Chapter 2
Changes in Discourse Patterns During Scientific Inquiry: A Co-teaching Model for Teacher Professional Learning

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2.1 Introduction

One of the goals inherent in K–12 science education curricula across Canada and other parts of the world, especially the United States, Europe, and Australia, is to provide students with opportunities to engage in the practices of scientific inquiry, which include asking questions, planning and carrying out investigations, and analyzing and interpreting data (e.g., British Columbia Ministry of Education, 2016; Ontario Ministry of Education, 2007; Rocard et al., 2007; Tytler, 2007; United States National Research Council, 2013). Students need opportunities to use "the methods and procedures of science to investigate phenomena, test and develop understanding, solve problems and follow interests" (Hodson, 2014, pp. 2545–2546). In this kind of inquiry, students perform activities of scientific investigation; and they need opportunities to share ideas through dialogic discourse at all stages of the process (Lehesvuori et al., 2011).

The recommendation to include scientific inquiry extends to elementary curricula. Elementary teachers often have little science education background, which makes this curricular recommendation particularly difficult for them to achieve (Steele et al., 2013). Accordingly, various frameworks have been developed to support elementary teachers and their students in scientific inquiry. One such framework is the Steps to Inquiry Framework (SIF; Pardo & Parker, 2010); however, one issue with learning to use SIF is that teachers can find it difficult to transfer their new knowledge into the classroom. This chapter focuses on a co-teaching model for teacher professional learning that involved two professionals: an expert teacher with a science background

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and experience using SIF, and a novice teacher who was learning to incorporate scientific inquiry into his Grade 1 classroom using SIF. We were particularly interested in analysing the discourse patterns that occurred during each phase of the co-teaching model. The research question addressed was: How did discourse patterns change in a Grade 1 science classroom throughout a co-teaching experience?

2.2 Literature Review

The literature review provides a brief history of scientific inquiry along with an introduction to SIF. The co-teaching model and its use for teacher professional learning in science education are described, and teacher–student and teacher–teacher discourse patterns are discussed.

2.2.1 Scientific Inquiry

The term *scientific inquiry* refers to the particular ways of observing, thinking, investigating, and validating that scientists use in their work (American Association for the Advancement of Science, 1993/2009). Scientific inquiry in the classroom begins with students developing their own questions then designing and conducting their own scientific investigations. Efforts to implement scientific inquiry have a long history in North America beginning with Dewey (1910), who introduced the idea that students need opportunities to engage with the practices of science and scientific thinking as well as opportunities to learn science as a subject matter. He later proposed that the questions students investigate need to relate to their own experiences (Dewey, 1938).

The focus on scientific inquiry in school science curricula gained prominence in North America by the 1960s (Schwab, 1960, 1962). This prominence continued through the 1970s as indicated by the National Science Teachers Association (1971) position paper on science education that recommended students have "an opportunity for investigative activities involving open inquiry" (p. 49). However, typical school science practical experiences were teacher-directed; for example, the teacher provided a question and a plan for students to follow to achieve a predetermined answer. Researchers began advocating for authentic scientific inquiry experiences for students that were more open and more akin to the practices of scientists (e.g., Hodson, 1996; Roth & Bowen, 1995).

Studies indicate that scientific inquiry approaches where students generate questions, design experiments, collect data, draw conclusions, and communicate findings—all of which emphasize students' active thinking and responsibility for learning—are associated with increased interest (Anderson, 2002; Kang & Keinonen, 2018; Minner et al., 2010), motivation (Tuan et al., 2005), and improved science learning as long as the inquiry is appropriately guided by teachers (Aditomo & Klieme, 2020; Furtak et al., 2012; Lazonder & Harmsen, 2016). It is important to

note that more recently, secondary investigations of PISA scores from 2015 have indicated a negative association between students' scientific literacy scores on PISA and the amount of scientific inquiry teaching that students report in their classrooms, on the PISA questionnaire (Cairns & Areepattamannil, 2019; Oliver et al., 2021). These investigations have led to recommendations that scientific inquiry teaching should be curtailed in classrooms (Cairns & Areepattamannil, 2022). However, we would agree with Sjøberg (2018) who stresses that we should not use higher scores on standardized achievement tests to make decisions on whether or not to include science inquiry teaching in the science curriculum. Sjøberg (2018) makes the very important point that we should be more concerned about the beneficial effect of scientific inquiry teaching on students' developing positive attitudes, critical thinking, engagement, interest and motivation, noting that "a written (or digital) test like PISA can hardly measure the skills and competencies acquired in experimental work in a lab or on an excursion; neither can it capture the kind of interest, curiosity and enthusiasm that may be the result of argumentation, inquiry, and the search for solutions to questions that the students have formulated themselves" (p. 200).

