benefit from opportunities to engage in small-group activities while conducting investigations, interpreting data, and drawing conclusions.
> Teachers use assessment strategies that evaluate higher-order cognitive understanding on the part of pupils, as opposed to low-level recall of information.

Principles, such as these, which are grounded in constructivist theory, can serve as a referent for teaching science by aiding teachers in making decisions concerning effective practices (Brooks and Brooks, 1993; Lorsbach and Tobin, 1992; Tobin, Tippins and Gallard, 1994; Yager, 1991).

Lorsbach and Tobin (1992) also pointed out that the current reform of science education had as a major goal the involvement of students in experiences that more closely model the science that scientist do. Constructivism as a referent for teaching can aid in achieving this goal.

The notion of cognitive dissonance, as mentioned previously, plays an important role in the process of knowledge construction according to constructivist theory. Accordingly, teachers must provide pupils with opportunities to experience problems or phenomena which cause this event (Anderson et al., 1994; Brooks and Brooks, 1993; Saunders, 1992; Yager, 1991). Brooks and Brooks (1993) point out, however, that it is often difficult for a teacher to discern when cognitive dissonance has reached a point where student frustration and loss of interest become predominant. To increase student motivation to learn and opportunities to construct new knowledge, educators argue that students should be afforded chances to define their own problems. These problems should be those which are personally relevant to the student (Brooks and Brooks, 1993; von Glaserfeld, 1989; Yager, 1991). The teacher's primary role in this process is to help students clarify for themselves their questions of formulate investigations to answer the question, and interpret the results of such investigations in light of what they already knew or have learned (Brooks and Brooks, 1993).

One thing is clear, the constructivist theory of knowledge construction requires substantial change in the traditional roles held by teachers and students (Anderson et al., 1994). The teacher must become less of an authoritarian and more of a guide or facilitator of learning. Students must become active agents responsible for their own learning through the study of personally relevant topics or issues. However, creating such a classroom environment is a difficult challenge (Lorsbach and Tobin, 1992). As teachers learn more about constructivist theories and develop appropriate teaching strategies, they too must aid students in learning the skills necessary to become successful learners (Lorsbach and Tobin, 1992).

Constructivist views of learning result in defining learners as they are actively involved in the learning process through experiencing natural phenomena and social interactions with others. In accepting constructivism as a referent for science instruction, teachers need to alter their views of how students learn, see their roles in classroom settings as facilitators or mediators rather than dictators and dispensers of knowledge, and use teaching approaches that facilitate the active participation of students as well as assessment procedures that ascertain the learning needs of students (Yutakom, 1997).

The questions for this study were how earth science teachers taught the class in terms of constructivist teaching views and how an earth science teacher interacted with her students in terms of communicative approaches and discourse pattern. In this study, measuring a teaching practice in the viewpoint of constructivist teaching was assessed by observing each class video of fourteen earth science classes with a main emphasis on the three aspects: teaching implementing focus on students' ideas and concerns with student-relatedness.; the class involved students with various experiences of scientific practice; the class involve students in the activity and discussion and encourage them to do.

Methodology

Participants

Fourteen earth science teachers participated in this study. They had more than 5 year experiences of teaching. They were asked to videotape their best teaching of earth science. Most of them tried their understanding of constructivist teaching in their classes of 9th and 10th earth science as they interpreted. Teachers used more frequently interactive talks and students' hands on activity in them than usual as well.

Among fourteen teachers, T12's RTOP score was highest and provided her video of 10th earth science class for the in-depth analysis. The school where this class belonged was the normal public high school. This class had a topic of an ocean current. It was observed and every single talk was transcribed. This data was analyzed for exploring science teaching interaction focusing on communicative approaches and discourse patterns.

Table 1. Three subsets of reformed teacing observation protocol (Piburn et al., 2000)

Lesson Design ad Implementation
-Lessons respecting students' prior knowledge and preconceptions
-Lessons design to engage student as member of learning community and determined by students' idea
-Student exploration preceeded formal presentation
Content
Propositional Knowledge
-Involving fundamental concepts and promoting conceptual understanding
-Teacher having solid understanding of subjects and connecting contents with daily experiences
-Students using elements of abstraction properly
Procedural Knowledge
-Using a variety of means and predicting/hypotheses
-Students engaging in critical thinking and reflecting their learning
-Valuing challenges, constructive criticism
Classroom Culture
Communicative Interaction
-Involving communication of their ideas and questioning to trigger divergent thinking
-High proportion of student talks
-Discourse driven by students talk and climate to respect others' saying
Student/Instructor Relationship
-Encouraging to generate conjectures, ways of interpreting evidences and alternative solution.
-Being patient with students and acting as a resource person.
-Instructor as listener.

