Teacher discourse strategies used in kindergarten inquiry-based science learning

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Abstract

This study examines teacher discourse strategies used in kindergarten inquiry-based science learning as part of the Scientific Literacy Project (SLP) (Mantzicopoulos, Patrick & Samarapungavan, 2005). Four public kindergarten science classrooms were chosen to implement science teaching strategies using a guided-inquiry approach. Data were collected during lesson observations; teacher discourse strategies were analyzed using qualitative and quantitative procedures. The results showed that the teachers used 13 distinct types of teacher discourse strategies in the classroom. Teacher discourse strategies were grouped into four higher levels of discourse categories. The results indicated that the nature and relative proportion of the different types of teacher discourse varied both across teacher and within teachers across classrooms.

Keywords: Teacher discourse, inquiry-based science learning, explanation, instructional strategies, kindergarten

Introduction

Various instructional strategies used in the generation of explanations by children have been examined by science educators. Numerous studies have shown that when teachers provide students with the appropriate scaffolding during learning, the children are likely to engage in the generation of explanation (Gagnon & Bell, 2008; King, 1994; McNeill, Lizotte, Krajcik & Max, 2006; Tabak & Reiser, 1999). However, most of these studies focus on middle school children and older rather than kindergarten children (King, 1994, McNeil et al., 2008; Tabak & Reiser, 1999). Studies that investigate the role of instructions in preschool children focus on linguistic development of explanatory discourse rather than on the development of categories or kinds of teacher discourse strategies. They do not specify forms of scientific explanations from non-scientific explanations (Beals, 1993; Peterson & French, 2008).

The purpose of this study is to examine teacher discourse strategies used in inquiry–based science learning. Being able to provide explanation is a key form of knowledge construction and is also regarded as a key goal of inquiry in order to understand natural phenomena (Sandoval & Reiser, 2004). During discourse, prompting can also be used as a part of instructional materials, for example prompts that are generated from computer assisted instruction as well those that are embedded within written task instructions. It must also be noted that these are not necessarily limited to prompts that are provided by teachers during discourse.

Theoretical Framework

This current study focuses mainly on teacher discourse strategies used in inquiry–based science learning. Several researchers have suggested that scaffolding is needed from teachers for students to generate scientific explanation successfully. For example; the teachers can provide students with prompts and a chance for the students to explain their thoughts (Bell, Semetana, & Binns, 2005; Gagnon & Abell, 2008). Ogbon, Kress, Martins, and McGillicuddy (1996) discussed various ways in which teachers can engage students in explanation during science learning, for instance, by showing counterintuitive results, using examples, and asking for clarification.

Walsh (2013) noted that theories are important and there are several types of theories which include grand theories, case theories, and mid-range theories. Lyons (2018) defines theory as a set of ideas that are organized which tries to provide explanation for a phenomenon. Smith and Hamon (2017) define a theory as a tool that is used for describing and understanding the world. They also stated that a theory is regarded as a general framework with ideas that explain how they are connected to each other. In addition, Smith and Hamon (2017) highlighted that theories could be used for asking and answering questions regarding specific phenomena. In another study, White et al., (2015) explained several types of theories and state that a scientific theory is as “a set of systematically related propositions that are empirically testable” (p.6). We do acknowledge that there are several theories that exit and are important to research. However for this particularly study we focus on constructivist theory and grounded theory. Constructivist theory is important to inquiry learning (Tillinger, 2013) and children successfully construct higher levels of knowledge when they are actively trying to master their world (Lightfoot et al., 2013). Several researchers (Glaser, 2017; Glaser, & Strauss, 1967; Denzin & Lincoln , 2003) have written extensively on grounded theory. Denzin and Lincoln (2003) explained that grounded theory is important in qualitative revolution and qualitative research provides a systematic social scientific inquiry. Denzin and Lincoln (2003) also mentioned that grounded theory methods include systematic inductive procedures that are used for the collection and analysis of data. They agreed that “grounded theory is durable because it accounts for variations; it is flexible because researchers can modify their emerging or established analysis as conditions change or future data are gathered" (p.252).

Teacher discourse strategies are important and should not be overlooked. However, there are little to no studies that examine the relationship between instructional strategies and students' generation of scientific explanation during science learning in kindergarten. In an attempt to fill the gap in the literature, this study explores different kinds of teacher discourse strategies and examines how teacher discourse during inquiry-based kindergarten science instruction facilitates the development of scientific explanations among kindergarten students.

Teacher Scaffolding and Modeling of Scientific Explanations.

Research has documented the importance of investigating the construction of scientific explanation (Faye, 2014) with the aid of teacher's scaffolding. For example, Tabak and Reiser (1999) conducted a study which examined how teacher instructional strategies related to high school student's construction of biological explanations. They found that establishing opportunities and expectations for the construction of explanation are very important during classroom science discourse. Further, Tabak and Reiser (1999) argued that teachers need to assist students in generating explanations. They noted that the teacher in their study used various strategies to support students' construction of explanation during learning. These included using a set of norms to guide the production of high quality scientific explanations. Specific instructional strategies that were used included guided prompts, general elaboration prompts, specific elaboration prompts, restating driving questions, critiquing and questioning students' initial statements, encouraging causal explanations, synthesizing and re-voicing the remarks of students. Their results showed that students can be trained to generate scientific explanations although they depend heavily on the teacher to assist with the explanation construction process.