Scientific inquiry teaching is embedded in the British Columbia Science education curriculum where this study took place. It takes the form of curricular competencies which form the cornerstone of the science curriculum (BC Science Curriculum, 2015). However, scientific inquiry has been shown to be difficult for teachers to implement (Capps et al., 2016; Crawford, 2007; Fazio et al., 2010; Steele et al., 2013), especially for elementary teachers who often have little science background (e.g., Kim & Tan, 2011; Yoon et al., 2012).

2.2.2 The Steps to Inquiry Framework (SIF)

The SIF (Pardo & Parker, 2010) was created by a team of teachers in Ontario; it was based on Buttemer's (2006) inquiry boards and ideas about how to support student-centered science investigations (Bell et al., 2005; Goldworthy & Feasey, 1997) and gradual release of responsibility during inquiry (Bell et al., 2005; Whitworth et al., 2013). SIF is intended to support teachers and students with enacting science inquiry using step-by-step posters and student pages. It guides teachers to listen to and record their students' ideas, thereby moving teachers toward student-centered instruction. The beginning level posters that were used by the teachers in our co-teaching study are shown in Fig. 2.1. These posters are freely available in English and French (Youth Science Canada, n.d.). We had previously studied SIF implementation after 2-day workshops and found that, despite initial enthusiasm, few teachers actually implemented the SIF (Alexander et al., 2018; Rees & Roth, 2017; Rees et al., 2013). We decided to study how a co-teaching professional development experience might better support teachers in implementing SIF and developing dialogic discourse.
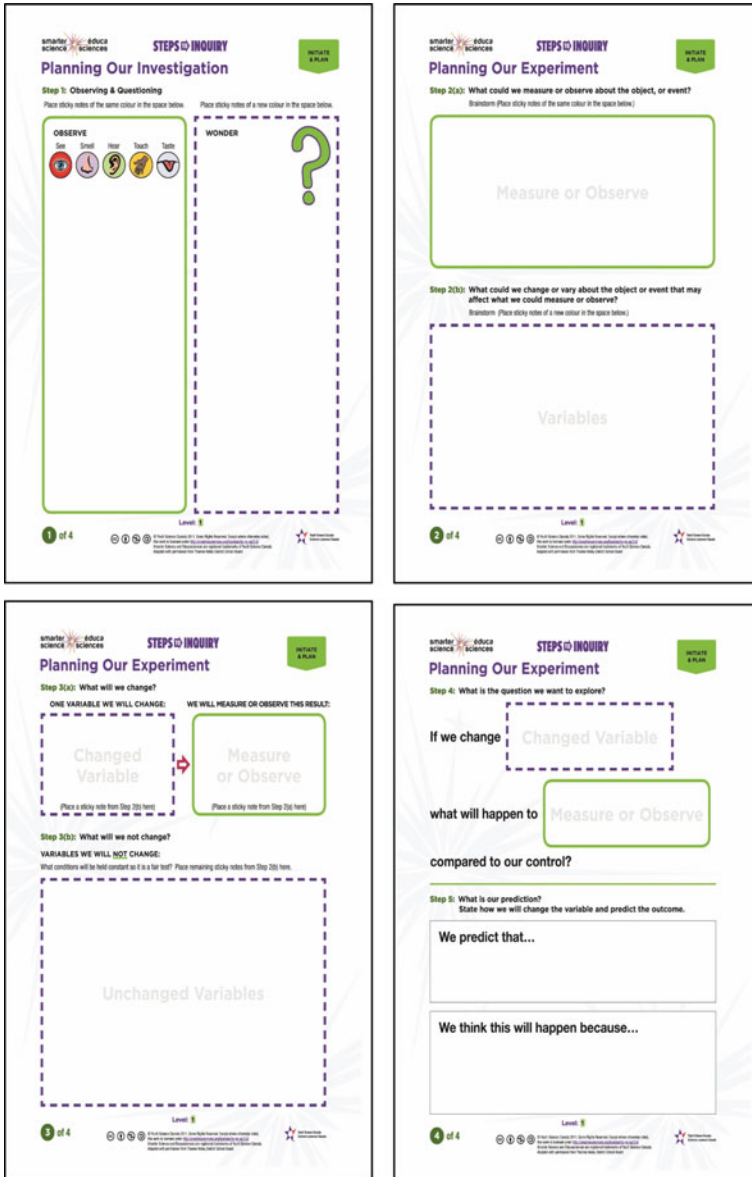
Fig. 2.1 Four SIF posters for planning investigations and experiments (Youth Science Canada, n.d.)