Table 2. Communicative approaches (Mortimer and Scott, 2003)

	Interactive	Non-interactive
Authoritative	Question-Answer-evaluation	Lecturing
Dialogic	Discuss-student voice	Reviewing student voice

Instruments

The constructivist teaching practices of fourteen earth science teachers were measured by the Reformed Teaching Observation Protocal (Piburn et al., 2000). The RTOP consists of 25 Likert scale items dealing with the extent to which instruction is reformed and aligned with constructivist dogmas. Each item is ranked on a 0 to 4 never observed to very descriptive scale with a full points of 100.

Secondly, communicative approaches were analyzed by means of coding classroom talks during the class according to the framework in Table 2. Firstly the talks were divided firstly into interactive and non-interactive. If there were found any student and teacher interaction, it would be coded as interactive. If not, such as lecturing, it would be non-interactive. There is another aspect of classroom talk. It is authoritative vs. dialogic. Both can be either interactive or non-interactive. In case of authoritative, a teacher asks questions first and then students answered, which is coded as authoritative and interactive. If there is lecturing without any involving students, it will be coded as authoritative and non-interactive. In dialogic interaction, students's voice can be heard more frequently without teachers' authoritative or evaluative comments. If teachers only reviewing students' comments and discussion, it will be coded as dialogic and non-interactive. For this study, the following was used as an coding framework based on the research of Mortimer and Scott (2003).

This study used a framework for classifying discourse pattern developed by Oh et al. (2003) to evaluate T12's class who obtained the highest RTOP scores. It consisted of monologues mostly of teachers, dialogues including question and answer and Initiation-Response-Evaluation. IRE again are differentiated as IR (E) with correction, IR (E) with motivation, and IR (E) with elaboration. In this study the modified coding system was developed: IR (E) with correction is IRC, IRE with motivation is IRM, IR (E) with elaboration and feedback is IRF.

Inter-rater reliability was built from agreement rate of two science educators. Each instrument reached over .80 agreement enough to achieve reliable degree of inter-rater reliability.

Results and Discussion

Teaching practice

RTOP scores of fourteen teachers, which ranged from 30 to 75, are shown in Table 3.

The mean RTOP scores of them was around 1.9 which was interpreted as constructivist teaching practices were tried but not very descriptively and teachers needed more experiences and training of adopting related strategies. Based on the mean value of RTOP scores, subsets of lesson design (mean value of 1.7) and implementation, student/instructor relationship (1.79) were a little bit descriptive, while procedural knowledge (1.5) and communicative interactions (1.43) were barely found in observed classes overall. Interestingly propositional knowledge (2.5) was scores a way above the total average and interpreted as quite descriptive. In summary, there were found in general tendency among subsets as higher scores in propositional knowledge and lower in communicative interaction and procedural knowledge.

Earth science classes as observed in this study focused on transferring propositional knowledge to students rather than communicating with them and scientific procedures. Teachers and students were not accustomed to learning processes including interaction and scientific inquiry which require relatively long periods of time of teacher training and more effort to complete the tasks and, in the end, provide few clear answers for student-led-inquiry. Teachers usually feel the need to gain information in the most direct way, where information is learned for its own sake and not as a means of solving problems (Cho and Seo, 1997). The direct ways of gaining information, however, rarely result in real learning. Reading about scientific concepts or having a teacher explain them is not enough (Yager, 1991). It resulted in the higher scores in propositional knowledge subsets of observed earth science classes.

As Joyce and Showers (1980) reported, resistance from students and teachers is so great that efforts to change instruction may be put off indefinitely. They also found that initial efforts that do not meet with instant success (probably the norm rather than the exception) were often abandoned. The main problems that the teachers encountered during adopting new teaching strategy include the pressure to cover all topics in the Korean national science curriculum and to gain acceptance by parents, communities, and school administrators. Such problems have been often found as obstacles to changes in teaching practices, and they are difficult to overcome by teachers alone. These facts suggest that an effective professional development program must be connected to other aspects of school change (Darling-Hammond and McLaughlin, 1995).