In a similar study, Renkel (2002) investigated the benefits of learning when high school students are trained to produce scientific explanations of high quality when they are provided with examples such as instructional explanations. The participation in his study included 48 students who were working on how to solve problems dealing with probability. There were 12 males and 36 females in the study who completed both pre- and post- test problems on probability. The experimental group was given self-explanation activity supplemented with instructional explanations (SEASITE) principles, which is an explanation training program that uses a group of instructional principles that are used in example based learning as well as the developmental of instructional explanations (Renkl, 2002). Similar to the experimental group, the control group was also involved in self-explanation however; this group did not receive the SEASITE principles. The results of Rankle's study showed no differences exist between the two groups of students. He concluded that students in the self-explanation group did just as well as those who were given supplemental instruction that includes good examples.

Several studies have investigated how teacher prompts can facilitate the generation of explanation by students during science learning (e.g., Chi, DeLeeuw, Chuiu & LaVancher, 1994; Chi, 2000; Chi, Siler, Jeong, Yamauchi & Hausmann, 2001; McNamara, 2004; Nokes et al., 2011; Palincsar & Brown, 1984; Van Meter, 2001). Chi and colleagues' (1994) study showed that compared to students who were not prompted to provide self-explanation, students who were provided with prompts to self-explain learned better and showed a deeper understanding of the course content. It must be noted that prompts can be incorporated into instructional materials for example computer assisted instructions as well as written task instructions and are not restricted to prompts provide by teachers during discourse.

Chi (2000) investigated college physics and college biology courses in order to determine whether there were differences among the two courses as it relates to instructional prompts and students' self-explanation. Chi found that the students were prompted in generating self-explanations more in biology in comparison to physics course. Chi (2000) noted that in both physics and biology classes, students who produced self-explanation showed better performance in the course than those students that did not produce self-explanation.

Aleven, Koedinger and Cross (1999) used the PACT geometry tutor to determine how students produced explanation (Aleven et al., 1999). The PACT geometry tutor is a curriculum which is made up of a variety of geometry topics which included angles, circles as well as Pythagorean Theorem. The PACT geometry tutor was designed to help students in reasoning and explanation of answers. Aleven et al. (1999) stated that students' comprehension of geometry will improve if they are trained to give explanations for answers. Both of the experiments assessed the effectiveness of teaching students how to explain their answers during student learning. In the first experiment 41 high school students enrolled in a high school geometry who were placed either in an experimental group (reason condition) or control group (answer only condition). Aleven et al. (1999) concluded that there were benefits to teaching students how to provide explanations for their answers. Students who were in the experimental group (i.e., students who were asked to give reasons for their answers) performed and learned better during problem solving in comparison to the control group (i.e., students who were not asked to give reasons for their answers) group. Due to time constraints in the first experiment the control group completed the problem in a shorter period because they were not required to generate explanations. Alvin and colleagues' (1999) second experiment consisted of 53 high school students who were in two geometry courses that were controlled by time factor which involve a seven hour time period for students in both experimental and control groups. The results revealed that those students from the experimental group had gained significantly from the pre-to posttest. They also performed much better on problems that required reasoning than the control group.

Bielaczyc, Pirolli and Brown (1995) investigated self-explanation strategies as well as self-regulation that students used while using the Lisp Tutor. The Lisp Tutor is a program which is made up of variety of programming instruction as well as exercises which allow the students to write Lisp code. There were 24 students who recently graduated from a university that participated in the study. There students were divided into instructional and control groups. The instructional group consisted of 11 participants while the control group consists of 13 participants. During the exercise the participants were provided with prompts in order to read aloud as well as state their ideas verbally.

Bielaczyc et al. (1995) also investigated the role explanation plays in learning. They investigated the effect of instructional strategies which facilitated students' explanations during learning at a college level course in programming. The study consisted of several stages. At the introductory stage, students were allowed to practice and think out loud. The second stage, which is called the pre-intervention stage, involved the collection of data on students' explanation and performance while participants' study as well as explained the help sections in the instructional manual. The third stage which is called the instructional stage (received special training in self-regulation and self-explanation as well as Lisp tutoring) or involves the assignment of participants to an intervention or control group (received Lisp tutoring). The intervention group was given explicit training strategies which consisted of structured one-to-one interaction by the experimenter and each student.

The learning strategies entail the elaboration and identification of the existence of relationships between major point and during the use of text. It also involves the generation of meaning and forms in order to code the Lisp as well as connect concepts with the aid of examples and text. A variety of questions were asked on self-explanation as well as self-regulation strategies (e.g., students were asked to provide explanations and descriptions of certain application features, provide explanation on the usefulness of strategies based on specific category, presentation of methods for the application of self-interrogative strategies, give explanation of when, and why as well as how to used the strategies and provide discussion on self-regulation strategies). After the completion of the instructional stage the post intervention stage was next, this involves the collection of data and final programming performance as well as explanation. The data were collected from both the intervention and the control groups. The students were allowed to ask as well as answer questions verbally. The pre-and post instructional stages consisted of an encoding stage which describes students' explanation and study of instructional materials. For the last stage, students were provided with problem solving activity which includes novel programming.

Bielaczyc et al. (1995) concluded that the performance of the intervention group was better than the control group in several areas. For example, the intervention group provided better explanation on major points during the programming activities as well as explain Lisp codes. Based on the data that was collected from the instructional and post instructional stage the interventional group generated more explanation in comparison to the control group.

