

The roles of teachers and types of questions in the science classroom

A study of communication patterns in high school level biology lessons

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Abstract

Teacher-student communication in the classroom is crucial for effective student learning and a teacher can play different roles by asking related questions. Teachers use of the right questions at the right moment stimulates and invites the students to have a closer look, reinvestigate or revisit the problem. The teachers play various roles while asking the questions to continue the classroom discourse. Therefore, the purpose of this study was to investigate various roles of a high school teacher in a science classroom discourse. The study also pursued how these roles are related to the types of questions asked by the teacher during classroom communication. A framework, constructed by Chen and his colleagues, has been used to categorize types of teachers' roles to find the relationship between the roles of the teachers and the types of questions asked in a science class. A case study has been presented in this report with observations from two high school level biology lessons. Both audio and video recording were deployed to capture the lessons as well as a notebook was maintained. These recordings have been transcribed for a qualitative data analysis. In this study, five types of questions have been observed in two biology lessons: concept, confirmation, remembering, challenging and encouraging. Furthermore, based on Chen and his colleagues Framework, only three roles of the teacher was found: dispenser, coach, and participant. The findings revealed that the concept, confirmation and remembering types of questions are related to the teacher role as dispenser, the challenging types of questions are related to the role as coach and encouraging type of questions are related to the teacher's participant role. The teacher acted mostly as a dispenser in the classroom discourses. There were some rooms where the teacher might exercise more as a coach and participant to improve the classroom interaction. No connection between the content of the questions and the role of the teachers was found from the observations. Therefore, this study suggests that further research should be continued with a broader scope to analyze the teachers' questioning roles, its relationship with the content of the questions and its impact to promote student learning.

Keywords

Science classroom, high school biology, teacher roles, types of questions

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1 Introduction

Teachers' roles in science are immensely important for student learning and skill development (Martin & Hand, 2009). Central focus of the science teaching requires active participation of the students in classroom discourse, hence, increases the involvement of students in more scientific thinking (Pasley, Weiss, Shimkus, & Smith, 2004). Traditionally, teachers' role has been observed as teacher-centered within the science classroom, with an emphasis on transmission of the scientific knowledge (Martin & Hand, 2009). A noticeable finding was observed in a study where a teacher asked 117 questions to the students and on the contrary, there was no single question raised by any of the students in 6 biology lessons (Kebede, 1999). Kebede also mentioned that recall questions predominate the classroom. The author referred the term recall questions that is raised only by the teacher and students only memorize and give short answer. In that case, teacher does not encourage the student to think further.

Sinclair and Coulthard stated (as cited in Huq & Amir, 2015, p. 61) that a teacher-centered communicative pattern in the classroom is called I-R-E (Initiation-Response-Evaluation) where teacher poses questions, students give the answer and then teacher evaluates the answer. A study showed that in the evaluation turn in I-R-E, the teachers use of acknowledgement tokens namely, "uhm", "okay", "alright", "yeah" might accelerate student responses and create an area of comfort for the students to make their understanding coherent and to promote students' thoughts (Huq & Amir, 2015). In classroom discourse, they found a distribution pattern of these tokens, namely, 'strong acknowledgement tokens' (such as: yeah or okay) and 'passive reciprocity tokens' (such as: uhm, uhhm, or hmm). Their findings suggested that the usage of 'ok' responses from the teacher offers further talk in discussion and they also claimed that the findings of their study could be used to generate a learner-friendly classroom. On the other hand, a number of authors have significantly criticized teachers' continuous use of the I-R-E discourse format. Lemke stated that the teachers ask too many questions in a classroom and they have misconception that I-R-E structured discourse encourages maximum student participation (as cited in Wells, 1993, p. 2). Lemke urged teachers to use less I-R-E discourse format (ibid.). Dysthe (1996, p. 9-10) has stated that a teacher constantly asks questions in a classroom conversation and students are invited to answer. The question type is often closed, and the teacher rarely uses the students' answers as detailed or further progress in the conversation. When a teacher does not follow up the students' answer, this creates an interruption in the conversation. Responding in such a way, there will be a breach of communication because the student's answers are not taken into account (ibid., p. 59).

There are many studies that have been done on the classroom conversations and it was claimed that teachers' questions may create a situation to motivate and promote students with basic understanding and thus to have an ownership of learning (Chen, Hand, & Norton-Meier, 2016). Science teachers and students work together to develop understanding of phenomena (Reiser, Berland, & Kenyon, 2012). To develop the understanding of science content, teachers need to use questioning practices that help students to use evidence and reasoning to make sense of phenomena (Benedict-Chambers, Kademian, Davis, & Palincsar, 2017). Teachers' uses of questioning can be a key factor to stimulating interaction

in a classroom discourse by which students can be more interested to learn. Different types of questioning provide different roles to promote students' conceptual understanding (Chen et al., 2016).

Even though asking questions is significant, but its effectiveness varies how purposely teachers choose their questions to achieve certain goals (Strother, 1989). Elstgeest (1996, p. 52-53) emphasized that a teacher should apply the right question at the right moment in the classroom. A well put question stimulates and invites the students to have a closer look, reinvestigate or revisit the problem. It has been shown that teacher's higher-level questioning improves the amount and the quality of conversation that appears in the science classroom (Treagust, 2007, p. 382). On the other hand, Chen et al. (2016) explained in their study that a teacher can have various roles during classroom discussions. In the same study, Chen et.al. started to see a relationship between the types of questions posed by a teacher and his/her role to stimulate classroom discourse (Chen et al., 2016). This study tries to explore what type of role a teacher plays while posing questions in science classroom discourse.

Purpose of the study and research question:

Chen et al. (2016) explained in their study that a teacher can have various roles during classroom discussions. In the same research, Chen et al. started to see a relationship between the types of questions posed by a teacher and his/her role to stimulate classroom discourse. With this reference, the purpose of this study is to explore what type of role a teacher plays while posing questions in science classroom discourse. Therefore, the main research question in this study is:

How teachers' roles are related to the types and contents of questions asked by the teachers and the students?