2.2.3 Co-teaching

Our research was centered around a co-teaching model in which two teachers worked in a classroom and shared responsibility for student learning, co-planning, co-teaching, and co-reflecting on student learning (Murphy, 2016; Roth & Tobin, 2002). Although co-teaching is most known for its use in special education (Friend et al., 1993; Harbort et al., 2007; Pancsofar & Petroff, 2016), its use in initial science teacher education has been well documented (e.g., Murphy, 2016; Rees et al., 2022; Roth & Tobin, 2002; Scantlebury et al., 2008); it has also been used for in-service science teacher education (e.g., Roth et al., 1999).

The co-teaching approach used in this study involved a gradual release of responsibility from the expert teacher to the novice teacher through three phases: I Do, We Do, You Do (Duke & Pearson, 2002). In October, the expert teacher observed the novice teacher's usual practice. In November, the expert teacher demonstrated a full SIF-supported science unit with the novice teacher assisting—the I Do phase. In January, the novice teacher conducted a full SIF-supported science unit with the expert teacher assisting—the We Do phase. In February, the novice teacher conducted a full SIF-supported science unit on his own—the You Do phase.

2.2.4 Discourse Patterns

We were interested in exploring how discourse patterns changed during the co-teaching process. The interactions between teachers and students in classrooms has been studied since the 1970s, and it is evident that particular discourse patterns are associated with teacher-directed and in student-centered interactions. Two of the most common teacher-directed discourse patterns in science classrooms are the Initiation-Response-Evaluation (I-R-E) and choral response (Lemke, 1990; Mehan, 1979) while student-centered interactions tend to be more dialogic (Scott et al., 2006).

In the I-R-E pattern, the teacher initiates the interaction with a question, a student responds, and the teacher evaluates, as shown in Turns 1–3 in Table 2.1. Sociolinguists agree that overuse of the I-R-E pattern in classrooms can present a barrier for student learning (Cazden, 2001; Mercer & Dawes, 2014). It can limit students to speaking only when answering test-like questions that teachers provide and evaluate, it can result in a situation where teachers talk on average two-thirds of the time, it can prevent students from deciding when to speak, and it can inhibit students from speaking directly to each other.

A related teacher-directed discourse is choral response, where the whole class responds as a group to a prompt from the teacher, as shown in Turns 4 and 5 in Table 2.1 (Pontefract & Hardman, 2005). Most often used for recall of knowledge, choral response has been seen as suitable for reinforcing knowledge such as decoding, wordlists, and number facts (Rosenshine, 1983). As with I-R-E, overuse of this discourse form can present barriers to students' learning.

Table 2.1 Example of the Phases in I-R-E and Choral response discourse patterns

Turn	Phase	Speaker	
1	Initiation	Mr. Holmes	What is Stage 2, Emma?
2	Response	Emma	Sprout
3	Evaluation	Mr. Holmes	Sprout
4	Prompt	Mr. Holmes	Everybody?
5	Chorus	Students (in unison)	Sprout!

Table 2.2 Example of a student-centered dialogic discourse pattern

Phase	Speaker	
Initiation	Teacher	So, what did you change?
Response	Student	I changed metal, I put metal on there so then I would see how fast it goes
Feedback	Teacher	Yeah
Response	Student	And Brian had two cars
Feedback	Teacher	Yeah
Response	Student	And I and then and, and one of them goes faster and Brian …
Initiation	Teacher	You talk about yours. You changed what it rolled on the bottom?
Response	Student	Yeah
Initiation	Teacher	And what happened to how fast it went?
Response	Student	Um, it goes faster
Initiation	Teacher	On the metal or on the normal floor?
Response	Student	On the metal
Evaluation	Teacher	Okay (nodding), that's a very interesting result, thank you

In contrast to teacher-directed discourse patterns, student-centred discourse pattern involves students responding to open-ended questions (Alexander, 2010; Christoph & Nystrand, 2001). This pattern is sometimes called a dialogic pattern of discourse (Scott et al., 2006) that can be represented as I-R-F-R-F, where F indicates feedback (Mortimer & Scott, 2003). Chains of dialogue will flow and are cumulative (Alexander, 2010); responses are followed and built upon, as shown in Table 2.2.

One component of SIF-supported scientific inquiry is an emphasis on student-centered discourse. In our research, we examined how a novice teacher acquired this discourse pattern through co-teaching, a model that provided multiple opportunities to ask questions and receive just-in-time suggestions. Thus, the novice teacher had the opportunity to alter his practice in the moment to adapt and improve his approach to science inquiry.

2.3 Methods

This qualitative case study (Yin, 2018) looked at both the science education activities and the teacher–student discourse that took place in a Grade 1 classroom: first, before the co-teaching experience and then through the three phases of co-teaching. This study also examined co-teacher interactions to see how teaching with the expert teacher supported the novice teacher in his classroom.