King (1994) investigated strategies that teachers use to teach 4th and 5th

graders on how to produce scientific explanations. The study consisted of three groups: guided questioning- explaining, lesson based questioning with explanation, and unguided questioning with explanation. Guided questioning- explaining involve the engagement of students in discussions where questions are used to make connections with the lesson. Lesson based questioning with explanation involve the engagement of students in discussion that are guided by questions and explanations which utilizes lesion and experience based questions. Unguided questioning with explanation involves the engagement of the control group in untrained questioning. The group consisted of 30 grade five students and 28 grade four students. The data was in the form of video and audio tape lessons. It also consisted of pre and post test of the three groups. The results revealed that the performance of the participants of the question-based (Group 1) group was better than the participants of the experience-based group (Group 2) and control group (Group 3).

Sandoval and Reiser (2004) investigated student's inquiry and how explanation supports inquiry using a qualitative approach. The participants for their study consisted of 69 students. The students were enrolled in a biology course from three 9 grade classes who used the curriculum (Explanation Constructor) developed by the researchers on evaluation. The Explanation Constructor provides online assistance and prompts to students as they engaged in explanation constructions during inquiry. The researcher collected data over a four week period. They used audiotape, videotape, field notes and observation for their data collection. The analysis also included data from a focus group session that was conducted with four of the students. The results showed that, on average, students generated less than two explanations per problem during inquiry. The authors concluded that the Explanation Constructor assisted students in generating explanations and evaluate the progress of their explanations in relation to the students' inquiry questions.

McNeill et al. (2006) examined the effects of various types of explanations scaffolding (continuous scaffolding or faded scaffolding) on how they impact students' learning and scientific explanation. They also developed a curriculum which assisted students at the seventh grade level in their understanding of scientific explanations. The results of McNeill et al's study showed an increase in scientific explanations and better explanations throughout classroom learning when students' were provided with continuous scaffolding and written explanations, as well as teacher scaffolding and modeling of explanation. In addition, students who received the faded scaffolding condition (i.e., those students who were given similar instructional assistance for explanation from the initial stage of learning and then gradually reduced during learning) produced less scientific explanations.

In another study McNeil et al. (2008) investigated the effects of the adoption of an explanation framework on students' science learning while they received science instruction. Their study consisted of thirteen teachers who taught at the 7th grade level, and 1,197 students who were from an urban and a suburban school. Data collection was carried out over an eight week period during an implementation of a chemistry unit in every classroom. The lessons were videotaped along with both pre-and posttest evaluations of students' comprehension and chemistry explanations. The researcher collaborated with teachers to assist them in providing support during the evaluation and generation of students' explanations of chemistry. Comparison of the pre- and post test showed that the students exhibit significant learning outcomes for scientific explanation. In addition, the data from the classroom lessons that were videotaped indicated that students' generation of scientific explanation were increased during the instructional unit. The teacher instructional practices that supported students' scientific explanation also varied significantly. The authors concluded that the variation was in relation to the systematic differences of the amount as well as the quality of scientific explanations generated by the students throughout learning outcomes based on the posttest.

Many researchers have investigated the function of inscriptional tools for example, science notebooks, three dimensional models, and diagrams in fostering scientific explanation development of students (Ainsworth & Loizou, 2003; Haefner, Zembal-Saul & Avraamida, 2002).

Ainsworth and Loizou (2003) agreed with the claim that students learn better when they are provided with diagrams that have information on the human circulatory system, than students who were provided with text. High school students were selected randomly in their study and they were given text and diagram materials in one group and text only in another group to study. All of the students received pre-and posttest to determine their knowledge about circulatory system. The results showed that students from the text and diagram group provided more causal self-explanations as well as scored higher during the posttest in comprising to the text only group.

Several research have been conducted at the preschool level (Meacham, Vukelich, Han, & Buell, 2014; Brenneman, 2009; Conezio, & French, 2002; Leslie, 2013; Maherally, 2014). However many of the researchers have referred to children as natural scientist (Gropik, 2012; Gopnik, Meltzoff, & Bryant, 1997; Graaf, Segers, & Verhaegen, 2015; Worth, 2010). Gropik (2012) explained that "children use data to formulate and test hypotheses and theories in much the same way that scientists do" (p.1625). She noted that when children watch others they can learn about casual relationships and based on the evidence that they received from teachers they can draw different conclusions rather form the evidence that they have gather themselves. In other studies it has shown that young children have often regarded as natural curiosity (Conezio, & French, 2002; Klahr, Zimmerman, & Jirout, (2011; Gropik, 2012; Tillinger, 2013; Worth, 2010). Conezio and French (2002) explained that preschooler's shows curiosity and often wonder about the world. Gropik (2012) noted that the brilliance and natural curiosity that children poses when incorporated with science could be used to help them become better at science teaching and learning. Therefore it is vital to know that activities that encourage play, present anomalies, and ask for explanations can prompt scientific thanking way better that the use of direct instructions (Gropik 2012). Ernst-Slavit and Pratt (2017) noted the importance of asking questions in the science classroom and how the questions that the teachers asked can be used as models for the types of questions that they would like their students to ask. Brown and Minnesota (2017) explained that science is taught at the K-12 level where understanding and explaining the natural world are practices that are accepted and that asking questions about the world are considered universal. Nevertheless, it is important that everyone is aware that even though young children can engage in scientific thinking many of the children have left school and have not learned much about science (Klahr, Zimmerman, & Jirout, 2011).

