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Turkish Elementary Students' Classroom Discourse: Effects of Structured and Guided Inquiry Experiences That Stimulate Student Questions and Curiosity

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ABSTRACT

This study focuses on structured and guided inquiry instruction regarding question asking behaviors and curiosity of elementary students in Turkey. 177 sixth graders in 8 science courses were randomly assigned to treatment groups. Analysis of the data revealed that students in the guided inquiry groups asked higher-cognitive level questions and were more encouraged to go beyond retaining a given body of information or simply following instructions compared with others. Students in the guided inquiry groups were found asking questions about electric circuits and providing explanations for their observations and testing hypotheses related to their observations. Through these experiences, students were afforded opportunities to think creatively and cultivate their imaginative spirits. These are seen as initial steps in attracting students to doing real science. Students became more curious about phenomena; conversely their counterparts in the structured inquiry groups asked lower cognitive level questions and exhibited only slight curiosity about phenomena.

KEYWORDS
Discourse, student questions, curiosity, inquiry experiences

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Introduction

Questioning techniques are considered critically important components for students as they engage in experiences ranging from conducting successful experiments to learning more about the society in which they live. Charles (2003) declared that people express their curiosity by asking questions. Others see questions as the starting point for inventiveness, communication, imagination, innovation, intuition and learning (Costa et al. 2000). Asking

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questions is regarded as the spark responsible for triggering critical and creative thinking processes (Dillon, 1988; Olsher, 1999; Cuccio-Schirripa & Steiner, 2000) which actively and purposefully organize our understandings. In addition, many other researchers have emphasized that it is essential in generating new ideas (Aguiar et al, 2010; Krajcik and Sutherland, 2010; John and Mergendoller, 2010; Yang et al., 2005; Williams, 2005), problem solving and for successfully navigating school and daily life (Chaffee, 1988; Otero & Graesser, 2001; Troff & Warburton, 2005; Yeh, 2002). The literature evokes the importance of question-asking behaviour in science education. Science is what a scientist does and science itself can be described as asking questions and engaging in the process of finding plausible explanations to those questions. Scientists raise questions about natural phenomena and, if no explanation exists, they begin researches to find reasonable explanations that improve our understanding of the phenomena. As scientists work, they observe phenomena, formulate hypotheses, and perform experiments in an effort to answer their questions. They use questions leading them to investigations which subsequently generate further questions and ideas. Despite its importance in real science, it is not employed in the way it should be in many current science classes (Kane & Staiger, 2012; Marshall, Smart and Alston, 2017; Weiss et al. 2003). Unfortunately, questions asked in most of current classes are predominantly questions requiring only answers studied before by students. In this context, such questions are less helpful for students in terms of starting science.

Current classrooms

Student views of science and interest in it are strongly influenced by their experiences at school (Aschbacher, Erika, and Ellen, 2010; Christidou, 2011). Therefore, greater emphasis needs to be placed on the development of more effective teaching approaches and cultivating scientific atmospheres where students can direct their learning and follow their intrinsic curiosities. Unfortunately, a significant portion of the current science classrooms are dominated by drills, recitation, cookbook step-by-step laboratory activities, and lower level teacher questions (Gilat & Yarden, 2003; Kathleen et al., 2003) which stifle originality, imagination, instinct desire and curiosity. These experiences in traditional classrooms force students to recite ‘correct’ answers. Answers expected from students are answers that textbooks demand and that teachers already know. Students are not encouraged to ask questions and express their own thinking (Aguiar et al. 2010; Crooks, 1988; Dillon, 1988; Graesser & Person, 1994; Mollborn and Hoekstra, 2010; Otero & Graesser 2001; Van Zee et al. 2001).

In traditional learning environments, flow of the discourse is controlled completely by teachers (Van Zee, 2000**;** Vivienne & Mroz, 2002**)**. Teachers usually ask lower cognitive level questions to solicit predetermined information (Myhill & Dunkin 2005). When that information arises, the teacher often asks another question or ends that communication and proceeds to present more information for the day. However, in this sequence, if the desired answers are not provided by students, the teacher provides them, so that the class session can continue. The discourse can easily turn into traditional I-R-E pattern (Mehan, 1979), teacher solicitation and student response or teacher solicitation, followed by student response, and teacher reaction (Bellack et al, 1967; Cavallo et al. 2003). These sequences of discourse flow do not permit students to express their ideas or freely raise their questions. Dillon (1998) conducted a research in traditional classrooms and found that students ask few questions and those questions are generally factual questions which do not require higher cognitive level thinking. In a similar study Keeling and his friends (2009) observed 38 senior-level undergraduate biology students in eight laboratory sessions. They gave full credit to students to able to encourage them on writing questions. Their goal was; to identify type and quality of questions, changes over time on these aspects and their effects on academic achievements. Analysis of these questions revealed that most of the questions were seeking additional descriptive information about the topic and only few of them challenged their understanding, or required explanation and integration of information. These results show that science classrooms are far from providing expected learning environment where students can experience real science and talk about science. Conversely, science classrooms need to provide a learning environment where students can direct their learning by asking questions, proposing possible explanations, designing experiments, collecting data, and communicating evidence (Ketelhut et al 2010; Osborne, 2010).

Student questions

Research suggests that wonderment declines in students as they go through the education system (Haussler & Hoffmann, 2002; James & Smith,1985). Learning environments need to stimulate intrinsic motivation for learning real science. When students are empowered in classrooms and their questions are used as starting points for discussions; view of the classroom, flow of discourse the and the students' interest in real science and their positive attitudes to it change in a way emphasized by well known science education organizations AAAS, NRC, and NSTA. In a study Rop (2002) observed an American high school chemistry teacher over a year. This study suggests that student questions are indicators of student understanding, interest in the subject matter, desire to learn which of those play important roles on regarding flow of the classroom discourse. Student initiated questions are valued by many researchers *(*Aguiar et al. 2010; Aschbacher et al,2010; Christidou, 2011; Ketelhut et al 2010; Mollborn et al,2010; Osborne, 2010*)*and Windschit (2003) highlighted the importance of student questions:

> *For a science student, developing one's own question and the means to resolve the question suggests an inquiry experience that is profoundly different from the far more common tasks of science schooling which consist of answering questions prescribed in the curriculum using methods also preordained in the curriculum or by the classroom teacher (p. 114).*

To promote question asking behavior among students, teachers need to challenge student thoughts, ideas, and points of view, so that an environment allowing students to pursue their curiosity and to ask questions is cultivated. Edwards and Bowman (1996) found that when appropriate learning environment is created, students ask higher-cognitive level questions. Graesser and Person (1994) in their study worked with college students and 7th graders. College students tutored 7th graders. During tutoring sections 7th graders asked more questions than those in other more normal classroom settings. In a recent study Hofstein et. al. (2005) worked with 12th grade high-school chemistry students. Over a two year period, students were taught with inquiry and traditional instructional formats. Students in inquiry-laboratory group asked better and more meaningful and scientifically sound questions than the ones in traditional laboratory-type group. In another research study Chin et. al. (2002) came up to similar inference that the learning environment and the learning task have great effect on students' questions. For nine weeks, they observed six eight graders during class activities. Throughout problem solving activities, students elicited wonderment questions that required comprehension, prediction, application and planning rather than procedural questions. When the teacher changed the teaching method and provided step-by-step instruction, the students elicited fewer questions and most of them were procedural in nature. In another study Marbach-Ad and Sokolove (2000) used two instructional approaches, active learning and traditional method for students in an undergraduate biology course for two semesters. They found that students experiencing an active learning course pose higher-cognitive level questions "Questions resulting from extended thought and synthesis of prior knowledge and information, often preceded by a summary, a paradox, or something puzzling."(p.858) compared with students in the traditional course.