2.3.1 Context

The setting of this study was an elementary school in a small city in Western Canada. This public K–6 school was a school of choice, meaning that students from anywhere in the city could choose to attend if they wanted to focus on science and technology. The school had an inquiry-based teaching philosophy. The school served a high proportion of low-income families.

2.3.2 Participants

Participants included two teachers and 17 children: Mr. Wise (the expert teacher), Mr. Holmes (the novice teacher), and Mr. Holmes' Grade 1 students (all names are pseudonyms). Mr. Wise held a bachelor's degree in science and a master's degree in education and had worked at the school for 8 years. He had experience conducting SIF-supported scientific inquiry for 4 years in his Grade 6 classroom and aiding other elementary teachers doing SIF-supported scientific inquiry for 2 years. In this chapter, we focus on his support of Mr. Holmes, a teacher new to the school who had little experience with teaching science. Mr. Holmes had a bachelor's degree in language arts and had 4 years' teaching experience. The 17 students were aged 6 to 7 years old. Following approvals from the university research ethics board, the school district, and the school principal, informed consent letters were sent to the students' parents and guardians inviting their participation in the study; all agreed to do so.

2.3.3 Data Collection and Analysis

Data for this study consisted of approximately 12 h of video and audio recordings and approximately 100 photographs. Video and audio recordings were taken in the classroom before SIF-supported scientific inquiry was introduced (3 days for 1 h each day) and through the three phases of co-teaching (3 units of approximately 3 h each).

Following existing recommendations for data collection (Roth & Hsu, 2010), one fixed camera video-recorded the whole class, and two handheld cameras followed the two teachers. Audio recorders were set on student tables to capture dialogue that might be missed in the video recordings. The aim was to record, as much as possible, all activities and discourse in the classroom. In addition, we photographed the SIF posters and students' work in booklets.

Data analysis included creating running records (see example in the Appendix) and conducting interaction analysis (Jordan & Henderson, 1995) of teacher–student discourse. We independently constructed running records of video recordings and discussed any issues of interpretation until consensus was reached. The running records included information about classroom events and subevents; examples are teacher organizing students in large- or small-group activities or students conducting scientific inquiry activities, such as collecting observations, developing wonderings, identifying variables, and completing experiments. Photographs of SIF posters and students' work in booklets were used to augment the descriptions of events and deepen our understanding of classroom activities.

To conduct the interaction analysis of teacher–student discourse, we first transcribed the videos taken with the two cameras focused on the teachers, using the fixed-camera videos and audio recordings to fill in gaps and create a verbatim transcript. Next, we worked as a team to examine the videos, read the transcripts, then code the teacher–student discourse patterns as I-R-E, choral response, or dialogic. We used the running records to provide context for the occurrence of discourse patterns.

2.4   Results

To answer our research question *How did discourse patterns change in a Grade 1 science classroom throughout a co-teaching experience?* We begin by describing the classroom activities and discourse patterns that we observed before co-teaching began. We present each of the I Do, We Do, and You Do phases of the co-teaching model in the same way.

2.4.1   October: Before Co-teaching Began

In October, before the co-teaching began and the SIF-supported scientific inquiry was introduced, Mr. Holmes chose the topics of pumpkins, life cycles, and dinosaurs based on the science curriculum, the time of year, the students' interests, and available materials. During our visits, the desks were in rows on one side of the room and the students remained in their desk most of the time. Mr. Holmes mainly taught from the front of the classroom, either standing or sitting on a stool, and circulating at times to give out and retrieve paper. The students were quiet and demonstrated care in following Mr. Holmes' instructions. For example, when preparing to do some

deskwork, students needed to retrieve their pencils from their cubbies. Mr. Holmes called, in turn, to the leader of each of the four rows, to lead their row quietly to the cubbies and return to their seats.

Near the beginning of the pumpkin science unit, Mr. Holmes asked the students to recall what they had previously observed about pumpkins. They raised their hands, and he selected a couple of them to respond. Next, he read a book about pumpkins, talked about pumpkin patches, and asked a variety of closed and open-ended questions. Then he showed a video about the life cycle of pumpkin plants, asking questions throughout, and followed up by sharing a story about pumpkins and composting. He showed a pumpkin and invited them to think-pair-share about what they still wondered about pumpkins. He wrote some of their wonderings on the smartboard then asked them to write one of their wonderings on a sticky note to put in their journal. Finally, he asked them to divide a page into quadrants then draw and label the four stages of the pumpkin plant life cycle. He wrote the words *flower*, *seed*, *sprout*, and *pumpkin* on the smartboard for them to copy.