Peterson and French (2008) investigated the co-construction of explanations throughout classroom discourse with preschools between the ages of three and four as well as their teachers while they worked and learned about color mixing unit as part of the ScienceStart curriculum over a five weeks period (Peterson and French 2008). Based on the approach of Beals (1991, 1993), and Callanan, Shrager and Moore (1995) studies, this work looked at the linguistic perceptive of children's development of explanatory discourse, such as children development and used of causal connectives. Peterson and French (2008) noted that young children generated responses that were more topic-relevant, utilized terms that were more standard color and employed more causal connectives towards the ending of the unit.

The above discussion illustrates that instructional support is useful for students to generate scientific explanations of the highest quality. However the frequency and nature, of how teacher discourse strategies are used during science inquiry learning to influence students generating of explanations remains unknown. In the following section, I will describe details of the study.

Methods

Research Questions

This study addresses two research questions:

1. Do the categories of teacher discourse strategies vary by teacher?
2. What kinds of discourse strategies do teacher employ in classroom discourse during inquiry-based science learning?

Research Design

This study was carried out as part of the Scientific Literacy Project (SLP) (Mantzicopoulos et al., 2005). The purpose of this study was to investigate teacher discourse strategies during classroom science learning. Data were collected from four kindergarten classrooms at a Midwestern elementary school taught by three teachers while they were working on the unit on butterfly and living things. All four classrooms used the 5-week butterfly life cycle unit that was developed by Samarapungavan, Mantzicopoulos, and Patrick (2008).

The unit was made up of inquiry activities which varied in length of approximately 30-40 minutes per session that occurred twice per week. The main data source for this study was derived from videotapes from classroom science lessons. The method of quantitative content analysis was employed to determine the kinds and frequency of teacher discourse strategies produced during classroom science discourse (Samarapungavan, Westby & Bodner, 2006; Samarapungavan & Wiers, 1997; Vosniadou & Brewer, 1992). Quantitative content analysis procedure is used for data analysis of teachers' discourses strategies during science learning (Chi, 1997). Quantitative content analysis maybe defined as a research method that involves the systematic placement of communications content into groups which are based on statistical principles in order to identify the relationship within those groups (Riffe, Lacy & Fico, 2005). A detail description of each of the components is provided below as well as the instructional context.

Instructional Context

Year 1 data from the Scientific Literacy Project (SLP) were used. This research project was a partnership between Purdue University and one Midwestern elementary school in order to teach science using a guided-inquiry approach (Mantzicopoulos et al., 2005). Samarapungavan et al., (2008) provided detailed information of the learning outcomes and implementation of the first year of the SLP. The SLP inquiry curriculum designs and promotes the exploration of science by children in context that are interactive and discourse rich that is centered on reading activities and integrated inquiry.

The curriculum was checked to ensure its consistency with the academic standards of Indiana for kindergarten science classrooms (Indiana Department of Education, 2006). The following are the major concepts that were of interest:

1. Scientific Inquiry Processes: a) Understand that science involve asking questions and make predictions regarding the natural world; b) Understand the empirical foundations of science: scientific information are evaluated based on their consistency with empirical evidence; and c) Understand basic tools that are used to collect, record, analyze and distribute data (Samarapungavan et al., 2008).
2. Life Science: a) Understand living things and their characteristics. For example, living things need air, food and water. They reproduce and they can respond to their environment.; b) Functions and Structure: Understand the structure and characteristics of plants and animals that help them to grow and develop.(e.g., physical and behavioral characteristics) and c) Understand the live cycles of living things: which include birth, growth, reproduction and death (Samarapungavan et al., 2008).

Each unit was made up of three groups of activities. These include Pre-inquiry, inquiry, and post inquiry activities. Pre-inquiry activities are whole class activities used to activate prior knowledge, layout the objectives for the investigation and provide the children with the framework of the task. During this phase teachers introduced important ideas in regards to the nature of science to the children. The Inquiry activities consisted of task which involved children's investigation of the life cycle of the butterfly. While the activity was carried out children asked questions and made predictions about the outcomes. They discussed how the investigation could provide data that are relevant to science learning. In addition, they made notes in their science notebooks, and reached conclusions.

At the beginning of the inquiry phase, there was an introduction about the live monarch larvae that was placed on the plant of the milkweeds. The children were asked to make prediction about the growth of the larvae and its development into adult stage. After observing the larva the children asked and answered questions that were related to what they observed (Samarapungavan et al., 2008). The children wrote, drew, and pasted pictures of the monarch butterfly growth and development into their science notebooks.

The Post inquiry activities consisted of activitieswhere children were allowed to communicate their findings. The children were engaged in a discussion about the results from their investigation. The teacher guided the classroom discourse on science by modeling and scaffolding the dialogue and thinking of the children (Samarapungavan et al., 2008).

Participants

This study consisted of three female teachers that are Caucasians who taught the kindergarten classes in the SLP. There were four classrooms that operated for half day during the implementation of the inquiry unit. Of the three teachers, two were veteran teachers who had more than ten years experience in teaching while the other teacher was a second year teacher. The three teachers taught three of the kindergarten classroom in the morning and one of the teachers also taught an afternoon kindergarten classroom.