Taking student initiated questions as starting point of discourse also affects the quantity and quality of student generated questions and the quality of their discourse. To examine the effect of student initiated questions, Chin and Osborne (2010) worked with 129 students at ages 12-14 from two different countries. Students worked in groups and discussed two different temperature graphs given (A-B). They found that students engaged with activities produce more productive discourse; "questions which focused on the key inquiry ideas and a greater variety of salient concepts "(p.896) when their own questions are used. They also found a positive relationship between student questions and quality of arguments.

Teachers can use questions, discussion, debate, field trip, loosely-structured or problem based activities which are conducive to facilitate critical thinking, conceptual conflict and challenging ideas and previous knowledge, instead of using direct instruction and well-structured activities which are less effective in cultivating curiosity, critical thinking and constructing new knowledge (Marbach-Ad & Sokolove, 2000; Troff & Warburton, 2005).

Current reforms in science education also call for shifts towards science instruction which is consistent with the nature of scientific inquiry (AAAS, 1989; No Child Left Behind Act of 2001; NRC, 1996; The National Academy, 2007; Next Generation Science Standards, 2013). In these experiences students engage actively in questions about nature, concentrating on the collection and use of evidence (NRC, 1996). An inquiry as the central instructional strategy in science classrooms allows teachers to create an environment where students can explore real life problems which consequently enhance the quality and quantity of their interaction with peers and teachers. These environments are also considered important in engaging and motivating students to study science and help them to develop more positive attitudes towards science (Bryan et al, 2011; Krajcik and LeeAnn, 2010). However, although most of research has been done on students' question asking behaviours, little has been done on effects of various inquiry approaches on students' question asking behaviours.

Curiosity

According to Scriven & Paul (2005) critical and creative thinking occurs when people engage in, apply, analyze, synthesize, and evaluate cognitive processes. Structurally, curiosity, critical, and creative thinking are correlated with questioning ability (Chin et. al., 2002; Chin & Chia, 2004; Otero & Graesser 2001). Asking questions or being asked questions (Rowell & Ebbers, 2004; Van Zee et al, 2001) enables students (or the population in general) to review their current knowledge, makes them more capable of synthesizing, analyzing, and evaluating data as they criticize ideas and defend positions. It is well documented that higher cognitive level questioning strategies promote critical and creative thinking and challenge ideas concerning current scientific knowledge (Fitzpatrick, 1994; Hand et al., 2002). Conversely, lower cognitive questions hinder thinking and lead to an absence of differing opinions; furthermore, they are often focused on a single correct answer (Charles, 2002; Good & Brophy 1991; Joyce & Harootunian, 1967; Newton, 2002; Pate & Bremer, 1967; Wertsch, 1998).

Human has innate inquisitive abilities to understand phenomena around the world. These challenging phenomena trigger its instinct desire to explore, investigate, solve and understand. It is his nature to try to give a meaning to them. When the new encountered situation is something that does not fit his previous and present knowledge, this creates uncertainity, conceptual conflict which have to be solved or be explained better. People pose questions; respond to discrepancies, pursue answers, persist in challenging, express their understanding or to request further explanations to counter this disequilibrium. For this reason, curiosity questions have been recognized as intrinsically motivating and creating a desire to learn something. Hidi and Renninger (2006, pp 115) defined curiosity as "the type of verbal or nonverbal questioning that a learner generates in the process of organizing and accommodating new information" and Arnone (2003, pp 1) viewed curiosity as a "heightened state of interest resulting in exploration". Furthermore, other literature evokes curiosity questions as one of the most important spurs for educational achievement, maintaining motivation and developing positive attitude towards science, and scientific literacy (NRC, 1996).

There is no common consensus on what curiosity questions are in literature. In a recent research study, Driscoll and Lownds (2007) worked with 455 elementary 2nd and 3rd graders. As a part of their plant science study they visited 4-H Children's Garden for three full days. This field trip spot was a great source for experimental learning and provided hands-on science where students could touch, smell, observe and even taste. After the field trip, the students were encouraged to write down their questions on the Wonder Wall; a large plywood board covered with brown butcher paper. They categorized the written questions on the Wonder Wall as basic information questions or wonderment questions. They identified factual and exploration questions such as; "What is the biggest flower here? Do you pick the food you grow every year? Do you grow apples?" (p. 109) as basic information questions. On the other hand, they distinguished 'clarification of ideas' questions such as; "How do you keep the garden so green?", 'expanding knowledge' questions such as; "Why are the potatoes blue?" and 'conflict between previous and current knowledge' questions such as; "Do smaller seeds grow faster or slower than bigger seeds? and "Why are some flowers scented?" as wonderment questions (p. 109). Questions written on the Wonder Wall constituted 50% basic information and 50% wonderment questions. This result shows that regardless of age level, experimental learning environments and hands-on science activities trigger student thinking and encourage students to wonder. In another study Marbach-Ad and Sokolove (2000) worked with undergraduate biology students. They used two instructional approaches, active learning and traditional method for an undergraduate biology course for two semesters. During the first year, they used active learning. This course was designed based on constructivist theory where interactive instructional approaches were used. Students were encouraged to talk and ask questions about topics covered in lessons, media and problems around the world related to the topic. The following year, they used traditional approaches for the same undergraduate biology course. Teacher's lecturing was dominant in the traditional class and little time was allocated for discussion. Marbach-Ad and Sokolove (2000) developed their own taxonomy to classify the questions in eight categories. However, to be able to compare questions in two classroom settings, they grouped these categories. Questions at categories 0-3 which were looking for simple definitions, basic misunderstanding or required functional responses were grouped together and viewed as lower-level questions. Questions in categories 4-6 which were seeking more information, extended thoughts, required analysis and synthesis, integration of information, summarizing paradoxes, puzzlement and developing hypothesis were grouped together. These questions at categories 4-6 were viewed as curiosity driven questions which required higher level thinking skills. Student question asking behaviors in these two courses were compared. Students in the active learning course posed higher-cognitive level questions than the students in the traditional course did.