2 Theoretical Framework

2.1 Teachers' Role – A Framework

The communication that occurs in classrooms, plays a vital role in student learning. In the classroom discussion, students express their own ideas and reasoning while students are asked or challenged by the teachers' questions (Benedict-Chambers et al., 2017). Through different type of questioning the teacher performances his/her different roles and communicate with the students.

The communication in the classroom can be studied in many ways. A framework is used in this study which is developed by Chen et al. (2016) to find out how the teacher performs her different roles by posing the different types of questions in the classroom. It is chosen from Chen et al. (2016) because it fits more appropriately with the research question and aim of this study.

Chen et al.'s (2016) framework is basically a way to conceptualize the idea of “teacher roles” by breaking it down into two dimensions: ownership of ideas and ownership of activities. This leads to 4 distinct roles: i.e. dispenser, moderator, coach, and participant; which are each associated with a set of characteristic activities that the teacher engages in. The different activities are: lecture, guide, recognize, compare, integrate, challenge, elicit, exchange, and encourage (figure 1). Chen et al. (2016) developed this framework by performing a multiple-case study on a 4-year professional development project in early elementary science classroom. They implemented an argument-based inquiry approach called Science Writing Heuristic (SWH).

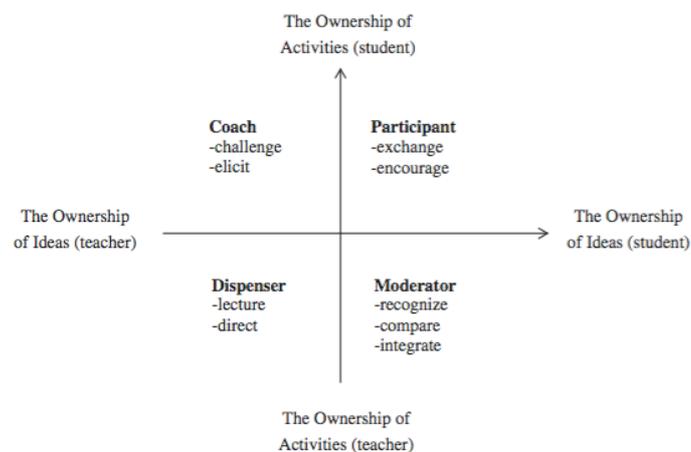


Figure 1. Framework for teacher roles of questioning from two combinations of ownership of ideas and ownership of activities (Chen et al. 2016).

A teacher in a **dispenser** role communicates with the students by posing questions through activities namely lecture and guide. In that role, teacher owns both the ideas and activities in the classroom. A teacher as a **moderator** - recognizes, compares, and integrates different ideas from students in the form of a network by raising questions and reach to an agreement in the classroom discourse. In that role, teacher allows students to control the ideas while a teacher-controls activity. As a **coach**, the teacher continuously challenged the students and asked to clarify their ideas until they reached in an answer with evidence, assumption and reasoning. In that role, teacher has the ownership of ideas while students control the activities in the classroom. Teacher also acts as a **participant** whenever he/she encourages students and exchanges ideas with the students through questioning strategy. Both of these are very important as these create more opportunities for students' learning where students take the accountability for the discussion and have their ownership in the classroom.

A teacher can have different types of roles in his/her classroom. The types of teachers' roles are not limited in the classroom discourse i.e. one teacher can take on several roles even during one single lesson.

2.2 Types of questions

Bloom stated that teachers' asked questions can be divided into six categories, namely, understanding, remembering, applying, analyzing, evaluation and creating (as cited in Airasian, Cruikshank, Mayer, Pintrich, Raths, & Wittrock, 2001, p. 30-31). Remembering means students retrieve related knowledge from long term memory and understanding defines as making the meaning from instructional messages. Applying means as using a method in a given situation. Analyzing defines as breaking material into its integral parts and how the parts are related to each another. Evaluate defines as making judgements based on standards. Creating describes as putting elements together to form a novel, rational or to make an original product.

Al-Zahrani and Al-Bargi (2017) claims that, teacher asks two types of questions in classroom discourse: display questions and referential questions. During display type of questioning, teacher knows the answer before; such questions are usually asked for confirmation check, comprehension checks or clarification requests. During referential type of questioning, teacher does not know the answer and such questions demand interpretations and judgments from the students.

Dös, Bay, Aslansoy, Tiryaki, Cetin, & Duman (2016) stated that there are two types of questioning in the classroom based on student response. One is convergent questions, where a single short correct answer is required. These types of questions are also called as closed-ended questions because students are not expected to extend their discussions (*ibid.*). For example, after teaching about DNA, the teacher might ask "what is the name of the cell duplication process? this question is a close-ended question as the answer was precise and did not require further explanation. On the other hand, Dös et al. (2016) also stated that questions or problems which required students to answer by analysis, synthesis, or evaluation using their interrelated knowledge, are called divergent questions. These types of questions are also stated as open-ended questions because students are expected to contribute their original idea (*ibid.*). By exploiting their idea and pre-knowledge they are expected to extend their discussions. These types of questions might have several answers. For example, "How does the cell make a copy of a DNA molecule?" is an open-ended question. For such a question, students are supposed to know the mechanism and organelles characteristics to formulate the answer.

Benedict-Chambers et al. (2017) observed four categories of teachers' questioning in their study. These are: explication questions, explanation questions, science concept questions and scientific practice questions. Explication questions provide students with an opportunity to clarify their evidence in the form of 'what' happened in the investigation. Explanation questions ask students to explain 'why' or 'how' a scientific phenomenon works. Science concept questions guides students to use scientific language to term observed phenomena. Scientific practice questions support students in developing knowledge and skills in operating scientific practices (*ibid.*).