It is obviously acceptable that organizing a constructivist classroom requires rigorous intellectual commitment, and therefore it is a difficult work for teachers (Brooks and Brooks, 1999). Moreover, most teachers have not been educated in constructivist settings, and becoming a constructivist teacher can hardly be achieved by a short term professional development program without ongoing follow-up efforts (Lieberman and Miller, 1999). Therefore, it is necessary that teacher professional development programs are structured as long-term plans. As Yager (2001) argues, ongoing support across an entire year and beyond should be provided to help teachers move through the developmental phases of change. Indeed, what results in changes in science teaching is not accomplished solely by teacher involvement; real change requires collaborative efforts for improving educational conditions in conjunction with teacher commitments.

T12's teaching directed student-led inquiry

Compared to other thirteen teachers' classes, T12 obtained the highest scores of RTOP. Specificly in

Table 3. Fourteen earth science teachers' RTOP scores

Item	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
1	2	1	2	3	3	3	2	2	3	3	1	4	2	3
2	1	3	2	4	2	3	2	2	1	2	3	3	3	2.5
3	1	3	1	2	1	3	1	3	3	2	3	4	3	1
4	2	2	0	1	1	1	1	2	2	2	2.5	3	2.5	2
5	0	1	0	3	1	0	1	1	0	0	2	2	2	3
lesson design and implementation mean(sum)	1.2 (6)	2 (10)	1 (5)	2.6 (13)	1.6 (8)	2 (10)	1.4 (7)	2 (10)	1.8 (9)	1.8 (9)	2.3 (11.5)	3.2 (16)	2.5 (12.5)	2.3 (11.5)
6	3	3	2	2	4	2	4	3	3	3	3	3	3	2
7	3	2	2	3	3	2	1	2	3	3	3	3	3	2.5
8	3	4	3	4	4	3	3	3	3	3	4	4	4	3
9	3	3	1	1	3	1	3	2	2	3	3	3	2.5	1.5
10	2	2	0	3	2	2	1	2	0	3	2	3	2	2
propositional knowledge mean(sum)	2.8 (14)	2.8 (14)	1.6 (8)	2.6 (13)	3.2 (16)	2(10)	2.4 (12)	2.4 (12)	2.2 (11)	3 (15)	3(15)	3.2(16)	2.9 (14.5)	2.2 (11)
11	2	3	1	1	2	2	1	2	2	2	3	3	3	3.5
12	1	3	1	1	1	0	1	1	1	1	0	3	1	1.5
13	1	2	0	2	2	0	1	1	1	1	2	3	2	2.5
14	1	2	0	2	3	1	1	1	1	1	2	3	2	3
15	1	1	1	1	2	1	1	1	1	1	1	3	1.5	1
procedural knowledge mean(sum)	1.2 (6)	2.2 (11)	0.6 (3)	1.4 (7)	2 (10)	0.8 (4)	1 (5)	1.2 (6)	1.2 (6)	1.2 (6)	1.6 (8)	3 (15)	1.9 (9.5)	2.3 (11.5)
16	1	3	1	3	1	1	1	3	1	1	1	2.5	1	2
17	2	1	1	2	3	1	1	1	1	1	2	3	2	2
18	1	3	2	3	2	1	1	2	1	1	1	2.5	2	2.5
19	1	2	1	2	1	1	1	1	0	1	1	3	1	1
20	1	2	2	2	1	2	1	2	0	1	2	3	2	2
communicative interaction mean(sum)	1.2 (6)	2.2 (11)	1.4 (7)	2.4 (12)	1.6 (8)	1.2 (6)	1 (5)	1.8 (9)	0.6 (3)	1 (5)	1.4 (7)	2.8 (14)	1.6 (8)	1.9 (9.5)
21	2	3	2	3	2	3	1	3	1	2	2	3	3	2
22	1	3	1	2	2	1	1	2	1	2	2	3	2	1
23	1	2	2	3	2	2	1	1	2	1	3	3	2	2
24	1	3	1	3	2	3	1	2	2	1	2	3	2	2
25	1	2	1	2.5	2	1	1	1	1	1	1	2	1.5	1.5
student/teacher relationships mean(sum)	1.2 (6)	2.6 (13)	1.4 (7)	2.7 (13.5)	2 (10)	2 (10)	1(5)	1.8 (9)	1.4 (7)	1.4 (7)	2 (10)	2.8 (14)	2.1 (10.5)	1.7 (8.5)
total mean (total sum)	1.52 (38)	2.36 (59)	1.2 (30)	2.34 (58.5)	2.08 (52)	1.6 (40)	1.36 (34)	1.84(46)	1.44(36)	1.68(42)	2.06 (51.5)	3(75)	2.2(55)	2.08(52)

terms of lesson design and implementation, her class described clearly the instructional strategy and activities respected students' prior knowledge and student exploration preceded formal presentation. Yet it is not clearly described that the focus and direction of the lesson was often determined by students' originating ideas as shown in most teachers' classes.