Aims and research

Purpose of this research was to investigate varied inquiry experience effects on the quantity and quality of questions formulated by students and its effects on curiosity driven questions. This study is considered helpful in allowing science educators to increase their understanding of inquiry approaches and their potential for generating an environment where student initiated questions are valued and curiosity is increased. The study was guided by the following two specific research questions:

1.How does learning in structured and guided inquiry learning environment affect student question asking behaviors during activities?

2.How does learning in structured and guided inquiry learning environment affect curiosity driven questions formulated by students?

Method and procedure

Participants

Four elementary science teachers and their 177 out of 196 sixth graders (around 12 years old) in eight courses, from 2 different public elementary schools from eastern Turkey, volunteered to participate in the study. Reset of the students (19) did not want to participate in the study. All academic achievements for the students in the classroom were in average range. The participants' socio-economic status and gender were generally typical of Turkish public schools. All groups attended a regular science classroom dealing with basic issues about electricity; serial and parallel circuits, as mandated in the national curriculum. Each teacher randomly assigned one of their courses as the structured inquiry group and the other as the guided inquiry group. The structured and the guided inquiry groups consisted of 61 males and 32 females, 50 males and 34 females, respectively. The structured inquiry groups and the guided inquiry groups were taught with structured and guided inquiry approaches, respectively. Students worked in a physics laboratory in groups of three or four students. When different teachers implement different methods, implementer difference can occur (Ary, Jacobs, & Razavieh, 1996; Merrill, 2001). To diminish the implementation or implementer bias, the structured and the guided inquiry groups were exposed to a single teacher and the same amount of time was provided for both instructional approaches. Teachers were aware of the structured and the guided inquiry groups' differences and were asked to implement both the structured and the guided inquiry approaches faithfully in order to minimize the internal validity threat.

Data collection

Four researchers observed each elementary science course, took field notes and audio recorded conversations of each group. Classroom observations and verbatim transcripts of each group's audio recorded discourse served as the major source of data for this study. To achieve deeper understanding about the function of questions and the discursive practices used in the science classrooms, the two researchers transcribed the verbal discourse of the audio recorded conversations. Two other researchers checked the verbatim transcriptions via listening to the audio recorded conversations. Any mistakes noted were corrected. These double checked verbatim transcripts were analyzed and used to identify question types.

Researchers used a revised version of Graesser and Person's (1994) taxonomy of question types (Table 1) to analyze questions used by students. This taxonomy includes the following three sub-scales: Lower Cognitive Level Questions (LCLQ) (which require simple answers, recall factual information and process of recognition), Higher Cognitive Level Questions (HCLQ) (which require more detailed relational responses, foster creative and critical thinking and retrieve analysis, synthesis and evaluation process) and Task Oriented Questions (TOQ) (which express sentences necessary for maintaining the discipline in the classroom).

The two researchers independently identified and categorized the question types from verbatim transcriptions. Then they came together and compared their classifications. Any differences in classification were reviewed and discussed until the classification differences were resolved. Any uncompromised questions were taken out of the data pool. To answer the first research question: the quantity and quality of questions formulated by students during the courses facilitated differently were compared.

Table 1. Grasser and Person's (1994) taxonomy of question types revised by Erdogan & Campell 2008)

Question Type	Description	Example
Lower Cognitive Level Questions		
1. Verification	For yes/no response to factual questions	Is it possible to transform electrical energy into other forms of energy?
2. Disjunctive	Questions that require a simple decision between two alternatives	Is this a series circuit? Or a parallel circuit?
3. Concept Completion	Filling in the blank or the details of the definition	In a parallel circuit the components are all ……….connected.
4. Feature Specification	Determines qualitative attributes of an object or situation	What is the importance of electricity in our life?
5. Quantification	Determines quantitative attributes of object or situation	How many different ways did she connected wires?
Higher Cognitive Level Questions		
6. Definition	Determining meaning of a concept	What do you guys know about series circuits?
7. Example	Request for instance of a particular concept or event type	Where can we see series circuit connection in the classroom?
8. Comparison	Identify similarities and differences between two or more objects	What are the similarities and differences between series ad parallel circuits?
9. Interpretation	A description of what can be inferred from a pattern of data	What kind of circuit that flash light has?
10. Causal Antecedent	Asks for an explanation of what state or event causally led to the current state and why	What do you guys know about electrical circuit of flash light? How that happens?
11. Causal Consequence	Asks for an explanation of the consequences for an event of state	What will happen when we attach another bulb to the buttery?

12. Enablement	Asks for an explanation of the object, agent, or processes allow some action to be performed	How do you know which materials are conductor of electricity.
13. Expectational	Asks about expectations or predictions (including violation of expectation)	How many light bulbs can we attached to the battery without dimming the lights?
14. Judgmental	Asks about value placed on an idea, advice, or plan	Should we let Student A touch that wire, on the basis of what your thinking is? If we add 20 batteries in a series circuit, what would happen, what do you think?
Task Oriented Questions		
15. Group dynamics	Leads to discussions of consensus or negotiation of how group should proceed	So, Student C, do you know what your group members are talking about? Can you tell what your group members have been doing?
16. Monitoring	Help check on progress, request for planning	Um, so what did you want to do next?
17. Self –directed learning	Relate to defining learning issues, who found what information;	So might there be learning issues we can, we can take a look at?
18. Need clarification	The speaker does not understand something and needs further explanation or confirmation of previous statement	Are you, are you, Student F are you talking parallel circuit connection?
19. Request/Directive	Request for action related to PBL process	Why don't you give, why don't you give Student S a chance to get the board up?

Description of Instruction

The structured inquiry groups

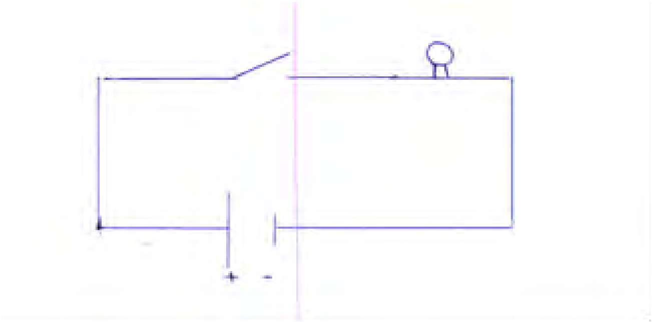
Students in the structured inquiry groups were exposed to structured inquiry approaches. In this type of classroom, the teacher provides research questions to explore, as well as the procedure to be followed and all required materials. However, students do not know the answer in advance and have to determine the outcomes regarding the relationship among variables or making generalizations from the collected data. These kinds of investigations are introduced before the target concept is taught and not used as confirmation lab activities as used in the traditional ones. During the structured inquiry activities, teachers became facilitators and guides of the students in the learning process.

In this group, students were assigned to groups of three or four. In order to complete the hand-on investigations, teachers presented student activity sheets which provided step-by-step instructions for students to follow. However, students had to determine the outcomes of the investigation. All the required materials; sockets, bulbs, batteries, battery holders, wires, wire strippers and etc. were provided for the students. Below is a sample from that activity sheet.