2.4.2 Discourse Patterns Before Co-teaching

During our October visits, the two most prominent discourse patterns that we observed were the choral response (Pontefract & Hardman, 2005) and the I-R-E (Mehan, 1979), examples of which are shown in Table 2.1. In these patterns, Mr. Holmes did most of the talking and students answered questions with one or two words. We did see some evidence of a discourse pattern similar to dialogic (Scott et al., 2006) when Mr. Holmes asked, "What do you remember about pumpkins?" The students' responses were longer and the turns were more cumulative than in a standard I-R-E pattern. In total, during the three days of video recordings, the frequencies of the three discourse patterns we observed were choral response (42%), I-R-E (37%), and dialogic (20%).

2.4.3 November: I Do Co-teaching Phase

Mr. Wise and Mr. Holmes had previously met to plan their first SIF-supported unit on marbles and ramps. With Mr. Holmes assisting, Mr. Wise would lead three 1-hr classes using equipment that included marbles, ramps, and blocks of different sizes and materials. When we arrived for the first class in November, the students were sitting in a circle on the floor at the front of the room. Mr. Wise was standing beside three SIF posters that were on the wall, and Mr. Holmes was sitting beside him. Mr. Wise introduced the unit by talking about making observations using their senses. He showed the materials that would be used and demonstrated rolling a marble down a ramp. He showed the booklets with the student pages that would be used to record their observations. Mr. Holmes organized the students into pairs and helped Mr. Wise

distribute the basic materials. The students had 10 min to set up a ramp and roll a marble down it, making observations and recording those observations with drawings and words in their booklet.

Mr. Wise then asked the students to bring their booklet and sit in a circle in front of the room. Once they were settled, Mr. Wise led the class in sharing observations that he and Mr. Holmes wrote on sticky notes and attached to the poster in the section labeled observations (Fig. 2.2). Then Mr. Wise talked about wondering; he explained that after scientists make observations they take time to wonder about those observations. The students returned to where they had been working and recorded their wonderings in their booklet. At the end of the class, the teachers collected the booklets and the students returned their materials.

When we returned for the second lesson, the students were sitting in their desks and Mr. Wise was at the front of the room. He began by reminding them about observing and wondering, then he and Mr. Holmes distributed booklets and asked
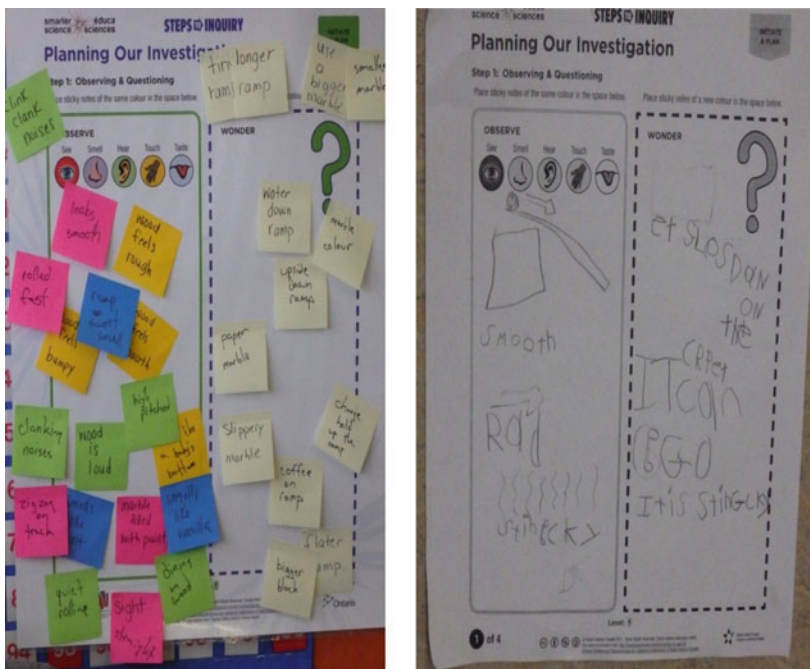

Fig. 2.2 An Example of a Completed SIF Poster (left) and a Related Student Page (right) *Note* The coloured sticky notes on the SIF poster (left) are the students' responses to the question *What did you observe?* Each colour represents observations made using a different sense (e.g., sight, smell). The yellow sticky notes are their responses to the question *What did you wonder?* At the top of the student page (right) in the observe section is a student's diagram of the block, ramp, and marble. Observations include the words "smooth ra[m]p" and "stincky." In the wonder section are the words "et slosdun on the crpet" and "itcan go it is stingcky" that we interpreted as "I wonder if it [the marble] slows down on the carpet" and "I wonder if it [the marble] can go if it is sticky"

them to sit with their partner to talk about their wonders from the last class. A little later when Mr. Wise asked them to come sit in a circle at the front of the room, he asked them to share their wonders, which he and Mr. Holmes wrote on sticky notes and attached to the poster. Mr. Wise told the students that they would now try out some of their wonders. He and Mr. Holmes handed out equipment. Students explored for 8 min before Mr. Wise asked them to leave their equipment and return to the circle. Mr. Wise asked the students to tell what they had changed and what had happened. He and Mr. Holmes recorded responses, which Mr. Wise explained were variables, on sticky notes that were placed on the second SIF poster. Then they returned to their spot to write or draw things that could be variables. At the end of the class, they returned their materials and Mr. Holmes collected their booklets.