In propositional knowledge, most subset items were quite descriptive and it was very well described that the teacher had a solid grasp of the subject matter content. Interestingly even in procedural knowledge, most items were quite descriptive. She used lots of classroom talks and student inquiry. In student/teacher relationships, it was found that students' active participation, acting as resource person and generating conjectures were descriptively encouraged. Still being teacher as listner was not clearly described in her lesson.

Lastly in communicative interactions, it was less descriptive that students were involved in the communication of their ideas to others using a variety of means and media, and high proportion of student talk and a significant amount of it occurred between and among students.

In constructivist teaching practices, T12' class was quite descriptive in related strategies. Yet her class needed to comprehend more student oriented inquiry and quality interaction. Ironically T12's class described exemplary constructivist teaching represented as student-led inquiry but at the same time implicated impediments in science teaching interaction being a core element of it. Communicative interaction of RTOP is quite related to communicative approaches and discourse patterns. How was her class in terms of these?

Communicative approaches: T12 interacted with students but held authority of knowledge

Interactive/authoritative communicative approaches

T12 tried verbal interactions with students. Compared to other teachers, in her class transcription included few monologues. She maintained a great deal of interaction with students in her class but they often paid little attention to the students' ideas. This type of communicative approach is interactive but authoritative. In her class, this type of communicative approaches were found abundantly. The following is an example of this type.

T: This is the picture of geological beds. I will show you several examples. Count how many beds in the pictures. Do you see several types of beds? How many beds?
S: Four!
T: Well. You had better count again. Next according to grain sizes of sediments, discuss sedimentary environments with your team members.
S: (discussion in team)
T: Use your own bed picture and interpret what happened to the bed?
S: Two materials are sedimented
T: Yes, two materials were sedimented.
T: What would be the historic event?
S: Just two materials are.. in turn.
T: Two materials were sedimented chronically. For example, the red one is shale.
Red shale means the original rocks were red. Marine products were red, which made red shales. The next grey part is turf. What does volcanic turf mean?
S: Volcano.
T: There were volcano once. The volcanic ashes were sedimented. During forming sedimentary rock of volcanic ash, some other sedimentary materials were captured.

In this conversation, there was found that T12 interacted with students very much. However the role of students was only nodding and repeating her words.

Interactive/dialogic communicative approaches

Especially when she tried to explain some concepts still with keeping interaction, interactive/authoritative approaches were found. When talks were related to simple observation of phenomena and procedures of experiment, teachers interacted with students with interactive/dialogic communicative approaches. In short, T12 preferred these approaches when she did not need to deal with complicated understanding of the phenomena in her interaction with students.

T: You observe accumulating beds. The bottom was green. And then?
S: Yellow.
T: What do you call this?
S: beds.
T: Yes it is bed. What would be needed for forming beds?
S: Sediments.
T: And ?
S: Water?
T: OK. you might need water But water is not necessary. Most case, water is needed for making beds. Where does the sediments or sedimentary rocks form?
S: River, Sea

In the conversation, T12 and students discussed quite vividly. However most cases of this were related to simple describing phenomena.

Non-interactive/authoritative communicative approaches

This type of communicative approaches are barely found in T12's class. Middle of the lecture, the quiet atmosphere focusing on the very complicated understanding leaned on teacher monologue. Students can not even say their words and interrupt a teacher's saying. T12's monologue consisted of explaining and summarizing a whole process of inquiry and core concepts. She explained the relationships between sedimentary environments and materials.

Non-interactive/dialogic communicative approaches

A dialogic communicative approach that is also non-interactive appears to be self-contradictory (Mortimer and Scott, 2003). A dialogic approach is one where attention is paid to more than one point of view, and a non-interactive approach excludes the participation of other people. T12 tried to persuasively explain a certain concepts without using complicated terms or jargons rather using what students observed. This type of talk was T12's review of the lesson and reinforcement of what she taught at the end of the class.