Coding and Analysis of Teacher Discourse Strategies

Teacher discourse strategies data were taken from inquiry lessons that were videotaped during the implementation of year1 of the SLP. The data were transcribed based on the techniques that were developed by (Psathas, 1995). “Top down” and “bottom up” quantitative content analysis procedures were used to analyze the data as well as assess and refine the categorization process where necessary (Samarapungavan, Westby & Bodner, 2006; Samarapungavan & Wiers, 1997; Vosniadou & Brewer, 1992).

In order to code the teacher discourse strategies from the transcripts, a name search for each teacher was carried out from the lesson transcript of each class. This was done by identifying Turn Construction Units (TCUs) in the transcripts for each teacher (Sacks et al., 1978). TCU maybe defined as a unit of conversation that is semantically complete which represents a social action that is identifiable (e.g., carrying out an observation) (Sacks et al., 1978).

Each TCU was assigned into the coding categories listed below:

1. Asks explanatory questions: This category represents the teacher discourse strategy where students were asked by the teacher to provide an explanation. (e.g., how do you know that (a tulip bulb) is the skin? Or why do you think it is an onion). The top down coding procedure was used to develop this category. This category was one of those that were identified by (Graesser, Baggett & Williams, 1996) stating that questions which need deep explanation and reasoning are those questions which ask about how, why, as well as what in order to provide logical reasoning and causal chains.
2. Asks for description/ meaning: This category represents the teacher discourse strategy where students were asked by the teacher to describe or give the meaning of concepts (e.g., what does it mean). The top down coding procedure was used to develop this category. This category was one of those that were identified (King, 1994) which suggested that teacher ask questions (e.g., what does it mean? Or give a description of the circulatory system in order to help students generate explanation.
3. Asks for examples of a concept: This category represents the teacher discourse strategy where students were asked by the teacher to provide example of concepts and procedures (e.g., what else do you wonder about things). The top down coding procedure was used to develop this category. This category was one of those that were identified (Tabak & Reiser, 1999) which suggest words that teachers can use to help expound on their statements (e.g., what else and why).
4. Ask student to elaborate or clarify: This category represents the teacher discourse strategy where students were asked questions to obtain more in-depth responses (e.g., tell me more). The top down coding procedure was used to develop this category. This category was one of those that were identified (Tabak & Reiser, 1999) which explains how teacher asked students to expound on their stories with the aid of prompts (e.g., tell me more, why and what else).
5. Sets or explains learning task: This category represents the teacher discourse strategy where the teacher explains learning tasks (e.g., we are going to learn about something called tools). The top down coding procedure was used to develop this category. This category was one of those that were identified (Laurillard, 1979) which states that students must be informed of the learning task that they are going to do.
6. Describes / defines concept / models reasoning process: This category represents the teacher discourse strategy where the teacher gave definitions for

concepts or process (e.g., science is about the world around us). The top down coding procedure was used to develop this category. This category was one of those that were identified (Bielaczyc et al., 1995) which note that learning strategies encompasses the elaboration and identification of relationships among major points when using text, when identifying meaning and form in coding the LISP as well as making connection between concepts by means of examples and text.

7. Scaffolds understanding of concept / process: This category represents the teacher discourse strategy where the teacher gave clues, prompts and hints to assist students in learning task (e.g., could you try to smell it?). The top down coding procedure was used to develop this category. This category was one of those that were identified (McNeill et al., 2006) which explain that students produce more as well as better explanations when continuous written scaffolding as well as instructional modeling is used in classroom. In contrast, students who were placed in faded scaffolding conditions (students that were given similarly instructional support from the beginning of the explanation and learning stage but the instructional support faded gradually) produced less explanation.
8. Clarifies or rephrases student response: This category represents the teacher discourse strategy where the teacher rephrases students' responses in order to add more clarity. The top down coding procedure was used to develop this category. This category was one of those that were identified (O'Connor & Michaels, 1993) which suggest that the teacher rephrase which results in clearer communication.
9. Repeats students' response: This category represents the teacher discourse strategy where students' responses are repeated by the teacher. The top down coding procedure was used to develop this category. This category was one of those that were identified (Tabak & Reiser, 1999) which indicate that students' responses are reiterated by the teacher in order to assist them in understanding what they said.
10. Expresses agreement: This category represents the teacher discourse strategy where students' responses are confirmed by the teacher (e.g., yes, correct). The top down coding procedure was used to develop this category. This category was one of those that were identified (Brophy, 1981) which state that students receive feedback from their teacher (e.g., correct and ok).
11. Teacher praises / affirms student responses: This category represents the teacher discourse strategy where the teacher uses (e.g., that's great or good).

The top down coding procedure was used to develop this category. This category was one of those that were identified (Brophy, 1981) which explain this category can lead to children academic performance.

12. Classroom management response: This category represents the teacher discourse strategy where teachers guide the behavior of students as well as maintain discipline (e.g. you need to stop hitting your head on the wall) (Marzano & Marzano, 2003). The top down coding procedure was used to develop this category.
13. Other: This category consisted of all TCUs that were articulated by the teachers which are indirectly related to science topics (e.g., the teacher talking to herself). The bottom down coding procedure was used to develop this category.

The teacher discourse strategies listed above were placed into second order categories. This includes, Asks explanatory questions, Asks for description / meaning, Asks for examples of a concept, Requests student to elaborate or clarify, were placed in groups to form Teacher Conceptual Questions.