Parallel and series circuit worksheet

1) Follow the instructions below and design an electric circuit as shown in Diagram 1. Make careful observations, record the condition of electric circuits, and answer the research questions below before carrying out the following steps.

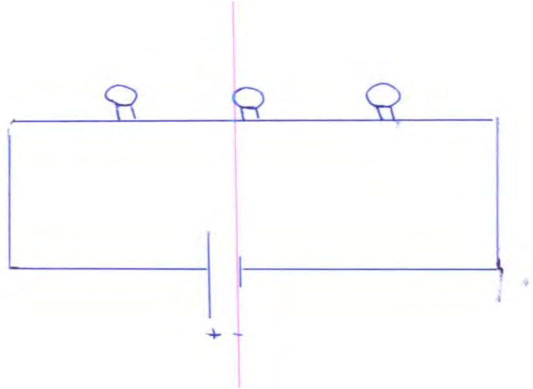
Diagram 1



1. Insert the battery into the battery holder.
2. Insert the light bulb into the socket.
3. Connect one end of the wire to the light sockets.
4. Attach the other ends to the battery holder.
5. Wire the switch as shown in Diagram 1 so that it has one wire to the battery holder and one wire to the light bulb.
6. What do you predict is going to happen?
7. What will happen when the bulb is unscrewed?
8. What will happen when the switch is on and off?

1. Follow the instructions below and design an electric circuit as shown in Diagram 2.

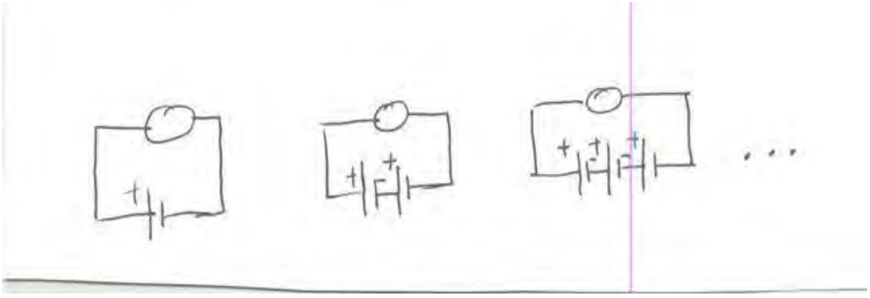
Diagram 2



   1. Unconnected one of the wires that connect to the light bulb and battery.
   2. Add another bulb as shown in Diagram 2.
   3. Wire the bulb in such a way that it has one wire to the battery holder and one wire to the light bulb.
   4. Each time, after adding a new bulb to the circuit, try to answer the research questions below.
   5. What happens to the brightness when you add a new bulb?
   6. Which bulbs are brighter?
   7. Why are there lightening differences among bulbs?

2. Follow the instructions below and design an electric circuit as shown in Diagram 3.

Diagram 3



   1. Insert the battery into the battery holder.
   2. Insert the light bulb into the socket.
   3. Connect one end of the wire to the light sockets.
   4. Attach the other ends to the battery holder.
   5. Each time, after adding a new battery to the circuits, try to answer research questions below. Observe the appearance of the circuits and record what you see.
   6. What happens to the brightness when you add new batteries?
   7. In which condition is the bulb brighter?
   8. Why are there lightening differences among three conditions?

2) Did you discover anything about the relationship between brightness of the bulb and the battery combination through this activity? If so, what did you discover?

The teacher did not give direct information about electricity to the students before the activity. However, the teacher introduced the question of the day ‘Describe as many ways as you can to make a bulb glow brighter.’ and generated an environment where students could discuss the question further. After completing the small discussions, the teachers introduced all the materials in the experiments and instructed students to follow the steps indicated on the worksheet. Each group worked through this as the teacher walked around the room. Below is a transcribed conversation sample that took place between the teacher and a group of students in a study group.

[In general, this group was talkative. Students seemed very comfortable with each other. They did the activity looking at the worksheet more often than other groups.]

S [A]: Design an electric circuit as shown in Diagram 1. [One student read the directions on the activity sheet.]
S [A]: Insert the battery into the battery holder. [Student A gave directions to the others.]
S [B]: Does it matter how we placed the battery?
S [C]: Just insert it.
S [D]: Okay boss, what then? [Another student interrupted.]
S [A]: Insert the light bulb into the socket. [The student read the directions on the activity sheet.]
S [B]: Okay.
S [C]: Connect one end of the wire to the light sockets. [Student C interrupted the conversation and gave directions to the students.]
S [C]: The wires are in two colors; red and black. Does it matter? Do wires also have positive and negative ends? [The student tried to draw the attention of the teacher, raised his hand and called the teacher.] Teacher, teacher!
S [B]: I don't think it matters. [Talking about wires]
T: [The teacher approached the group.] Does yours have exposed ends?
S [C]: No, it doesn't.
T: How's your investigation going?
S [B]: Not well. There is no light.
S [C]: …got a new wire. [Replacing new wires]
T: Are the batteries in the right position? [In response to the light not working]
S[C]: I don't know.
S [A]: [Another student interrupted the conversation.] Insert it as positive to positive and negative to negative.
T: Is student C the only one whose mind works?
S [A]: No.
T: Why is he the only one responding to my questions?
T: [To the whole class] Make sure you inserted the battery in the right position. Just make sure you're following the directions… Which step of the procedure are you on?

The guided inquiry groups

Students in the guided inquiry group were exposed to the guided inquiry approach which is one step ahead of the structured inquiry in the inquiry spectrum. The guided inquiry approach encouraged active student participation and knowledge construction more than it did in the structured inquiry process. The teacher provided only the research question concerning the hands-on investigation. The students had to formulate their own methods, get appropriate materials, and determine the outcomes. In this way, they directed their own learning; asked questions, made predictions, designed experiments, collected and analyzed their data. In this learning environment, the students were encouraged to search, use resources, and go beyond the activity sheets. The students genuinely engaged in the business of "doing science". The student empowerment in the classroom resulted in improved student learning in following ways:

- Mastery of science concepts
- Use of science process skills
- Development of more positive attitudes towards science
- Ability to apply concepts and processes in new contexts
- Creativity

- Understanding of the nature and history of science (Campbell, 2003; Lee, 2001; Myers 1988; Iskandar, 1991; Mackinnu, 1991, Liu, 1992; Blunck and Yager, 1996; Kimble, 1999, Shin, 2000).

In the guided inquiry groups, students worked in groups of three or four. After groups were formed, the students were asked to work in their groups to brainstorm ideas about electricity and where it might be used. Upon completion of these small brainstorms, the teachers allowed the students to share their ideas with the whole class. Meanwhile, the teacher asked questions to bring the students to the starting point of the investigation. Below is a sample of the discourse that took place between the teacher and the students.

T: Okay everybody, I want you to think about electricity. Where can you use electricity? Think about it for a couple of minutes and give some examples. [Students started to think about it.]