At the beginning of the final lesson of the unit, the students were sitting in a circle at the front of the room. Mr. Wise stood by the posters and showed how he would plan an experiment by moving sticky notes from Poster 2 to Poster 3. He indicated one thing that he might change and one thing that he might measure as well as things that he would need to keep the same. Mr. Wise and Mr. Holmes then gave them their booklets and asked them to find a spot on the floor to work while planning their experiment—what they would change, what they would measure, and what they would keep the same. When they had a plan, they went to Mr. Wise, told him the plan, and were given the materials they needed. They had 15 min to conduct their experiment before Mr. Wise asked them to return their materials and sit in a circle at the front of the class. Mr. Wise asked each pair what they had changed and what they had measured.

2.4.4 Discourse Patterns in the I Do Co-teaching Phase

During our visits in the I Do phase, we observed I-R-E and choral response patterns when Mr. Wise introduced activities to the students at the beginning of each class. We observed the dialogic pattern when he asked students to share their observations, their wonderings, and their ideas of variables to change and measure, and when he asked them about their experiments. The relative frequency of the patterns was different than in the unit prior to co-teaching: dialogic was the most frequent (71%), I-R-E was next (28%), and choral response was rarely observed (1%).

2.4.5 January: We Do Co-teaching Phase

Prior to our visit in January for the We Do co-teaching phase, Mr. Wise and Mr. Holmes had met to plan the second SIF-supported unit that involved cars and tracks. Mr. Wise suggested the unit because he had done it before. He had already gathered materials so that groups would be able to choose sizes and shapes of

cars; lengths, widths, and materials of track; and materials for the car to land on. Mr. Holmes would lead the unit and Mr. Wise would assist when needed.

When we arrived, the students were sitting in a circle at the front of the room. Mr. Holmes was standing beside the three SIF posters, and Mr. Wise was standing at the side of the room. Mr. Holmes asked Mr. Wise what to do first; Mr. Wise suggested starting with a review about making observations, then distributing booklets and materials so that the students could make observations. However, Mr. Holmes jumped ahead in that plan and asked what they wondered about and what variables they could change. Mr. Wise spoke up and suggested to Mr. Holmes that they needed to start with observations. Because some students had their hands up already to answer Mr. Holmes' question about wondering, he took one question. Then, following Mr. Wise's advice, he explained that first they would be observing what happened with the ramp and car. They were given 10 min to work in pairs at spots around the room to set up their track, roll the cars, and record their observations. Both teachers circulated to provide support as needed. The teachers called the students to bring their booklets back to the circle, where Mr. Holmes sat on a stool and Mr. Wise stood beside him. Mr. Holmes began by asking what they had found out; however, Mr. Wise stepped in to ask instead what they had observed, which had been the task.

Following Mr. Wise's correction, Mr. Holmes asked what they had observed while Mr. Wise wrote the observations on sticky notes and attached them to the poster. Then Mr. Holmes, with assistance from Mr. Wise, explained that they would go back to their spots to talk about and record their wonderings. Both teachers circulated to assist as needed. For the rest of the class and the remaining two classes of the unit, the teachers worked together to follow the SIF as Mr. Wise had during the I Do phase. Mr. Holmes took the lead but asked Mr. Wise for help about what to do next and adjusted his plans accordingly.

2.4.6   Discourse Patterns in the We Do Co-teaching Phase

In the We Do phase, the three discourse patterns were again evident. We observed the I-R-E pattern when Mr. Holmes introduced activities and the choral response pattern when he asked students to repeat what was written on the SIF posters. We noted that Mr. Wise and Mr. Holmes worked together to generate dialogic discourse. The frequencies of discourse patterns were similar to the frequencies observed in the I Do phase: dialogic (80%), I-R-E (15%), choral response (5%).

In this phase of the co-teaching model, we were interested in the dialogic interactions between the teachers. Our analysis showed that Mr. Holmes and Mr. Wise interacted frequently throughout the We Do phase of co-teaching. During the 117 min of video-recorded class-time, we noted 88 interactions that we categorized as shown in Table 2.3.

