CLASSROOM INTERACTION IN PHYSICS TEACHING AND LEARNING THAT IMPEDE IMPLEMENTATION OF DIALOGIC TEACHING: AN ANALYSIS OF STUDENT-STUDENT INTERACTION

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Abstract. This case study presents the analysis of student-student interaction in physics classrooms to determine the aspects that might constrain the implementation of dialogical teaching. Interaction among students in three lesson topics from grade 7, namely 'mechanical advantage' 'efficiency', and 'types of simple machines' were analysed with respect to three features including function of students' talk, modes of students' participation in the group work and their response to each other's point of views. The results indicate that students used their talks for different purposes in which most of them seemed to have insignificant contribution to the co-construction of knowledge because of their low quality and low frequency of occurrences. The student-student interaction during the group-work session was characterized mainly by domination, 'cumulative' type of classroom talks in which members of the group accept the group leader's ideas without critical evaluation and absence of exploratory talk. The overall results likely imply that the low quality of the groupwork task and the

ineffective teacher interventions potentially affect the implementation of dialogical approach in the teaching and learning of physics.

Keywords: interaction, dialogic teaching, physics teaching, student-student interaction

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Introduction

Educational innovations are very important to improve students' learning outcomes and the quality of education provision (OECD, 2016). Educational innovation can be thought of a better way of doing things in the process of teaching and learning (Murphy et al., 2014). This includes pedagogical, scientific, methodological, and technological innovations (Mykhailyshyn et al., 2018).

Dialogical teaching as pedagogical innovation has been proposed as a teaching approach that involves students in discussion rather than simply accepting one's own truth (Alexander, 2001). Unlike the traditional approach which focuses on transmitting knowledge without considering the understanding of the learners (Lyle, 2008), in dialogic teaching, students have the opportunity to analyse and evaluate other's points of view thereby widen their conceptual understanding (Alexander, 2006).

The idea of dialogical approach of teaching and learning is based on Lev Vygotsky (1978) who recognised knowledge as socially constructed and language as the driving force behind cognitive development. He described language as both a cultural tool (for the development and sharing of knowledge amongst people) and as a psychological tool (for structuring the processes and content of individual thought). He also argued that "human learning presupposes a specific social nature and a process by which children grow in to the intellectual life of those around them" (Vygotsky, 1978). The human mediation accord-

ing to Vygotsky appears first in the form interaction between people (interpersonal interaction), and then again in an internalized form (intrapersonal interaction).

The implementation of dialogic teaching in Ethiopia is at its infant stage as it is introduced since 2015 by "Transforming the Pedagogy of ATEM Subjects" (TPSS) project. The project implemented the approach and observed its effect on the teaching and learning of physics in teacher education colleges and second cycle primary schools (grade 5 to 8). Beside the project, two PhD dissertations focusing on dialogical teaching have been conducted (Mesfin, 2017; Mekbib, 2015) earlier than the TPSS project. Even if the students who were taught by the dialogical teaching approach have performed more than those taught by the 'traditional' approach as verified by the findings of the dissertations and the research project, their improvement was not convincing to the expected level (Mekbib et al., 2019).

Even if the recognition of the importance of dialogic approaches to teaching and learning and their potential for raising standards of learning appear to be spreading in the literature (Osborne, 2012; Aufschnaiter et al., 2007; Garcia & Anderson, 2007; Hajhousseiny, 2012), the implementation of dialogic approaches in classroom discourse is not easy. Regarding this, Lyle (2008) suggests that research is needed into what classroom processes can best support dialogic practice in classroom settings. With regard to the importance of classroom culture in the implementation of dialogical approach of teaching and learning, Boyed & Markarian (2015) also suggested that it is necessary to build a classroom environment that supports dialogical teaching. Beside this, most studies on dialogical teaching focussed on the analysis of the potential benefits of the approach on student learning (Osborne, 2012; Lyle, 2008; Mercer & Littleton, 2007) and how to enhance teachers' capability to employ dialogical teaching in science classrooms (Lefstein & Snell, 2014; Pimentel & McNeill, 2013).

In the process of teaching and learning in a classroom, there are always interactions that exist between teacher and students and also among students.

The social interaction performed during classroom teaching and learning creates a culture which reciprocally influences the practices of social interaction (James & Biesta, 2007).

Many studies related to classroom interaction have been conducted with different focusses. Some studies focus on the analysis of interaction between students (Kumpulainen & Wray, 2002; Arcidiacono & Gastaldi, 2011; Sánchez et al., 2013; Ambrosino et al., 2015); some on student-teacher interaction (Mortimer & Scott, 2003; Muhonen et al, 2017). The objects of analysis in such studies were either student and /or teacher talk (Flanders, 1970; Viiri & Saari, 2006; Ogunleye, 2010) and some others focus on the methods and methodology of analysing classroom talk (Mercer, 2005; 2010; Mercer et al., 2004a). Although, the focus of interaction analysis changed from time to time according to the theoretical shift in the perspectives of learning, most studies on classroom interaction dealt with the examination of interaction with respect to students' learning (Mercer et al., 2004b; Mercer & Howe, 2012) .

In this paper, the analysis of student-student interaction was made to determine the aspects of student-student interaction that influence the implementation of dialogic teaching in physics classrooms in Ethiopia. Identifying these aspects is important in that it explores issues related to classroom interaction among students that could be considered in the teacher development training on dialogic teaching which is recently introduced to the Ethiopian education system.