T: Okay, what do you know about electricity? Can you give some examples?
S [A]: Lights in classrooms.
T: They work with electricity. What else?
S [B]: A television, a computer.. They work with electricity.
S [C]: A refrigerator also works with electricity.
S [D]: Traffic lights.
S [E]: Flash light.
T: What source of energy does that flash light have?
S [F]: A battery.
S [G]: Some toys, they also have batteries.
T: How does the flashlight work? Do you know?
S [F]: It has a battery and a bulb.
T: What are they for?
S [F]: To give energy [electricity] so that we can have light.
T: If you want to make the bulb glow brighter, what do you have to do?
S [G]: Hımm [silence for a couple of seconds, no answer from the students]
S [F]: We need more batteries.
S [C]: Use a bigger bulb.
T: Okay class, I want you to work in groups. We are going to make a simple flashlight. There are some materials here and if you need any other materials, you are free to take them from the equipment shelves. I want you to describe as many ways as you can to make a bulb glow brighter before you begin to test your ideas, see if your ideas work or not.

The students in the guided inquiry groups were encountered with a research question, ‘Describe as many ways as you can to make a bulb glow brighter and test whether it works or not.’ which has to be answered. The teacher did not provide any specific instructions or materials to follow. The students had to devise their own processes to overcome the problem. However, the teachers encouraged them to use any of the materials or equipment from the equipment shelves that they thought might be helpful. Below is a sample of the discourse which took place in a guided inquiry student group.

[Students formed groups and started to work on the project, the following is a sample from their conversations.]
S: [Students brought some materials from the equipment shelves.]
S [A]: What is this?
S [B]: It is a switch.
S [A]: Do we need it?
S [C]: [Another student responded to this question.] I don’t know.

S [D]: [Another student interrupted the conversation.] Hey, we have to make a plan first. What is our goal?
S [B]: To get light.
S [D]: Okay, what do we need for it?
S [B]: A battery, a light bulb…
S [C]: Wires. [A student interrupted the conversation.]
S [D]: Okay.
S [B]: What else do we need?
S [C]: We need wires to connect them. While I was trying to repair my toys, I saw how they were connected. [The student tried to assemble them.]
S [D]: Let's start! [The student started to make the assembly of the electric circuit.]
S [A]: Let's use these batteries. [The student showed a battery and a bulb holder.]
S [D]: Do they touch? [The student let one side of the wire touch the battery.]
S [B]: Does it go like this? [The students tried to make a circuit.]
S [C]: It doesn't matter.
S [A]: What are you doing?
S [D]: Maybe these two go here? [The students did not use the bulb holder. Instead they connected the end of the wires to the same place of the bulb.]
S [A]: Why isn't it working? [There is no light.]
S [C]: Oh yeah. Have you checked this? [The student attached the wires to the positive and negative ends.]
S [B]: This battery seems very old. Does it work?
S [C]: Are all these connected? [Showing the wire connection on battery holder]
S [D]: Is this supposed to work this way? [The teacher approached the group and the student asked a question to the teacher.]
T: Did you have light?
S [D]: No.
T: Why isn't it working?
S [D]: I don't understand why it isn't working!
S [C]: What is wrong? Why isn't it working?
T: It is OK if you write 'It is not working.' too. ? Just write down how you connected it.
S [D]: No, it's frustrating.
T: Check your assembly again. Try something else… Think about it.

Results

Table 2 indicates the total number of the student questions collected from the structured and the guided inquiry groups.

Table 2. Number of questions asked during activity by students in structured and guided inquiry groups

Group	N		Lower Cognitive Level Questions	Higher Cognitive Level Questions	Task Oriented Questions	Total
Structured Inquiry	93	Number of Question	89	112	39	240

Group		%	%37	%46.7	%16.3	%100
		Ratio per Student	0.95	1.2	0.41	2.58
Guided Inquiry Group	84	Number of Question	133	197	26	356
		%	%37.4	%55.3	%7.3	%100
		Ratio per Student	1.58	2.35	0.3	4.24

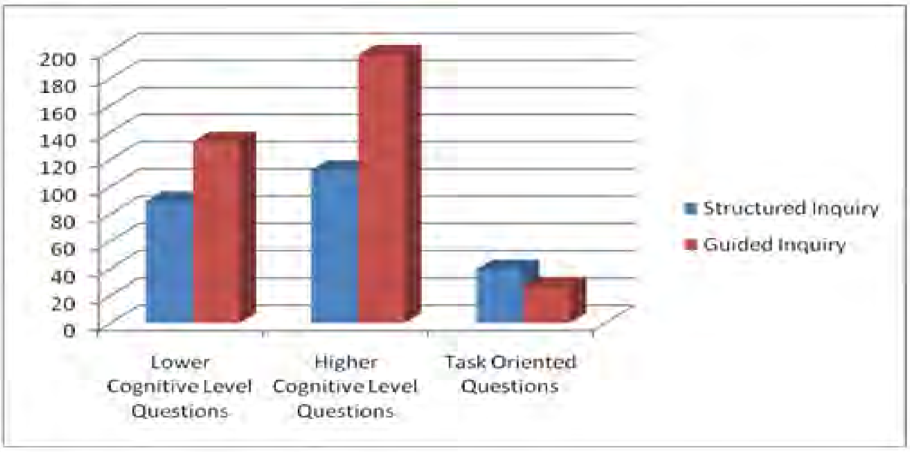


Figure 1. Frequency of Question Types Asked by Structured and Guided Inquiry Groups

Comparison of student formulated questions in the structured inquiry and the guided inquiry groups

The number of the questions asked during the activity done by students as seen in Table 2 indicates observable differences among student questions captured while comparing the structured and the guided inquiry groups. The high ratio of Low Cognitive Level of Questions at the structured inquiry groups and High Cognitive Level Questions at the guided inquiry groups are the major contributors for the differences found. These results show that there is a strong relationship between the type of the learning environment and the quality and quantity of the students' questions.

Curiosity question comparison:

The researchers and the teachers agreed to provide 5 minute free time to the students after completing the activity. The teachers did not say anything to the students and left them alone. During this time, researchers continued to observe the groups, take notes and audio record the conversations. The goal was to measure effects of varied inquiry instructions on students' curiosity. It was a way of considering movements towards open inquiry time.

Student discourse related to electricity content in these five minute free time was analyzed to identify curiosity questions. During the student discourse, not only a particular model of expression such as" I wonder", " How did that happen?", considered as curiosity questions were noted, but also "the type of verbal or nonverbal questioning that a learner generates in the process of organizing and accommodating new information" (Hidi and Renninger, 2006 p.115) was also considered as curiosity questions. This effort was an attempt to value expressions of curiosity.

When the activity was completed, most of the students involved with structured inquiry groups chatted with each other about different topics; grades, other courses, football, friends, TV shows, actors and actresses etc. . However, most in the guided inquiry student groups continued to ask curiosity questions and talk about topics related to their inquiries. Dialogues below represent samples of discourses which occurred in these 5 minute free time in the structured and guided inquiry groups.