According to Chen et al. (2016), challenging questions offer students to reflect on their understanding and "scaffold them to establish networks among their pre- and new-conceptions", hence students'

conceptual understanding develop. Encouraging questions and statements encourage the students to exchange their ideas and develop activities collaboratively in the classroom discussion (ibid.).

Based on the features of different types of questions, most of the questions types can be categorized as follows:

Table 1. Categories of different types of questions

Author	Categories		
	Single short correct answer required	Interpretation and judgement with evidence required	Other
Bloom (in Airasian et al., 2001)	Remembering Understanding	Analyzing Evaluation Creating	Applying
Al-Zahrani and Al-Bargi (2017)	Display	Referential	-
Dös et al. (2016)	Convergent/close-ended	Divergent/Open-ended	-
Benedict-Chambers et al. (2017)	Science concept	Explanation	Explication Scientific practice
Chen et al. (2016)	-	Challenging Encouraging	-

3 Method

Based on Chen's framework, a qualitative research approach has been used in this study to explore the role of a high school level biology teacher (Chen et al., 2016). The framework has also been employed to investigate how these roles of a teacher were matched and categorized related to the types of questions she asked in her biology classes. This framework fits appropriately to answer the research question of this study.

3.1 Sample

An experienced biology teacher from a high school in Stockholm was chosen randomly. Two-different groups of her students from year 3 were selected as well. Each biology class was consisted of 20 students. Study groups were selected regardless of the students' gender, culture, social class, occupation and religion.

3.2 Data Collection

To investigate how teacher roles are related to the type of questions and content in biology classes, three lessons were observed. The lessons were taught by the selected teacher. The biology teacher followed her normal lesson plan for all three classes. The students and the teacher were informed and consent were taken according to research ethics (Vetenskapsrådet, 2002) (see Appendix, attachment 1 & 2). Both video and audio recording had been done to capture the information at its best.

In the first lesson the students were taught photosynthesis, biology 2, in year 3. The duration of that lesson was 55 minutes (min) and the total number of students were 19. Eighteen students gave their consent to participate in that study. The student who did not participated chose to sit in the corner of the back bench. The teacher uses both power point presentation and a white board. The lesson was audio-recorded to capture the entire discussion in the class. Five audio-recording devices were used for sound recording. An audio-recorder was put on the teacher's front desk. One audio-recorder was put on the first bench where five students took their place and one was put on the second bench where another five students sat. In the last bench eight students took their places and two devices were put there for every four students.

Both second and third lessons were conducted with the same group of students where they were taught biotechnological methods namely protein isolation process, biology 3, in year 3. Duration of the second lesson was 90 min with 16 students. All the students agreed to participate in this study. The second lesson was on four different protein isolation process namely Western blot, SDS-PAGE (Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis), Immunoprecipitation and ELISA (Enzyme Linked Immunosorbent Assay). The Western blot is a widely used analytical technique to detect specific proteins in a sample of tissue used in molecular biology and immunogenetics. SDS-PAGE is a common method for separating proteins by electrophoresis uses a polyacrylamide gel as a support medium and SDS used to denature the proteins. Immunoprecipitation is a method of precipitating a protein antigen from a solution using an antibody which specifically binds to that particular protein. ELISA is a test that uses antibodies and dye change to detect a substance. Therefore, the teacher divided the students into four small groups so that each group can work on at least one protein isolation process. To start with, all of them read the process from their text books as well as took help from related web pages for further understanding. Thereafter, they discussed the process with each other in their own small groups.

The third lesson, continuation of the second lesson with the same students, was held for 80 min. The teacher created four new groups for that lesson consisted one member from each of the previous groups. In that way, each group had a member who could explain at least one of the four protein isolation process to the new group members. Group discussions from both the lessons were recorded. The recorders were set in front of each group and one was also placed on the teacher's front desk.

To capture the types of conversation between the teacher and students, the video recorder was placed at the back corner of the classroom which only recorded the teacher. Even though the video-recording was only for the teacher, but the students were not comfortable in classroom conversation and group

discussions. Due to their uneasiness, the video- recording was discarded in the third lesson. Note book was also maintained to write the important and interesting phenomena during whole class discussion and group discussions for all three lessons. Photos were taken with students' permission to remember the states of the classrooms and the conversations.

Between two biotechnology lessons, the third lesson was more interactive compare to the second one. In the third lesson, each group deployed multiple activities where students gave lecture in their own group, they compared and integrated their understandings to some other biological process. Students also encouraged and exchanged their ideas with each other to establish their understanding on the content. However, the students during the second lesson spent most of their class time in reading the text books and surfing internet, thus was not very interactive. Moreover, the students from the third lesson had to work individually with their computers for the last 30 minutes of their class time. Therefore, that second lesson and the last 30 minutes of the third lesson have not been used for the analysis of the classroom conversation.

3.3 Data processing and analysis

Audio-recording of the classroom conversations from the first and third lessons were listened carefully and transcribed accordingly. Transcription was added and validated with video-recording from the teacher, notebook documentation and the photos of the classroom. The names of the teacher and students were anonymized and pseudo names have been used. The teacher is named Lotta, and the students are identified with numbers with an "S", for example, S1, S2, S3 S35 for both the biology lessons. The symbol "S" was used if it was difficult to identify a student, or many students responded at the same time in the transcription. Each transcript was broken into single utterances. An utterance received a unique line number for an individual part to be more easily located (see Appendix, attachment 3). After several reviewing, the transcripts have been translated into English and double checked with a professional translator. To make the document more concise, certain utterances as well as daily life questions were removed which were not related to the classroom conversations from the transcription and translation of the classroom discourses (Chen et al., 2016; Kvale, 1997, p. 181-182). For example, "All of you look tired today, do you need to stretch your legs?" etc. Pause in a conversation is shown with dots within parenthesis in transcribed utterances. The shortest pause, for example: one second, is shown with one dot within the bracket, (.) and the shorter pause, for example: two seconds, is shown with two dots within the bracket, (..). A comparative long pause, for example: three seconds is shown with three dots within the bracket, (...). Conversations with more than three seconds of pause are shown with one hyphen within the parenthesis, (-). Non-recognizable words have been written within the parenthesis with a question mark, for example, (sun light is?) and for utterances (-?) has been used.