Discourse patterns: more repeated pattern of IREs in interective/dialogic vs. a simple IRE in interactive/ authoritative

Most talks in T12's class were started with teacher question and followed by student responses. There found a simple IRE and a repeated pattern of IRE. Compared to IRE, IRFRF, one of the repeated pattern of IRE, is quite a series or chains of student-teacher talks. A simple IRE can be controled by a teacher without being followed by students' another comments and questions. Rather IRFRF is a sort of on-going discussion between student and teacher where student and teacher hold the stick of the lesson together.

Interestingly there was some relation between discourse pattern and communicative approaches in this study. Interactive/authoritative communicative approaches were related to IRFRF chain and Interactive/authoritative to IRE as Mortimer and Scott (2003) found.

Interactive/dialogic (IRFRFRFR-IRE chain)

T: What is rock salt? (teacher initiation)
S: Salt rock (student response)
T: Yes, it is. It is a rock consisted of salt. Then what do we need making rock salt? (evaluation with feedback)
S: Dry weather. (student response)
T: Being dry. Have you been to the ocean camp? (teacher feedback)
S: No! (student response)
T: How about the island salt yard? If it rains there, is salt produced? (teacher feedback- teacher question for elaborating)
S: No it is not(student response)

Interactive/authoritative (IRE)

T: In a stream, you can find sediments. In a stream, as we observed in the experiment, where does sediments form in slow flow? or fast flow?(teacher initiation)
S: Slow....(student response)
T: It occurs in slow flow of stream. Then we can figure something out of the beds. Using beds, we can analyze sediments. The kind of sediments are analyzed that we find what environment would be when the sediments were deposited. (teacher elaboration and explanation)

Conclusions and Implications

It was found that most earth science classes showed strong in focusing and concerning propositional knowledge but weak in implementing communicative interaction and scientific inquiry procedures. This indicated that the teachers were closer to deliverers of pre-determined information than learning facilitators. For instance, they needed to learn how to encourage students to initiate examples and ask questions; how to use novelty, discrepancies, and curiosity to motivate student to learn; how to communicate with students integrating content and process, and making connections among major concepts.

With an in-depth analysis of science teaching interaction of the highest RTOP scored class, it was found that the earth science teacher used authoritative /non-interactive patterns more than dialogic/interactive. Interactive/authoritative communicative patterns were frequently observed in T12's class. She leaded students through a sequence of questions and answers with the aims of reaching one specific concept. Using non-interactive approach rarely found, T12 tried to present a certain concept. Interestingly interactive/dialogic appraoch was found when T12 and students explored ideas and generated new meanings. In short, the talks were accompanied by describing things and checking questions.

Also she more frequently used teacher initiation and student responses (IRE) discourse pattern. Classroom discourses mostly started with teachers' question and students' responses were followed. Interestingly, however it was hardly found that she interacted with their students in the form of IRFRF (teacher initiation -student response-teacher feedback-student response-teacher feedback). IRE is teacher initiated the conversation but IRFRF is initiated on-going teacher-student interaction. In the case of earth science, there are more conjectures and abduction used compared to other hard science areas. In earth science classrooms, typical interaction was mainly formed of IRFRF chains allowing students free conjectures and abduction.

Gold (1996) noted that much of what teachers learned previously disappears when they enter the classroom. Zeichner and Tabachnick (1981) pointed out that the effects of teacher preparation experiences are often lost during the first year of teaching as the teachers are socialized into their classroom environments. It is more likely that the teachers regress to teacher-centered styles of teaching. The teachers identified the pressure to cover the existing curriculum, lack of materials for constructivist teaching, and traditional views of students, parents, community, and school authorities about new approaches as problems they encountered during the implementation of constructivist approaches.

Teachers are most likely to internalize desirable teaching methods when both their hands and minds are engaged in such active learning situations (Radford, 1998). This indicates that teachers were dominant and central in the classrooms and that students did not take responsibility for their own learning. The score of less than 2 for RTOP indicates that students were moderately engaged in their learning experiences and that the lessons were at a transition stage moving toward student-centered. Therefore, it can be concluded that teaching practices, as compared with those observed before and right after the workshop, were notably changed as the teachers tried the new science teaching modules.

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