Dialogue 1. Examples of student discourse which occurred in the structured inquiry groups

S [A]: Electricity is everywhere and in our whole life. We greatly depend on it. Let's think about what would happen if we didn't have electricity.
S [B]: I think about stuff ...... Every day we use stuff which use electricity. Lights in your house use electricity. The TV and computer use electricity. The washing machine, dishwasher and dryer all use electricity.
S [A]: What would happen if we didn't have electricity?
S [C]: We would have to use other sources of energy or manpower to operate machines. We have man powered grind at our home and I tried it. It is really hard to wheel. Thank God we have electricity.
S [B]: How do we produce electricity?
S [A]: Out of dams, nuclear power, solar power and batteries.
S [D]: In a western movie, I saw that people produced electricity by wind turbines.
S [B]: How does a wind turbine work?
S [D]: I think it has a system similar to that of a bicycle dynamo that my father has. When the wheel turns the rubber stuff outside, the dynamo also starts turning and then … the cables go to the bulb and it gives light .
S [B]: How is the brightness?
S [D]: The faster you ride, the better brightness you get.
S [A]: I will get a .... [brand of a motorcycle] motorcycle when I grow up. I will give you ride guys.
S [C]: I saw a great one last night on TV.
S [D]: Did you watch the film on...... TV.?
S [A]: Our house was crowded yesterday. My father's friends came to our house and I couldn't..... How was that episode?
S [D]: It was great. A ....[name of a character in the film] rescued the girl and the kid from........ B...[name of another character in the film] however, B ....[name of a character in the film] was able to escape. There was great action!
S [A]: I should watch it.
S [B]: You can watch it on the internet.
S [A]: Which web site should I log in....?
S [B]: If you surf G........ [name of a search engine on the internet] for film names, you will find some web sites where you can watch the film.

S [A]: Can you help me, because many web sites just have a fragment of a film and nothing else.
S [B]: Just surf the net, you will get something!

Dialogue 2. Examples of student discourse which occurred in the structured inquiry groups

S [A]: We have approximately batteries of the same size and they produce different levels of electricity. Does it depend on their size? Or do they last more when they are bigger?
S [B]: It depends on the material inside the battery.
S [C]: What are you doing? Look at the label, what it is made of?
S [A]: It doesn't say anything about it. Just AAA 1.5V made in ....and doesn't charge [The student read the label on the battery.]
[There was a silence in the group and two students started organizing an afternoon out.]
S [B]: Do you have a plan for this evening?
S [C]: No, how about you?
S [A]: I don't have, either. How about eating a hamburger out ?
S [C]: Or maybe seeing a film?
S [A]: Hmm.. [The student thought silently for a couple of seconds.] That is OK with me.
S [B]: Do you know what is on?
S [C]:......... [name of the movie] A science fiction movie.
S [B]: Mmm. I know. It is great but I have already seen it.
S [A]: Well then go and see ....[name of another movie], then.
S [B]: I haven't seen it yet.
S [A]: It will be a great day.

Dialogue 3. Examples of students' discourse which occurred in the guided inquiry groups

S [A]: When there is a lightning, they say it provides electricity, is it true?
S [B]: Yes, it provides electricity I guess.
S [A]: So if it provides electricity, how does it lighten? How is that light produced?
S [C]: Hey, be clever! Look at the bulb; we attached it to the wire and the electricity from the battery illuminated it.
S [A]: So the electricity illuminated it.
S [C]: Yes, electricity provides light.
S [A]: So if we attached one end of the wire to the battery and left the other end open, it wouldn't provide light.
S [C]: It has to. [The student attached one end of the wire to the battery and left the other end open to see light.]
S [D]: It doesn't provide any light [Another student interrupted.]
S [B]: Or we can't see it because of the sunlight!
S [A]: Let's try it in a dark place.
S [D]: Are we going to wait till night?
S [A]: No, let's just compose a dark room [The students covered the area with their books to compose a dark room.]
S: [While the student was doing the experiment, others were jumping to each other's head to see it.]
S [B]: [The screams bothered the student doing the experiment.] Hey, be careful! Just make it dark!
S [B]: Nope, it doesn't give light!
S [A]: It will not provide light!
S [B]: Why not?

S [A]: Because lightning provides such a great amount of electricity that it harms or even kills people! The battery here can provide just a small amount of electricity.
S [A]: Look! We can touch the battery, it doesn't shock me ...
S [C]: Hey if that is the reason, electricity power lines go over poles. They have danger and high voltage sign and they are also dangerous to people. However they don't provide any light in the dark. I haven't seen any light yet, have you?
S [All together]: No...
S [D]: Why not?
S [B]: What causes a light bulb to glow?
S [C]: So.... [The student thought silently for a second.] The lightning provides much more electricity than the one going on power lines. That's why power lines don't provide light.
S [D]: [Another student jumped into the conversation.] How do utility workers repair power lines without getting hurt?
S [A]: Before they start working, they cut the power line and then they start to work. I saw them while working after heavy rain in our street. Our street power line was damaged by lightning and they cut all the power in the street. Also utility workers wear special gears and use special equipment to be safe around energized power lines.
S [B]: Why don't birds get shocked when they sit on the wires? And why do people get shocked?
S: .... [Students got silent for a couple of seconds.]
S [C]: I guess if they just stay on their one foot, then the circuit isn't completed and they won't get shocked but if they touch the power lines with their two feet, then the circuit is completed and Olaaa.... they get shocked and light occurs.
S: [Students laughed at this joke.]

Dialogue 4. Examples of students' discourse which occurred in the guided inquiry groups

S [A]: If the wire is nearly a couple of meter long, will the battery's energy be enough to lighten the bulb?
S [B]: [Another student expressed the student's inquiry in a different question form.] Does the length of the wire have an effect on the brightness of the bulbs?
S [C]: I don't know but let's try.
S [A]: Do we have a few meter long cables?
S [D]: [A student looked into the equipment box.] No, I can't find but we have wires with alligator clips at each end. What we need is to attach them to each other and get what we need, OK?
S [A]: Great!
S [D]: Let's try it! [Some students already started to attach the wires to each other.]
S [C]: Now it is time to make a simple circuit! [They assembled a simple series circuit.]
S [D]: It is show time! [The student attached one end of a 1 meter long wire to the battery holder and tried to enthuse the others.]
S [A]: [The students were disappointed with the result.] Nothing has changed; it has the same brightness.
S [B]: Is it a little bit duller than the small one?
S [A]: No it is the same.
S [B]: I have another question. Does the width of the wire affect the brightness?
S [C]: Can... try wires that are made of different metals and see if metal variety has an effect on the flow of electricity.
S [A]: Do we have time? It is almost break time!
S [D]: We have to get the required materials.
[The student moved towards the equipment shelf to find the materials required for the activity. Meanwhile, other students started to chat with each other.]