Type of questions were identified from the utterances in order to document any potential relation between teacher roles and her questioning while communicating with her students. For instance, with the question "What is light?" (line 187) - defined as an individual utterance- the teacher intended to have a proper definition of light for the students to memorize. Student responded by saying "Energy and photons" (line 188) and the teacher assessed the answer by replying "Exactly! energy and photons" (line 189) (see Appendix, attachment 3).

Here the students were offered with an opportunity to provide their answer in the form of question 'what'. The teacher put her assessment by saying "Exactly" and it showed her guidance and continuing the lecture further. Here, teacher acted as a dispenser by raising a remembering type of question through providing her guidance and lecture. Similar analysis has been used to analyze classroom discussions by Chen et al. (2016).

4 Findings

4.1 Types of questions

This section below is based on the conversation between the teachers and the students from lesson one and lesson three of the biology class. A total of 80 questions were asked by the teacher and the students during biology lessons. Twenty-two questions (27.5%) were asked by the teacher and the rest was asked by the students from both lessons. Five types of questions were observed during the classroom conversations, namely concept questions (23.75%), confirmation questions (41.25%), remembering questions (15%), challenging questions (11.25%) and encouraging questions (8.75%). Examples of the types of questions from two lessons are presented below:

4.1.1 Concept questions

By the concept type of questions, students get an opportunity to practice scientific language to name the scientific phenomenon. For instance, the following conversation can be considered.

225 Lotta: So they are pumped by ATP synthase and then ATP is formed.

226 S1: What is this called?

227 Lotta: Lumen, Åa (...) the inside is called the lumen.

S1 asked a question to the teacher, Lotta "What is this called?" (line 226) and Lotta replied, "Lumen, Åa (...) the inside is called the lumen" (line 227). Here, student did not get any opportunity to discuss further about the lumen structure and function. S1 only got an opportunity to practice scientific term "lumen" to name the scientific phenomenon. Lotta acted as a dispenser and she owned both the ideas and activities at that moment.

Lotta had dominant role focusing on describing the students' vast quantities of information on photosynthesis and asking students questions to get short, specific and correct answer. Lotta owned both the ideas and activities in the classroom.

The students also raised concept type of questions many times in the group discussion. It can be explained by the following conversations.

834 S27: You know that after electropho (..) electrophoresis, the gel is placed on a nitrocellulose membrane.

835 S29: Wait!

836 S28: What is what?

837 S29: Wait wait wait wait!

838 S27: Nitrocellulose membrane.

S28 asked to S27, “what is what?” (line 836) to know the scientific term. S27 replied “Nitrocellulose membrane” (line 838). The further thinking or clarification was not found on this scientific term and the discussion was closed after getting response on it. In this case, the student takes the ownership of the ideas and activities.

4.1.2 Confirmation questions

The confirmation type of questions helps students to increase their self-confidence and generally the discussion is very short. For example,

165 S1: Is it respiratory reaction?

166 Lotta: Respiratory reaction or what is called the last respiratory reaction of this cell respiration.

167 Lotta: Åå (..) respiratory reaction, absolutely! There are a lot of different complexes in a membrane.

In the above discussion, S1 wanted to be confirmed by asking Lotta “Is it respiratory reaction? (line 165), she replied “Åå (..) respiratory reaction, absolutely! There are a lot of different complexes in a membrane” (line 167). After her confirmation, the discussion was closed. Lotta owned both the ideas and activities at that moment.

The students also posed confirmation type of questions in their group discussions and the confirmation type of questions was the most frequent among all type of questions (38.75%). It can be described with the following conversations.

1003 S29: What then? Is it mercaptoethanol that breaking the bonds?

1004 S28: Uu (..) disulfide bridges.

1005 S29: Disulfide bridges.

In the above discussion, S29 ensured his/her understanding by asking, “What? Is it mercaptoethanol that breaking the bonds?” (line 1003). The other student, S28 who was on teacher role, evaluated and put his/her assessment by a short response “Uu (..) disulfide bridges “(line 1004). Then S29 reiterated “disulfide bridges” and showed his/her acceptance (line 1005). No further discussion was seen on it. The student owned both the ideas and activities at that moment.

4.1.3 Remembering questions

Lotta asked remembering types of questions most frequently (11.25%) in the classroom discourse. Through remembering types of questions, students were invited to retrieve related knowledge from long-term memory and answer the questions. For example,

- 314 Lotta: What is the thing that plants pick out?
315 S12: Carbon dioxide.
316 Lotta: Carbon dioxide, yes.
317 Lotta: So, in some way, we have carbon dioxide.

In remembering types of questions, usually the teacher use “fill-in-the-blank” questions and evaluate students’ factual knowledge rather than using questioning to elicit their thinking. Here, Lotta confirmed S12’s answer as the aim was to get a specific answer against a specific question. In such situation, the teacher controlled both the ideas and activities. One more example can be explained by the following conversations.

- 162 Lotta: Does this picture remind you of something?
163 S1: Yes, of cellular respiration.
164 Lotta: Cellular respiration, yes.

Remembering type of questions proposes the students to deliver a short response and then teacher evaluates with the word “yes” or “no”. In the above conversation, Lotta asked to the students “Does this picture remind you of something?” (line 162) and S1 responded, “Yes, of cellular respiration” (line 163). Teacher evaluated then by replying, “Cellular respiration, yes” (line 164). Such remembering type of question offered the students to deliver a short correct answer. S1 answered (line 163) and then teacher evaluated with the word “yes”. Lotta owned both the ideas and activities at that moment.