Sets or explains learning task, Describes / defines concept / models reasoning process, Scaffolds understanding of concept / process, Clarifies or rephrases students' response constituted the second order group Teacher Exposition of Concepts.

Repeats students' response, Expresses agreement and Teacher praises / affirms student responses constituted the group Teacher Affirmation Responses.

Classroom management response and other were placed in the same group to form Teacher Non- Conceptual discourse.

Teacher discourse strategies which are higher order categories were placed into two superordinate categories. This include, Total Teacher Conceptual Discourse (sum of basic categories 1 through 8,see Table 3 - Results)and Total Teacher Non-Conceptual Discourse (sum of basic categories 9 through 13, see Table 3- Results).

After coding the teacher discourse strategies an inter-rater reliability was carried out on the data using simple percentage agreement. Two raters were used and all of the data were scored by the researcher while a second rater coded 25% of the lesson. This rater was also a member on the SLP. There was a 95% strategiesinter-rater reliability agreement on the discourse strategies. Discussions were used to resolve the disagreement. In the following sections, results and discussions are provided.

Results

In this section, the results of the study are presented below. This includes the teacher discourse strategies that are used in classroom science discourse (e.g., variation of discourse strategies by teachers). It is also important to examine teacher discourse strategies in order to see how the use of these strategies varies from one teacher to the other.

The 13 distinct types as well as the frequency of teacher discourse strategies are listed in Table 2. The descriptive data provided in Table 2 reveals that teachers produced a significant amount of discourse (1717 TCUs). Related to the first research question the teacher that generated the most discourse was Teacher 3 who taught Classroom 3 (709 TCUs). While Teacher 2 who taught Classroom 2 (245 TCUs) generated the least amount of discourse. The teachers used various discourse strategies during the basic level (see Table 2). In terms of frequency, Category 3 (*Asks for examples of a concept),* was used the most with 675 times (39% of the total discourse) and it was also the most common teacher discourse categories among the four classrooms. This category represents the teacher discourse strategy where students were asked by the teacher to provide example of concepts and procedures (e.g., what else do you wonder about things).

Teacher 3: "What else do you wonder about things?"

Student: "Wonder like something you are like a star how you make are some how you got made".

The second most commonly occurring category used was 5. *Sets or explains learning task* (5) which occurred 197 times (34% of the total discourse). This category represents the teacher discourse strategies where the teacher explains learning tasks (e.g., we are going to learn about something call tools).

Teacher 2: "We are going to look at these things (a capsule sponge) let's make some prediction, lets first think in our head".

Student: "It could turn into an animal sponge".

It is important to note that categories three and five do not call for scaffold explanations from children and were ranked the highest of all the other categories.

The third most frequently occurring category used was 7. *Scaffolds understanding of concept / process* (7) which occurred 147 times (8% of the total discourse). This category represents the teacher discourse strategy where the teacher gave clues, prompts and hints to assist students in the learning task (e.g., could you try to smell it?).

Teacher 1: "It matches and what is that called, blended in?"
Student: "Camouflage".

The fourth most occurring category used was 8. *Clarifies or rephrases student response* (8) which occurred 124 times (7% of the total discourse). This category represents the teacher discourse strategy where the teacher rephrases student's responses in order to add more clarity.

Teacher 3: "Because it looks like it. So you are using your eyes to look at something, alright".
Student: "Ummm because it looks like".

The fifth most commonly occurring category used was 1. *Asks explanatory question* (1) which occurred 119 times (7% of the total discourse). This category represents the teacher discourse strategy where students were asked by the teacher to provide an explanation. (e.g., how do you know that (a tulip bulb) is the skin? Or why do you think it is an onion).

Teacher 2: "How can you we find out of if any of these predictions are right?"
Student: "Drop it".

The sixth most frequently occurring category used was 9. *Repeats students' response* (9) which occurred 114 times (7% of the total discourse). This category represents the teacher discourse strategy where students' responses are repeated by the teacher.

Teacher 1: "Butterflies can go in a cocoon?"
Student: "Butterflies can go in cocoons".

The seventh most frequently occurring category used was 11. *Teacher praises / affirms student responses* (11) which occurred 106 times (6% of the total discourse).

This category represents the teacher discourse strategy where the teacher uses (e.g., that's great or good).

Teacher 3: "Wow. Good job".
Student: "He is making into a cocoon".

The eighth category in order of frequency used was 12. *Classroom management response* (12) which occurred 98 times (6% of the total discourse). This category represents the teacher discourse strategy where teachers guide the behavior of students as well as maintain discipline (e.g. you need to stop hitting your head on the wall)

Teacher 2: "You guys pay attention".

There were similar examples found in teacher 1 and 3 class:

Teacher 1: "Please sit down. Put your science notebook down now. I want you to pay attention".
Teacher 3: "Turn around. Whoop, I need you right there. OK! Whoop, scoot back". "Turn around, so that you are sitting up and looking at me".

The ninth category used was 4. *Ask student to elaborate or clarify* (4) and 6. *Describes / defines concept / models reasoning process* (6) which occurred 46 times (3% of the total discourse). This first category (4) represents the teacher discourse strategy where students were asked questions to obtain more in-depth responses (e.g., tell me more).