S [A]: [Two girls were talking about a diet.] Have you seen C.... ? [Name of an actress in a film] She was wearing a really nice dress. I wish I could buy such a dress!
S [B]: Hey, I read about her diet on a fashion magazine. She lost 10 kilos in 3 months.
S [A]: How did she lose that much weight? Do you know that diet?
S [B]: You should eat lots of salad and fruit.
S [A]: God damn. My mother doesn't like salad!
S [B]: What does she like?
S [A]: She prefers meat.
S [B]: Well, then she can eat meat but not too much. She shouldn't eat bread and potatoes, either.
S [A]: How about drinks? Can she drink coke?
S [B]: Oh no, she should never drink coke. It contains a lot of sugar. She should drink just water.

Table 3 shows the relationship between the structured and the guided inquiry groups with respect to the number of curiosity questions asked. The structured inquiry groups asked 41 curiosity questions whereas the guided inquiry groups asked 95 curiosity questions. Table 4 represents some samples of curiosity questions that were asked.

Table 3. Number of curiosity questions asked during five minute free time by students in structured and guided inquiry groups

Group	N		Curiosity Questions	Total
Structured Inquiry Group	93		41	41
		Ratio per Student	0.44	
Guided Inquiry Group	84		95	95
		Ratio per Student	1.13	

Table 4. Sample of curiosity questions occurred in four dialogues

	Sample of Curiosity Questions
Dialogue 1	What would happen when we do not have electricity? How we produce electricity? How do wind turbines work? How is the brightness?
Dialogue 2	Does it depend on their size? Or the bigger they are the longer they are lasting.
	When there is a lightening they say that it provides electricity, is it

Dialogue 3	true, So if it provide electricity how it lighten, How that light produced So if we attached one end of wire to battery and leave the other end open should that provide light Why not What causes a light bulb to illumine? How do utility workers repair power lines without getting hurt? Why don't birds get shocked when they sit on the wires? And why do people get shocked?
Dialogue 4	If the wire is like couple of meter long will the battery's energy be enough to glove the bulb Does the length of wire have any effect on the brightness of bulbs? I have another question does the width of the wire effect the brightness Can I try wires that are made of from different metals and..... see if metals variation had any effect on the flow of electricity?

Discussion

Results of the study show that various inquiry learning environments have different effects on students' question-asking behaviors. The outcome of the study indicates that observable differences were found while comparing the structured and the guided inquiry student groups concerning types of questions asked during classroom activities and curiosity questions asked during five minute free time. In the forms of the inquiry spectrum (structured, guided and open inquiry) the open inquiry is the most valued one and considered as really looking like doing science. When teachers skipped to open inquiry, they cultivated an environment whereby students could ask questions, generate alternative hypotheses, design and conduct experiments to find solutions to the problem they identified. These kinds of actions have been seen more in the guided inquiry group compared to those in the structured inquiry groups. Students in the guided inquiry groups asked questions about electric circuits, provided explanations, designed experiments, and tested their hypotheses to get brighter lights. This learning environment cultivated a scientific atmosphere and encouraged students to examine, assess, produce and apply their knowledge which consequently enhanced scientific understanding and scientific "talk". During this process students critically thought about the problems and used their creativity. In the guided inquiry learning environment, not to know how to solve the problem gave the students the opportunities to expand their creative thinking, develop their imaginative abilities, challenge their ideas and previous knowledge, and evoke a real desire to resolve the dilemma. In this process, questions played an important role as seen in dialogues [See Dialogue 1, 2, 3, 4]. All these kinds of acts started with questions. Below is a sample of discourse which occurred in the guided inquiry groups during designing a circuit.

S [D]: [Another student interrupted the conversation.] Hey, we have to make a plan first. What is our goal?
S [B]: To get light.
S [D]: Okay, what do we need for it?
S [B]: A battery, a light bulb…

S [C]: Wires. [A student interrupted the conversation.]
S [D]: Okay.
S [B]: What else do we need?
S [C]: We need wires to connect them. While I was trying to repair my toys, I saw how they were connected. [The student tried to assemble them.]
S [D]: Let's start! [The student started to make the assembly of the electric circuit.]
S [A]: Let's use these batteries. [The student showed a battery and a bulb holder.]
S [D]: Do they touch? [The student let one side of the wire touch the battery.]

As it can be seen in the dialogue, to solve the problem or conduct an experiment, the students posted more questions which opened the door to this valuable path of doing science and talking about science.

In Dialogue 4, the students wondered about the effect of the wire's length on the brightness of the bulb. They looked into the equipment shelf; however, they could not find long cables to test their ideas. One of the students in the group recommended attaching each cable to each other. With this creative idea, they solved the problem and got a cable which was long enough to test their hypothesis. Similar to the case in Dialogue 4, in Dialogue 3, the students wondered how lightning produced light. They had previous knowledge that lightning produced electricity. However, they did not know how that light was produced. They challenged each other's ideas and these challenges revealed that electricity caused the light.

S [C]: Hey, be clever! Look at the bulb; we attached it to the wire and the electricity from the battery illuminated it.
S [A]: So the electricity illuminated it.
S [C]: Yes, electricity provides light.

This critical and creative thinking process led the students to set up a simple experiment to test their hypothesis. In all these situations, questions were the starting point of all the valued actions in doing and talking about science.

S [A]: So if we attached one end of the wire to the battery and left the other end open, it wouldn't provide light.
S [C]: It has to. [The student attached one end of the wire to the battery and left the other end open to see light.]

In contrast to this, in the structured inquiry groups, the teachers created an environment whereby students could follow the instruction of the teacher and activity sheet.

S [A]: Insert the battery into the battery holder. [Student A gave directions to the others.]
S [B]: Does it matter how we placed the battery?
S [A]: Just insert it.
S [B]: Okay boss, then what? [Another student interrupted.]
S [A]: Insert the light bulb into the socket. [The student read the directions on the activity sheet.]
S [B]: Okay.
S [A]: Connect one end of the wire to the light sockets. [Student B interrupted the conversation and gave directions to students.]

The students in the structured inquiry classroom had less need to engage in asking questions to solve problems. They simply followed directions on the worksheets which were provided for them to find the expected outcomes. The degree of the unknown was very low. To be able to solve the problem, they had to determine the relationship among variables. They were less involved with taking ownership in the process; as a result, the structured inquiry learning environments were less effective in cultivating an interest or curiosity and facilitating critical and creative thinking processes among students. Due to the structured inquiry learning environment atmosphere, the students asked fewer higher cognitive level questions and depended more on lower cognitive level questions. The structured inquiry situation was also effective as students stimulated various questions (see Table 2). However, as in its nature, the structured inquiry can be used as a starting point to reach the big goal of open inquiry. Stimulating students to raise and answer their own scientific questions can conceivably be a first step in their becoming genuinely motivated to do, learn, and talk about science. This can be done in insisting on mowing towards a more open inquiry spectrum where doing inquiry genuinely engages students in the business of science and hence gaining a propensity to raise scientific questions.