Table 2.3 Types of dialogic interactions between two teachers in the We Do phase

Type of interaction	Description	Example	Frequency
Aside	Teachers speak privately to each other, quietly and quickly	Mr. Wise said quickly and quietly to Mr. Holmes, "Probably you should demo this" indicating a step on the SIF poster that dealt with variables	27
Check-in	One teacher checks in with the other teacher (e.g., regarding what is coming up)	Mr. Holmes at one point said to Mr. Wise, "What do you think, maybe one more minute?"	25
Performance for students	Teachers speak to one another more loudly, more deliberately, and at a slower pace	Mr. Wise said slowly and in a loud voice, "So, what did we learn, Mr. Holmes?" Mr. Holmes responded, "I learned that if it [the track] gets too steep … it causes it [the car] to tumble."	15
Interjection	One teacher speaks up when the other teacher is leading	Mr. Wise interrupted Mr. Holmes, indicating that some clarification was needed	14
		Total	81

2.4.7   February: You Do Co-teaching Phase

Prior to our visit in February for the You Do phase, Mr. Wise and Mr. Holmes met to plan the third SIF-supported unit. Mr. Holmes suggested the topic of magnets and together they chose a magnetic kite activity that involved a paper clip attached to a string and a magnet used to make the paper clip travel through the air without touching it. Mr. Holmes had gathered the materials so that each group would be able to choose from a range of sizes of paper clips, string of various thickness and length, and magnets of different sizes and strengths. The teachers decided that although Mr. Wise would not join the class students from his Grade 6 class would join to assist the Grade 1 students.

When we arrived for the You Do phase, the students were sitting in a circle and Mr. Holmes was sitting beside the three SIF posters. He explained that they would be doing a new experiment and reminded them about making observations using their senses. He then explained the magnet activity and introduced the Grade 6 students who had joined the class to help. Mr. Holmes handed out booklets and materials; the Grade 1 students had 15 min to make their observations while he and the Grade 6 students circulated to help. Then he called the students back to the circle to share their observations. Over the next 2 days of the unit, Mr. Holmes continued to follow the SIF as Mr. Wise had during the I Do phase and both had during the We Do phase.

2.4.8 Discourse Patterns in the You Do Co-teaching Phase

All three discourse patterns were evident during the You Do phase. The dialogic pattern occurred during the times when the students were in a circle sharing what they had observed, wondered, and found out during their experiments. As in the I Do and We Do phases, we noticed the I-R-E pattern when Mr. Holmes introduced activities. The choral response pattern was relatively rare but was used when, for example, Mr. Holmes prompted the children to tell him the five senses. The frequencies of discourse patterns we observed in the I Do phase were dialogic (71%), I-R-E (26%), and choral response (2%).

2.4.9 Discussion

We found a substantial shift in discourse patterns before and during co-teaching. Through the I Do and We Do phases of co-teaching, Mr. Wise worked together with Mr. Holmes to implement SIF-supported units and to encourage student-centered dialogue (e.g., dialogic discourse patterns). In the You Do phase, Mr. Holmes implemented a SIF-supported activity on his own and was able to foster student-centered dialogue (see Table 2.4).

Examining the dialogic interactions between the co-teachers in the We Do phase, we found an average of one interaction every 1 to 2 min. Mr. Holmes was learning in the moment to implement SIF-supported science inquiry and associated dialogic discourse patterns with his students. During these interactions, Mr. Wise helped keep Mr. Holmes on track by offering corrections and suggestions; and Mr. Holmes frequently asked Mr. Wise questions. The co-teachers' interactions in our study fit the description of *huddles*, defined by Soslau et al. (2018) as short, focused meetings where teachers can learn from each other before, during, or after a lesson. Huddles can be used to help teachers engage in a particular strategy, develop their questioning and pacing, manage the classroom as well as model, provide corrections and enhancements, and clarify directions. In this study, the dialogic interactions could

Table 2.4 Discourse patterns before and during co-teaching

Phase		Who was teaching?	Discourse pattern		
			I-R-E (%)	Choral response (%)	Dialogic (%)
Before co-teaching		Novice teacher, on his own	37	42	20
Co-teaching	I Do	Mentor teacher, on his own	28	1	71
	We Do	Co-teaching	15	5	80
	You Do	Novice teacher, on his own	26	2	71

be viewed as huddles where the expert teacher helped the novice teacher implement SIF-supported teaching and discourse.