However, remembering type of questions was not found in students’ group discussions.

4.1.4 Challenging questions

Whenever possible, Lotta challenged students to express their understanding and establish link among their pre- and new concepts on photosynthesis. To illustrate the types of questions, the following conversation is considered in which Lotta discussed the reason behind diffusion process inside the mitochondria to her third-year biology students.

- 195 Lotta: And these protons will increase in numbers inside.
196 Lotta: And forms very high concentration.
197 Lotta: S7, where do you think the protons would take the way?

198 Lotta: A very high concentration is formed here inside.
199 S7: They want to come outside.
200 Lotta: They want out, yes.
201 Lotta: Diffusion! They want to equalize the concentration.

Lotta initially used two sentences with a series of key words before she put a challenging question “Where do you think the protons would take the way?” (line 197). These series of words were, “grow in numbers inside” (line 195) and “very high concentration” (line 196). These words assumed to help the students to elicit their ideas about the reason behind diffusion process. When teacher saw that the students were unable to answer, she stated again “A very high concentration is formed here inside” (line 198). This time teacher emphasized on two things, “very high concentration and here inside” (line 198). She added new words “here inside” to help the students to think more precisely. Then S7 responded with correct answer, “They want to come outside” (line 199). Using series of key words and presenting challenging type of questions, Lotta helped students to elicit their thinking and construct understanding. Students worked cooperatively with the teacher.

Students also used challenging questions to elicit the other students’ ideas about the reason behind scientific phenomena. For example:

455 S17: Why do people need to know the molecules structures?
456 S14: Yes, but it is because to compare with these proteins.
457 S17: Is there anything special people use?
458 S14: Criminal technique.
459 S17: Ok.

In the above conversations, S17 put a challenging question “Why do people need to know the molecules structures?” (line 455) which was a very important and interesting question. S14 responded “Yes, but it is because to compare with these proteins” (line 456) and the S14 asked a new question “Is there anything special people use?” (line 457) and S14 gave answer to it “Criminal technique” (line 458) followed by a reply from S17 “Ok” (line 459).

4.1.5 Encouraging questions

A common feature was in the classroom that students were encouraged often by the teacher to support their statements. Students were the owner both the ideas and activities. For instance, the following conversations can be taken into account.

267 Lotta: S9, what should I write that forms (...) like?
268 S9: Nayaa (...)
269 Lotta: NADP and by transforming.
270 S9: Electromagnetic radiation.

- 271 Lotta: Electromagnetic radiation, then we take it.
272 Lotta: Is it, are you happy with that formulation?
273 Lotta: That light-dependent reaction forms ATP and NADPH.
274 Lotta: By transforming electromagnetic radiation, it utilizes photons.

In the above discussion, it was observed that how Lotta encouraged a student in discussing the concept of sunlight as energy or electromagnetic radiation. She asked to a particular student who was willing to use the scientific term electromagnetic radiation instead of sunlight energy. She asked to S9, “what should I write that form (...) like?” to prioritize students’ concept on sunlight energy. Whenever student said, “electromagnetic radiation” (line 271), she replied, electromagnetic radiation, ok, we take it” (line 272) to encourage student by supporting his claim.

In some instance, the conversation continued in different way, example below:

- 249 Lotta: So light-dependent reactions it forms the energy or transforms light energy.
250 S9: Is not it light energy, physicists like to use and is it ultraviolet radiation that absorbs it?
251 S9: It's unclear, it does not work with visible light.
252 Lotta: Yes, they are specified as in visible light and they use in visible light.
253 S10: Yes, just that, light green is the only color which is not absorbed.
254 Lotta: Um, exactly, plants look green because it absorbs red and blue light.
255 Lotta: They cannot absorb green light. So that's why it excites or be sent it back.
256 S10: Reflected, that is why it looks green.
257 Lotta: Yes!
258 S9: But what was that reflection? Åaa (...) aaa (...) that was åå (...).
259 Lotta: It takes the light or energy in the photons and transforms them, is it better?
260 S9: Yes, absolute (with low tone)!
261 Lotta: I'm not a physicist. I try to use sunlight ener (...) as well as (...).
262 Lotta: I hope you understand, at least, what I mean, maybe physicists who would be right about that.

The student, S9 wanted to know about the light energy (line 250) which has a deep connection with the UV-ray and magnetic radiation. Lotta’s topic of choice encouraged student to continue this conversation. However, only one question was posed by Lotta and the discussion ended without exchanging more ideas among students or providing any concrete answers (line 261, 262).

Students were not only encouraged by the teacher but also by the other students. It was observed mostly during group discussions. The following two conversations can be seen.

- 879 S29: What is the function of membrane?
880 S27: (Aaa .. I'll just look over here?)
881 S29: Continue!

937 S28: Okay, but the secondary noticed in a similar way and it makes it possible to detect them.

938 S27: yes!

939 S28: And then?

940 S27: Then (...)

941 S28: Take it easy! Wait wait! No stress!

In the above conversations, S27 failed to give an answer, S29 from the group said, “continue!” (line 881) to encourage S27, and the conversation continued. It was also observed that the other student, S28 encouraged S27 by saying that, “Take it easy! Wait wait! No stress!” (line 941).

4.2 Relationship between the types of questions and the role of teacher

When Lotta posed concept type questions she expected short specific answers from the students. In this case, Lotta act as a dispenser. Furthermore, some of the questions expecting short answers were also confirmed by Lotta with “yes” or “no” and the conversation ends there. Lotta also asked certain questions to retrieve students’ knowledge on the subject. For example: “Does this picture remind you of something (line 162)?” In all three types of questions Lotta owned the questions. All these indicators fulfilled the criteria of Lotta taking the role of dispenser.

In some other instances, Lotta posed challenging types of questions. In this case, she acts as a coach in order to stimulate their existing knowledge as well as to link the existing knowledge with the newly acquired one. For example, Lotta asked a question to S7, “Where do you think the protons would take the way (line 197)?”