Another observable difference between the structured and the guided inquiry groups occurred while curiosity questions were being compared (See Tables 3 and 4). Even after completing the activities, most of the students the in guided inquiry groups continued asking questions originating from their curiosity about the topic studied. These differences were found to be statistically significant compared with the structured inquiry groups. It is obvious that the guided inquiry student groups were more engaged and motivated than the structured inquiry groups. They analyzed, synthesized, and evaluated their understandings in ways that were found less in the structured inquiry student groups. Analyses of dialogues also show that the guided inquiry student groups took autonomy in the process to such a degree that they continued to talk about electricity even after completing the experiment. To be able to decide how to solve the problem, designing their own methods, and doing the experiment alone increased students' motivation and interest and enabled them to talk about science.

As seen in Dialogue 4, a student's evocations of break time neither bothered nor prevented the other students from continuing to work. They were so concentrated and motivated that, they even did not hear other student's reminders.

S [A]: Do we have time? It is almost break time!
S [D]: We have to get the required materials.
[A student moved towards the equipment shelf to find the materials required for the activity. Meanwhile, other students started to chat with each other.]

The students in the structured inquiry groups also asked curiosity questions; however, due to the less need for inventiveness, intuition, engagement and instinct desire, they stimulated less high cognitive level questions. These results are also congruent with the previous research (Chin et. al., 2002; Chin & Chia, 2004; Otero & Graesser 2001) indicating that curiosity is correlated with questioning ability. Similar to previous studies, in this study when students stimulated higher cognitive level questions, they also demonstrated high curiosity or vice versa. The reason for this might be that when students ask higher cognitive level questions, they review their previous knowledge, try to give a meaning to newly encountered situations. For this purpose, they joined in critical and creative thinking processes. This progression generates instinct desire to the unknown. In the sample from Dialogue 3, one student expressed his wonderment by asking questions. In these wonderment questions the student evaluated his previous understanding about electricity and the desire to make meaning of it revealed innovative thinking.

S [B]: Why don't birds get shocked when they sit on the wires? And why do people get shocked?
S: .... [Students got silent for a couple of seconds.]
S [C]: I guess if they just stay on their one foot, then the circuit isn't completed and they won't get shocked but if they touch the power lines with their two feet, then the circuit is completed and Olaaa.... they get shocked and light occurs.

This level of intrigue of thinking processes and instinct desire to make sense of the new situation induce curiosity among students. In these conditions students usually indicate their curiosity by asking questions as observed in the result of this study.

An additional reason for the difference between the guided and the structured inquiry groups was that the curiosity questions could indicate the amount of challenges they faced. When the challenging phenomenon is something that they can overcome, however unknown, it triggers student instinct desire to explore, investigate, solve, and understand. These behaviors turn into curiosity. Students were more often found to be challenging their own and their friends' ideas about scientific knowledge and to be able to require explanations and integration of information, they postulated questions which were mostly driven by their own curiosities. This is the process where decisive and inventive thinking happens. Below is a sample of discourse from Dialogue 3.

S [A]: When there is a lightning, they say it provides electricity, is it true?
S [B]: Yes, it provides electricity I guess.
S [A]: So if it provides electricity, how does it lighten? How is that light produced?
S [C]: Hey, be clever! Look at the bulb; we attached it to the wire and the electricity from the battery illuminated it.
S [A]: So the electricity illuminated it.
S [C]: Yes, electricity provides light.
S [A]: So if we attached one end of the wire to the battery and left the other end open, it wouldn't provide light.
S [C]: It has to. [The student attached one end of the wire to the battery and left the other end open to see light.]

Asking questions (Rowell & Ebbers, 2004; Van Zee et al, 2001) enables students to review and reflect their current understanding, analyze, synthesize, evaluate data, criticize ideas and defend positions which last with knowledge construction. It has been well documented that higher cognitive level questioning strategies promote critical and creative thinking process. On the other hand, lower cognitive questions hinder thinking and divergent thinking; besides, they are often restricted to a single correct answer (Good & Brophy 1991; Joyce & Harootunian 1967; Newton 2002; Pate & Bremer, 1967; Wertsch, 1998).

The length of the conversation and the quality of the talk were other important differences between the dialogue of the structured and the guided inquiry groups. The dialogue in the guided inquiry students groups were longer, more content related and more science was spoken compared to that in the structured inquiry groups. Students in the guided inquiry learning environment gave their own decision for solving problems. This process forced them to think and solicit questions requiring comprehension, prediction, application and planning. More questions to understand the content were found in the guided inquiry groups than those in the structured inquiry group. These conceptual conflicts and the disequilibrium induced students to pose more questions, these questions leaded students to investigations as well as subsequently generating further questions and ideas, required acquisition of new knowledge, critical reasoning, persuaded the direction of discourse and prompted students to talk about other topics. Student practice of scientific communication goes further than that expected in attainment of the curriculum, which result in speaking more about science and controlling the direction of conversation. These kinds of actions are congruent with the action more emphasized in the National Science Education Standards. The NSTA exemplified scientific literacy as the major goal of science education. "Scientific literacy means that a person can ask, find, or determine answers to questions derived from their own curiosity about everyday experiences. This means that a person has the ability to describe, explain, and predict natural phenomena" (NSTA, 1996, p. 22). Even though there were significant differences between the structured and the guided inquiry student groups; students in each group were found doing these kinds of actions and doing science as scientist do. The result of the study showed that the more students do science as scientists do, the more they act as if they were scientists.

Conclusions

Inquiry learning environment enables students to go beyond obtaining a body of knowledge and following instructions. The students did not simply complete the activity to please the teacher, to receive a good grade, or to accomplish their duty as students. They completed the activity to satisfy their own desire to explore, investigate, solve the conceptual conflict and disequilibrium which made them able to understand the phenomena and often to give additional meaning to it. Both the structured and the guided inquiry enhanced students'question asking behaviours and cultivated curiosity. However, the guided inquiry learning environment was more effective than the structured inquiry learning environment. In the guided inquiry learning environment, the problem was less structured than it was in the structured inquiry, the learning environment and most of the problem was left to students. Because of this, the degree of the unknown was high in guided inquiry group. As a reason the students took ownership, were motivated to solve the problem and became so curious about the phenomena that consequently they postulated more questions to replace the original problem. Students' questions are an essential episode for starting the scientific process. Students direct their learning by asking questions, proposing possible explanations, designing experiments, collecting data, and communicating evidence. These kinds of acts and anxieties occur simultaneously when students start doing science.

When used as the central instructional strategy in science classrooms, an inquiry encourages teacher-student interaction, student-student interaction, students' question asking behaviors, and cultivate curiosity. Students' questions, responses to questions, participation in discussions, dialogues, and reflection foster critical and creative thinking skills. Sample of interactions in this study offer example of the roles the teacher and the students take in guided and structured inquiry science classrooms. As we see in these dialogues, guided inquiry learning environment which require more active linguistic and cognitive engagement than structured inquiry learning environment encourage curiosity and active student participation among students.

Disclosure statement

No potential conflict of interest was reported by the authors.

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