2.5 Conclusions

This study was designed to address the research question: How did discourse patterns change in a Grade 1 science classroom throughout a co-teaching experience? In the co-teaching model that we used, Mr. Holmes had first observed and assisted Mr. Wise in the I Do phase as Mr. Wise modelled SIF-supported scientific inquiry and associated dialogic discourse patterns. During the We Do phase, Mr. Holmes led a unit of SIF-supported scientific inquiry with the assistance of Mr. Wise. The two teachers interacted frequently (e.g., brief interactions or huddles); Mr. Holmes was able to learn in the moment by asking questions of Mr. Wise, who offered suggestions when they were most helpful. During the You Do phase, Mr. Holmes was able to build on his experiences during the I Do and We Do phases, implementing SIF-supported science inquiry and student-centered dialogic discourse with his students.

We found that by the end of the co-teaching professional learning experience Mr. Holmes was able to move toward the dialogic patterns associated with student-centered discourse. He led the class through the steps of observation then developing wonderings, planning and conducting an experiment, and communicating findings. His SIF-supported unit included frequent opportunities for dialogic interactions where students had opportunities to talk and share their thinking about their activities. The dialogic pattern was the most common pattern during the You Do phase, just as it had been in the I Do phase modelled by Mr. Wise and in the We Do phase when both teachers worked together. Although this qualitative case study was limited to one classroom, our findings support the idea that the I Do, We Do, You Do co-teaching model can be an effective approach to teacher professional learning.

Appendix

Running Record: Before Co-teaching, Class 2, total time: 38.30 minutes

Interval (min)	Activity: What is Mr. Holmes doing? What are the students doing?
00:00–1:40	Mr. Holmes, standing in front of class, asks students what they remember from the last class. Students are sitting in their seats facing front, raising hands to respond. He either calls on students to answer by name or by pointing to a student
1:40–04:05	Mr. Holmes, standing in front of class, introduces a book entitled *My Pumpkin*. While reading the book, he asks known-answer questions and/or provides prompts. Students are sitting in their seats facing front. They respond as required, either raising hand to answer or responding to prompt in chorus
04:05–6:46	Mr. Holmes, standing in front of class, talks about pumpkin patches. He asks a mix of known-answer and open questions about pumpkin patches and what it means to be a living thing. Students are sitting in their seats facing front. They respond as required, either raising hand to answer or responding to prompt in chorus
06:46 – 07:15	Mr. Holmes moves in the classroom to turn off the light and set up the video. Students are sitting in their seats facing front
07:15–12:20	Mr. Holmes is kneeling as the video is playing. He makes comments and asks students questions or provides prompts about the video. Students are sitting in their seats facing front. They raise hands and respond to known-answer questions as required and respond to prompts in chorus. Sometimes he pauses the video for the questions and prompts
12:20–16:35	Mr. Holmes stands up in front of the class, then moves to the side to carry a pumpkin, then back to the front again, sometimes moves to the middle too. He talks about topics related to pumpkins, pumpkin patches, and shares his story about composting. He asks known-answer questions to which the students respond. Students are sitting in their seats facing front or turning to the side. Lights are still off. Video is finished
16:35–17:37	Mr. Holmes turns the lights on and moves between the side of the classroom and the front then to the back. He asks students to turn to a partner and speak about one thing they are still wondering about in relation to pumpkins (Think-Pair-Share). Students are sitting in their seats, turn and speak with a partner
17:37–23:23	Mr. Holmes moves to the front then goes to the smart board. Students are sitting in their seats facing front. He asks them to share what they are wondering about pumpkins. They raise their hands. He indicates to students to answer, sometimes using their name or by pointing to a student. Students share their wonderings or what their questions are. He repeats their comments and sometimes adds some remarks. He writes some of the wonderings on the smartboard
23:23–28:30	Mr. Holmes is standing in front of the class. Students are sitting in their seats facing front. A designated helper student takes sticky notes and passes them to all the students. They already have pencils. He asks them to write their "wonder" questions on the sticky notes. He answers some questions about spelling and makes a few comments to remind some students of what they wrote. He occasionally points to words he has written on the smartboard so that they can copy them
28:30–33:50	Mr. Holmes walks around the classroom instructing students who are finished to go to their cubby, bring back their journal, and put their sticky notes inside it. Students are sitting in their seats facing front then start moving to get journals and go back to their seats

(continued)

Interval (min)	Activity: What is Mr. Holmes doing? What are the students doing?
33:50–38:10	Mr. Holmes shows students how to divide their page in four with a line in the middle and then to put another line across the middle creating four boxes for the stages of the pumpkin: flower, seed, sprout, and pumpkin. Students sit in their seats and do the task, sometimes asking questions about instructions and spelling. He repeats instructions and assists students. He puts the book on top of the smartboard to show an example
38.10–38.30	There is a fire drill. The bell rings. Mr. Holmes tells the students to stand up and make a line. Students stand next to their seats. (The class exits the building to the playground for the fire drill.)

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