While asking encouraging questions, Lotta directed a question to S9 and ask for suggestion. For example: “S9, what should I write that forms (...) like (line 267)?” She also encourages S9 to elaborate his/her answer further. When the student gave an answer, she supported that statement. For example: “Then we take it (271)” and “Is it, are you happy with that formulation (272)?” These types of questioning and supporting statements to encourage students are associated to teachers’ role as participant.

From the above discussion, this has also been found that all five types of questions have close relationship with the teachers’ role. However, the study did not find any connection between teachers’ role and the content of the questions. Same types of questions can have different types of content. For example: “respiration reaction” is a process under remembering type questions (line 165) and “marcaptoethanol” is a concept under the same type of questions (line 1003). Similarly, the content of the questions diverged under the same type of teacher’s role, for example, “diffusion” is a process (line 201) asked by the teacher as a coach and “proton” is a concept (line 197) asked while taking the same type of role.

Chen et al. (2016) sensed that the types of questions posed by a teacher is connected to his/her role as dispenser, moderator, coach and participant. In line with their study, the summary from the transcripts is clearly showing that the criteria for the types of questions that the teacher asked is directly connected to what role she is taking during the class conversation. The relationship between the types of questions and the teacher roles is presented in table 2.

However, a well-known classroom discourse pattern where teacher generally act as a moderator, mentioned in the Framework of Chen et al. (2016), was not observed in any of the two biology lessons presented in the findings. There was no interaction that teacher recognized, compared, and integrated different ideas from students in the form of a network by posing questions.

Table 2. Relationship between the types of questions and the teacher roles across two lessons.

Types of questions	Criteria	Teachers' roles
Concept	<ul style="list-style-type: none"> • Short specific answer • Conversation ends with the specific answer • Owned by the teacher 	Dispenser
Confirmation	<ul style="list-style-type: none"> • Questions are directed to a “yes” or “no” answer • Short specific answer • Conversation ends with specific answer • Owned by the teacher 	Dispenser
Remembering	<ul style="list-style-type: none"> • Retrieve related knowledge • Conversation ends with the answer • Owned by the teacher 	Dispenser
Challenging	<ul style="list-style-type: none"> • Elicit students thinking • Establish link between students' existing and new knowledge • Series of questions • Ideas owned by the teacher and activities owned by the students 	Coach
Encouraging	<ul style="list-style-type: none"> • Encourage students for further elaboration • Supporting the students' answer • Ideas and activities both are owned by the students 	Participant

5 Discussion and conclusion

In this study, it was found that the teacher posed five types of questions in biology classroom discourse, that are: concept, confirmation, remembering, challenging and encouraging type questions. However, 64 percent of her questions were concept, confirmation and remembering types to obtain factual information in the classroom with a single short correct answer. Moreover, the teacher also assessed her students' level of knowledge on biology through these three types of questions. This finding is supported by Al-Zahrani and Al-Bargi (2017) who named them display questions. These types of questions are called I-R-E by Sinclair and Coulthard (as cited in Huq & Amir, 2015, p. 61). Lemke named it triadic dialogue (as cited in Wells, 1993, p. 1) and according to Dös et al. (2016), these are "close-ended questions".

It was observed that when teacher applied concept, confirmation and/or remembering type questions she owned both the ideas in discussion and activities in the classroom. The teacher acted as **dispenser** where she expected to have short, specific, correct answer and not to extend the discussion. In the lesson on photosynthesis, whenever teacher got correct answers, for example, "carbon dioxide", or "cell respiration", there was no room for further conversation. As there was a single short correct answer she did not expect any further explanation. The teacher's role as a dispenser was also found in the study done by Chen et al. (2016). This study revealed that teacher's dispenser role is linked to the concept, confirmation and remembering types questions, even when students take the role of a teacher in a group discussion. The study found that when the teacher was acting as dispenser, it did not give any opportunity to the students to think further or elaborate the topic further. This limitation is also supported by Lemke (as cited in Wells, 1993, p. 1-2) and Dös et al. (2016).

Whenever the teacher challenged students to express their understanding by posing a challenging question, for example, "Where do you think the protons would take the way?", she owned the ideas of discussion and students performed the activities. By establishing a link between the students' existing and a newly acquired knowledge on, e.g., proton and diffusion process, students availed the correct answer. Here the teacher takes the role as a **coach** by posing a challenging question to elicit their understanding. Several challenging types of questions were also found across two lessons in this study, however the teacher stopped challenging the students after one or two questions. As a result, the students were not pushed enough to achieve higher level thinking and reasoning ability. According to Chen et al. (2016) and Al-Zahrani and Al-Bargi (2017), teachers' coaching role focused on eliciting and continuously challenging the students which promote "higher-level thinking" among the students and their reasoning abilities. Hence, in the findings the teacher's coaching role was related to the challenging type questions, but the activities did not obtain the maximum result. Students also raised challenging questions in their group discussions while the discussion pattern was more similar to the I-R-E discourse. This pattern of discourse is unusual for challenging type of questions. One reason could be that the question owner did not have the aim to elicit others thinking but only to get an answer.

There were some plausible moments during classroom discourse where the teacher acted as a **participant**. When it comes to encouraging the students, and exchanging ideas with them, only about 3% encouraging statements from the teacher were seen in this study. However, there was a lack of exchange of ideas between teachers and students as well as between students and students. In the second example presented in section 4.1.5, where one particular student (S9) was unclear about the concepts of “ultra-violet radiation”, “reflection” but the teacher did not continue sharing or exchanging ideas. Säljö (2014, p. 115) mentioned that the direct participation in the communication establishes a large part of how individuals will meet each other and take on new ways of thinking, reasoning and performing. In this case mentioned above, the students could have direct communication and argue with each-others’ ideas and finally the whole class could reach in an agreement if the teacher could pose an open question to all. Hence, the students could also take the responsibility for the discussion and have their ownership in the classroom. These types of questions could elicit the students thinking and more students could join the discussion. Thus, classrooms discussion could go further.