Teacher 3: "That what?"
Student: "Science someone"

The other ninth category (6) teacher discourse strategy where the teacher gave definitions for concepts or process (e.g., science is about the world around us).

Teacher 3: "Try to guess. That is called making a pre::::diction. Can you say, 'making a pre:::::diction?"
Student: "You could try to guess".

The eleventh category in order of frequency used was 10. *Expresses agreement* (10) which occurred 35 times (2% of the total discourse). This category represents the teacher discourse strategy where students' responses are confirmed by the teacher (e.g., yes, correct).

Teacher 2: "Exactly, an ant is an insect too".
Student: "Like an ant".

The rarest occurring category used was 2. *Asks for description / meaning* (2) which occurred 9 times (1% of the total discourse). This category represents the teacher discourse strategy where students were asked by the teacher to describe or give the meaning for concepts (e.g., what does it mean).

Teacher 1: "Can you tell me what camouflage means?" "What do you think camouflage means?"
Student: "Keeps things safe".

A number of teacher discourse strategies (see Table1) and conceptual discourse categories were also utilized by teachers (categories 1-4, Table 2), for example asking conceptual questions and explaining concepts and learning tasks (categories 5-8, Table 2). The teachers also involved in student affirmation where they express agreement and praise students for their responses (categories 9-11, Table 2). Teacher discourse strategies were also directed toward classroom management (category 12, Table 2).

Table 1. *Teacher Discourse Strategies*

Teacher Discourse Strategies
1. Asks explanatory questions
2. Asks for description / meaning
3. Asks for examples of a concept
4. Asks student to elaborate, clarify
5. Sets or explains learning task
6. Describes / defines concept
7. Scaffolds understanding of concept/process
8. Clarifies/rephrases students responses
9. Repeats students' response
10. Expresses agreement
11. Praises / affirms child responses
12. Classroom management
13. Other

Table 2. *Frequency of Teacher's Basic Discourse Categories by Class*

Basic Discourse Categories	Teacher 1 Class 1	Teacher 2 Class 2	Teacher 3 Class 3	Teacher 3 Class 4	Total
Teacher Conceptual Questions					
14. Asks explanatory questions	39	19	42	19	119
15. Asks for description / meaning	2	1	6	0	9
16. Asks for examples of a concept	200	130	216	129	675
17. Asks student to elaborate, clarify	8	11	19	8	46
Total Teacher Conceptual Questions	249 (55%)	161 (66%)	283 (40%)	156 (51%)	849
Teacher Exposition of Concepts					
18. Sets or explains learning task	46	15	90	46	197
19. Describes / defines concept	8	10	17	11	46
20. Scaffolds understanding of concept /process	43	12	63	29	147
21. Clarifies / rephrases student response	35	15	60	14	124
Total Teacher Exposition of Concepts	132 (29%)	52 (21%)	230 (32%)	100 (32%)	514
Teacher Affirmation Responses					
9. Repeats students' response	24	11	65	14	114
10. Expresses agreement	10	3	19	3	35
11. Praises / affirms child responses	20	3	66	17	106
Total Teacher Affirmation	54 (11%)	17 (17)	150 (21%)	34 (11%)	255
Teacher Non-Conceptual					
12. Classroom management	19	15	46	18	98
13. Other	1	0	0	0	1
Total Teacher Non-Conceptual	20 (4%)	15 (6%)	46 (6%)	18 (6%)	99
Total Teacher Discourse	455	245	709	308	1717

One of the teacher responses was coded as other; this was in response to an interruption that was not expected by one of the school employee who had a request that was not related to this classroom instruction (category 13, Table 2).

Table 3. *Frequency of Teacher's Superordinate Discourse Categories by Class*

Superordinate Categories	**Teacher 1 Class 1 (*n* = 14)**	**Teacher 2 Class 2 (*n* = 18)**	**Teacher 3 Class 3 (*n* = 20)**	**Teacher 3 Class 4 (*n* = 11)**	**Total (*n* = 63)**
Total Teacher Conceptual Discourse (sum of categories 1-8, Table 2)	381	213	513	256	1363
Total Teacher Non-Conceptual Discourse (sum of categories 9-13, Table 2)	74	32	196	52	354
Total Teacher Discourse	455	245	709	308	1717
% Conceptual Discourse	84%	87%	72%	83%	79%

In or to address research question number 2 the frequencies for superordinate coding are represented in Table 3 above. They were produced from an aggregate of the basic level categories and placed into two other higher level categories. Total Teacher Conceptual Discourse includes (sum of basic categories 1 through 8in Table 3) asks explanatory questions, asks for description / meaning, asks for examples of a concept, asks student to elaborate, clarify, sets or explains learning task, describes / defines concept, scaffolds understanding of concept /process, clarifies / rephrases student response and The Total Teacher Non-Conceptual Discourse includes (sum of basic categories 9 through 13 in Table 3) repeats students' response, expresses agreement, praises / affirms child responses, classroom management, and Other. A chi-square analysis was conducted and the results show 79% and 21% conceptual and non-conceptual teacher discourse respectively. A significant difference was shown in conceptual and non-conceptual discourse distribution by class χ^2 (3, N = 1717) = 37.81, p <.001and by teacher χ^2 (2, N = 1717) = 22.64, p <.001. Teacher 3 of Classroom 3 showed the highest Conceptual Teacher Discourse (513 TCUs). While Teacher 2 of Classroom 2 showed the lowest Conceptual Teacher Discourse (213 TCUs). The results show that the discourse strategies used across Classroom 3 and Classroom 4 taught by teacher 3 varied.