Treagust (2007, p. 382) stated that classroom discourse is directly affected by teachers’ questioning types where higher-level of questioning improves the amount and the quality of communication among students and teachers in a science classroom. Based on the limited scope and time of this research, only one teacher and her performance in two biology lessons have been taken into consideration to provides an image of relationship between type of questions and teacher’s roles which supports Chen et al.’s (2016) finding. However, this study did not find any integration of teacher’s multiple questioning strategies with the specific content and context which is not supported by Chen et al.’s (2016) study. As this study has been performed with a limited number of classroom observations, it cannot strongly be claimed that the roles of teachers are not related to the content of the questions. This needs more research with broader scope and bigger sample sizes and explore teachers’ questioning roles, its relationship with the content of the questions and its impact to promote student learning.

6 Validity and Reliability

A qualitative research analysis was used to explore of an experienced high school biology teacher roles during whole class discussions. To find out how the teacher roles are related with the types and content of questions, a validated framework which is developed by Chen et al. (2016) is followed. This framework is principally a way to conceptualize the idea of “teacher roles” and how each of these roles is associated with a set of characteristic activities appropriately fitted with the research question and aim of this study. Data was collected by classroom observation from two biology classes and the outcome of the study is consistent with the previous research (Chen et al., 2016). The research study group was selected regardless the students gender, culture, social class, occupation and religion. The students were informed and consent were taken according to research ethics (Vetenskapsrådet, 2002). To ensure the reliability total 5 audio-recording devices were used and each recording were matched with others. Student participation was ensured by discarding the video recording in lesson 3 as it was observed student feel discomfort during previous lessons. A note book was maintained and some

photos were also taken during the whole observation periods. Transcription was reviewed repeatedly and validated by video-recording, note book documentation and photo of the classroom. After several reviewing transcribed documents were translated into English and double checked with professional translator. After careful transcription and translation of the classroom discourses, the document was more concise by removing the utterances which were not related to the classroom conversations.

Due to time constrain, data was gathered only from 2 biology lessons, even though the outcome of the study was similar and consistence with previous studies but it might give us better validity and reliability if we could include more lessons. In this study, the same teacher conducted both the lessons however it could be relevant to compare different teachers' roles with another teacher or teachers as Chen et al. (2016).

7 Research Ethics

Data has been collected according to research ethical principles in which the teacher and students signed a written consent form (Vetenskapsrådet, 2002) (see Appendix, attachment 1 and 2). All parties were also being informed about the confidentiality where me and my supervisor will only be able to access the data with the original name and it has been ensured that all participants were guaranteed to be anonymous.

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Appendix

Attachment 1

Brev till lärare

Rabeya Begum, UM9100

Hej,

Jag heter Rabeya Begum och studerar till lärare vid Stockholms universitet. Som en del av min utbildning ska jag genomföra ett självständigt arbete. Jag ska alltså genomföra en studie och skriva en uppsats om något som har med undervisning att göra. Jag har valt att göra en studie om klassrumsdiskurs i naturvetenskaplig (NV) undervisning på gymnasiet.

Syftet att undersöka lärarens användning av olika typer av frågor i en biologi-klass. Jag räknar med att undersökningen kommer att ske under 2-3 lektioner. Jag kommer att göra ljudinspelningar i klassrummet och samtidigt videospelningar (bara av läraren) för att analysera samtalsmönster under ordinarie lektioner. Studien kommer förhoppningsvis att kunna bidra till bättre NV undervisning genom att förstå hur olika typer av frågor skapar olika möjligheter för lärande.

Resultaten kommer att redovisas i en uppsats. Namn på lärare och skola kommer att vara fingerade vilket innebär att det inte går att identifiera enskilda lärare eller på vilken skola studien har genomförts. Endast jag och min handledare kommer att ha tillgång till ljud- och video-inspelningarna. Datamaterialet kommer enbart att användas för min uppsats och inspelningarna kommer att förstöras när uppsatsen är godkänd.

Du tillfrågas härmed om deltagande i denna studie. Du kan när som helst avbryta deltagandet utan närmare motivering.

Om du har några frågor eller funderingar angående min studie, är du välkommen att höra av dig till mig (e-post: rabeya28@gmail.com) eller min handledare Jakob Gyllenpalm vid Institutionen för matematikämnet och naturvetenskapsämnenas didaktik, Stockholm Universitet (e-post: jakob.gyllenpalm@mnd.su.se).

Stockholm 2018-04-10

Med vänlig hälsning

Rabeya Begum

Lärarstudent Ämneslärarutbildning

Stockholm Universitet

Samtycke för deltagande i studie om klassrumsdiskurs– Lärare på XX-Gymnasiet, vt - 2018

Namn: _____ Lärare i: _____

Jag **vill** delta i studien

Jag **vill inte** delta i studien

Datum och underskrift:.....

Attachment 2

Information om deltagande i studentarbete till elever i klass xx och xx
Rabeya Begum, UM9100

Hej,

Jag heter Rabeya Begum och studerar till lärare vid Stockholm Universitet. Som en del av min utbildning ska jag genomföra ett en mindre undersökning om samtal i klassrum i naturvetenskaplig undervisning (NV).

Syftet att undersöka lärarens användning av olika typer av frågor i en biologi-klass. Biologi-läraren från den här skolan har erbjudit mig att genomföra min studie under hennes lektioner. Jag önskar genomföra studien i klasserna xx och xx.

Jag räknar med att undersökningen kommer att ske under 2-3 lektioner. Jag kommer att göra ljudinspelningar i klassrummet och samtidigt videospelningar (bara av läraren) för att analysera samtalsmönster under ordinarie lektioner. Studien kommer förhoppningsvis att kunna bidra till bättre NV undervisning genom att förstå hur olika typer av frågor skapar olika möjligheter för lärande.

Resultaten kommer att redovisas i en uppsats. Namn på elever, lärare och skola kommer att behandlas anonymt och konfidentiellt innebär att det inte går att identifiera enskilda elever eller på vilken skola studien har genomförts. Endast jag och min handledare kommer att ha tillgång till video- och ljudinspelningarna. Datamaterialet kommer enbart att användas för min uppsats och inspelningarna kommer att förstöras när uppsatsen är godkänd.

Du tillfrågas härmed om deltagande i denna studie. Du kan när som helst avbryta deltagandet utan närmare motivering. Jag ber dig fylla i nedanstående talong och lämna den till din biologi-lärare senast den 23 april 2018.

Om du har några frågor eller funderingar angående min studie, är du välkommen att höra av dig till mig (e-post: rabeya28@gmail.com) eller min handledare Jakob Gyllenpalm vid Institutionen för matematikämnet och naturvetenskapsämnenas didaktik, Stockholm Universitet (e-post: jakob.gyllenpalm@mnd.su.se).

Stockholm 2018-04-10

Med vänlig hälsning
Rabeya Begum
Lärarstudent Ämneslärarutbildning
Stockholm Universitet

Samtycke för deltagande i studie om klassrumsdiskurs – Årskurs NA15A och NA15B, XX-gymnasiet, vt 2018

Namn: _____ Klass: _____

Jag **vill** delta i studien

Jag **vill inte** delta i studien

Datum och underskrift:.....

Attachment 3

Transcript utterances in Swedish

Data processing and analysis

- 187 Lotta: Vad är ljus för något?
188 S1: Energi och fotoner
189 Lotta: Precis! Energi och fotoner!

4.1.1 Concept questions

- 225 Lotta: Så de pumpas genom att ATP syntas och då bildas det ATP.
226 S1: Vad kan kallas det här?
227 Lotta: Lumen, Åa... insidan kallas det lumen.
- 834 S27: Det är, ni vet att efter elektrofo..elektrofores så placeras gelen på en nitrocellulosa membran.
835 S29: Vänta!
836 S28: Vad är vad?
837 S29: Wait wait wait wait!
838 S27: Nitrocellulosa membran.

4.1.2 Confirmation questions

- 165 S1: Är det andnings reaktion?
166 Lotta: Andningskedjan eller vad heter sista andnings reaktion den här cellandningen.
167 Lotta: Åå..andningskedjan, absolut! Det sitter en massa olika komplex i ett membran.
- 1003 S29: Vad då? Det är markaptoetanol bryter bindnigarna?
1004 S28: Uu. Sulfidbryggor)
1005 S29: Sulfidbryggor

4.1.3 Remembering questions

- 314 Lotta: Vad då en av sakerna som växterna plockar ut?
315 S12: Koldioxid
316 Lotta: Koldioxid, jaa
317 Lotta: Så på något vis här har vi koldioxid
- 162 Lotta: Påminner den här bilden om någonting?
163 S1: Ja, om cellandning
164 Lotta: Om cellandning, ja

4.1.4 Challenging questions

- 195 Lotta: Och de här protonerna, kommer växa i antal innanför.
196 Lotta: Och bildar väldigt hög koncentration.
197 Lotta: S7, Var tror du protonerna vill ta vägen?
198 Lotta: Det bildas väldigt hög koncentration här inuti.
199 S7: De vill ut
200 Lotta: De vill ut, jaa
201 Lotta: Diffusion! De vill liksom utjämna koncentrationen.

- 455 S17: Varför behöver man veta molekyler strukturerna?
456 S14: Ja, men det är så för att jämföra med de här proteinerna.
457 S17: Är det något särskild man använder?
458 S14: Kriminal teknik
459 S17: Okej

4.1.5 Encouraging questions

- 267 Lotta: S9, vad skulle jag skriva att bilda... liksom
268 S9: Najee (...)
269 Lotta: NADP och genom att omvandla
270 S9: Elektromagnetisk strålning
271 Lotta: Elektromagnetisk strålning, Då tar vi det.
272 Lotta: Är den, är ni nöjda med den formuleringen?
273 Lotta: Att ljusberoende reaktionen bilda ATP och NADPH
274 Lotta: Genom att omvandla elektromagnetisk strålning, den utnyttja fotoner.
- 249 Lotta: Så ljusberoende reaktioner den bilda energin eller omvandlar ljusenergi.
250 S9: Är det inte ljus energi hos fysikerna tycker och det är ultraviolett strålning som absorberar den?
251 S9: Det är otydligt, also det går inte med synlig ljus.
252 Lotta: Ju, de är specificerade som på synlig ljus och de använder i synliga ljuset.
253 S10: Ja, just det, ljus grön är enda färg den inte absorberat.
254 Lotta: Um, precis växter ser grönt ut för den absorberar rött och blått ljus.
255 Lotta: De kan inte absorbera grönt ljus. Så det är därför det liksom exciterar eller utskickas.
256 S10: Reflekteras, så därför ser gröna ut
257 Lotta: Ååå
258 S9: Men vad var den reflektion? Åaa (...) aaa (...) det var åå (...)
259 Lotta: Den tar ljuset eller energi i fotonerna och omvandlar dem, är det bättre?
260 S9: Ja, absolut (låg volym)
261 Lotta: Jag är inte fysiker. Jag försökte
262 Lotta: Jag hoppas att ni förstår i alla fall vad som menas jag, kanske fysiker som skulle hålla rätt om det.
- 879 S29: Vad gäller visst membranen?
880 S27: (Aaa (...) jag ska bara se här borta?)
881 S29: Fortsätt!
- 937 S28: Okej, men de sekundära märkte på lik sätt och det gör möjligt att detektera dem.
938 S27: Åå
939 S28: Och sen?
940 S27: Sen då (...)
941 S28: Ta det lugn! Vänta vänta! Ingen stress!

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