Discussion

Several studies have examined instructional strategies but did not focus on kindergarten students (Gagnon & Bell, 2008; Kazempour & Amirshokoohi, 2013; King, 1994; McNeill, Lizotte, Krajcik & Max, 2006; Tabak & Reiser, 1999). This current study examines several categories of teacher discourse strategies used in inquiry–based science learning that have not been examined thoroughly in a sole educational study.

First, this study showed that students can generate scientific explanations in a novel setting where inquiry-based learning is guided by the teacher as the teacher uses different kinds of discourse strategies. There are numerous studies that have investigated the impact and nature of teacher discourse strategies as it relates to explanations with older children (McNeil et al., 2008; Tabak & Reiser, 1999), while as it relates to kindergarten classrooms only few studies exist. This study shows that during inquiry-based science learning, teachers are capable of using different kinds of discourse strategies. The teachers in this study used 13 distinct types of discourse strategies for example, asks explanatory questions, asks for examples of a concept, sets or explains learning task, asks for description / meaning, repeats students' response (see Table 1 in results). Teachers in this study used discourse strategies for example, asks students for explanations, asks students to classify or elaborated on their responses that has been considered effective with older children to aid in the production of scientific explanation (Tabak & Reiser,1999).

Second, this study showed that students' generation of explanations can be facilitated in an instructional setting by teachers where the teachers provided students with scaffolding (e.g., hints, modeling and prompts) in inquiry –based science learning. Other studies explore children's explanation and focus on share book reading conservation between parent and children (Callanan et al., 1995; Callanan & Oakes, 1992). In theses studies the students instigate the explanatory conversation and ask questions that requires an explanation. However, the explanations given are provided by the children's parents and not the children (Callanan et al., 1995; Callanan & Oakes, 1992).

Numerous studies have shown that the construction of scientific explanations by students is likely when scaffolding is provided by teachers (King, 1994; McNeill, Lizotte, Krajcik & Max, 2006; Tabak & Reiser, 1999). However it is important to note that the instructional context used in the four classrooms studied was inform because all of the teachers in this study was trained to implement science teaching using a guided-inquiry approach that facilities science talk and scientific explanation. During the analysis, the basis level of teacher discourse strategies was grouped into conceptual and non-conceptual categories. The results indicate that twenty-one percentage of the total teacher discourse strategies was non-conceptual where as seventy-nine percentage was conceptual. Also Classroom 3 Teachers 3 used the most conceptual discourse while Classroom 2 Teacher 2 used the least conceptual discourse. It is important to note that a strong causal attribution cannot be made because an investigation on children's explanations during non-inquiry-based science classroom was not conducted, although a significant sum of explanations discourse was generated by the students in the four classrooms studied.

Even though the classrooms investigated for this study received the same instructional dimensions in terms of instruction content, instructional materials and learning task there were different across the four classrooms in terms of teacher discourse that are not apparent. For instance, Classroom 3 Teacher 3 consists of the highest proportion of both teacher conceptual discourse and children's explanatory discourse. In addition, Teacher 3 also taught Classroom 4 which did not show any statistical significant differences in terms of teacher conceptual discourse and children's explanatory discourse among Teacher 1 Classrooms 1 and Teacher 2 Classroom 2.

There are several possible reasons why Classroom 3 Teacher 3 produced the highest proportion of both teacher conceptual discourse and children's explanatory discourse. For example, Classroom 3 Teacher 3 produced the lowest percentage of conceptual questions in terms of proportion of the total teacher discourse. Also she had the highest affirmation of responses in terms of percentage than the other classrooms.

There could be other sources that are influencing our study that we did not examine. For example, peer talk and prior knowledge during inquiry-based science learning that we plan to explore in future study.

Implications

Two implications of this current study are that the sample was limited in number (3 teachers). Hence the results may not be generalized beyond the scope of the study. Further studies using larger sample of inquiry-based kindergarten science teachers are needed to confirm and clarify the patterns of teacher discourse strategies and their relation to children explanations during science learning. Another implication is that this study was conducted in the United States and did not focus specifically on preschooler's inquiry-based science learning. Therefore the results should be interpreted with caution if it will be used by preschool teachers. However data that addressed preschooler's inquiry- based learning would need to be collected. In the same senses it is important that teachers expose and help children understand science leaning early. Tillinger, (2013) highlighted the importance of providing science exploration and instructions in the early years. Amsel and Johnston (in press) noted that early science education is considered to be key competent for young children. According to Conezio and French (2002) "scientific exploration presents authentic opportunities to develop and use both receptive and expressive language skills" (p. 14).

Conclusions and Future Research

The results of this current study indicate that the generation of children's scientific explanations was scaffolded by various discourse strategies (e.g., asks students to elaborate or clarify, and asks students for explanatory questions) used by teachers during inquiry-based science learning. Also that providing instructional opportunities and support to kindergartens is important for the production of explanations during the periods of inquiry-based science learning. The study also shows that the various forms of discourse strategies used in the classroom do vary by teachers. Future research is needed to study a larger number of teachers and include more inquiry-based classrooms. The results of this current study will provide important new information about how to comprehend teacher instructional dialogue with students and influence the development of scientific explanation in early science learning.

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