Three features of student-student interaction including functions of students' talk, modes of participation in the group-work and types of students' talks were considered in the analysis. The functional analysis of students' talks and their group participation was made based on a pre-defined category outlined by Kumpulainen & Wray (2002) and the types of students' talks were distinguished based on how participants in dialogue orient each other's points of view as devised by Mercer (2000) with allowance to emerging themes. We used these

frameworks because they are developed based on the sociocultural view which underpins the dialogic approach of teaching.

Aims and questions addressed

The aim of the current study is to explore the characteristics of student-student interaction in physics teaching and learning through socio cultural perspective and determine the aspects of the interaction that impede the implementation of dialogic teaching. Accordingly, the following questions are addressed: (1) what themes of functions of classroom talk emerge from student-student interaction; (2) how are students involved in group-work; (3) how do students orient each other's point of views during group-work; (4) what does the analysis of student-student interaction imply about barriers to the implementation of dialogical teaching.

Analytic framework

The analytical framework used in this study was based on the frameworks of Kumpulainen & Wray (2002) and Mercer (2000) that have been developed based on the socio-cultural perspective. The Kumpulainen & Wray's framework was used to analyse the functional analysis the students' talk and their participation in the group work. The sixteen functional categories were used for the analysis of the functions of language in the classroom and the seven modes of participation were used to categorize the kind students' participation in their group work. This framework has been used by some recent studies for analysing language functions (Arcidiacono & Gastaldi, 2011; Sánchez et al., 2013; Ambrosino et al., 2015; Muhonen et al, 2017).

The Mercer's framework which consists of three categories of talks: 'cumulative', 'disputational' and 'exploratory' was used to classify the students' talks based on how participants in the dialogue orient each other's points of view. As described by Mercer (2000), the disputational talk is characterized by unwillingness to agree with others perspectives and reassertion of one's point

of views. In cumulative talk, "speakers build on each other's point of views, add information of their own and in mutually supportive, uncritical way to construct shared knowledge and understanding". In exploratory talk on the other hand, participants of the talk engage critically and constructively with each other ideas and relevant information is added for joint consideration. Some studies employed this framework for analysing classroom talk (Mercer, 2005; Atwood et al., 2010; Arcidiacono & Gastaldi, 2011).

Research context

The research was conducted in Amhara region, particularly in one second cycle primary school of Dessie town. Data were collected from Grade seven physics class using observation of classroom videos which were recorded using digital video cameras while the teacher was teaching three lesson topics: mechanical advantage, efficiency and types of simple machines. The three lessons were recorded over three weeks' time, one lesson per a week. The teacher had 7-year experience in teaching physics in second cycle primary schools (grade 7 and 8) and was voluntary to be participant in this study. There were 45 students in grade 7 of which 16 are males and the rest females. The age range of the students was 13-18 years. Since the transition of medium of instruction from mother tongue to English begins from grade seven in the education system of Amhara region, classroom communication in second cycle primary schools is in some kind of Amharic and English mix (Mekbib et al., 2019).

Research methods

This study is a case study because it is an intensive holistic description of a single unit (i.e., student-student interaction in physics class) in its natural context. Observation of classroom teaching and learning process with the help of recorded videos was the instrument used to collect the data. All student-student communications in the recorded videos were transcribed and translated into

English for analysis purpose. Translation was made because the students used their mother tongue in most of their discussion.

From the three commonly used group organizations, the group-work session in which students supposed to do tasks in small group was considered for the analysis of students' interaction because it was in this session that students interacted with each other for relatively longer time. The interaction of a group of five students was analysed qualitatively. The English transcriptions of students' talk from the videos were collected and interpreted based on context of interaction and the objectives of the study. In addition, percentage and frequency counts were used to examine how often an event occurred in the interaction.

To determine the consistency of two raters on the classification of students' talk into different functional categories, an interrater reliability analysis using the Cohen's Kappa statistic was performed. The Kappa value was found to be 0.917 which indicates a strong agreement between the raters (McHugh, 2012).

Data analysis and interpretation

The analysis of the student-student interaction was made with respect to the three features: function of students' talk, modes of participation in the group work and types of student's talk. The process of classification of the students' talks into different functional categories and types of participation was carried out with the help of a pre-determined categories identified by Kumpulainen & Wray (2002). Similarly, to analyse how a student orients talks of another, a framework devised by Mercer (2000) was used. First, those talks that were explicit and could be categorized easily into the pre-defined categories were grouped according to their functions and types. Second, the students' talks that did not fit into any of the pre-defined categories were thematised to form new categories.

Notations and conventions used in the transcriptions

- Comments in a square bracket provide additional contextual information for the reader.
- Three dots (…) indicates that a section of the transcription has been omitted.
- When turns to speak are taken normally, each speaker's text begins with capital letter. When one speaker overlaps another, the first speaker's transcript is broken off with two dots and the new speaker's words are started with two dots and without capital letter.
- Texts inside double quotation ("…") indicates that it is a direct transcription of teacher's or student's utterances […] indicates pause by waiting for some kind of reaction.

Results

Functional analysis of students' talk

The functional analysis of students' talk is concerned with the purposes for which the students used their oral language in their group interaction. Table 1 presents the pre-defined functional categories outlined by Kumpulainen & Wray (2002) and used to analyse the functions of the students' talks in this study.

Table 1. Functional categories of talk identified by Kumpulainen & Wray (2002)

Function of Talk	Description
Responsive	Talk used to respond to a question or statement
Organizational	Talk used to organize work or learning process or control behaviour
Interrogative	Questions either requiring information or social approval
Judgemental	Talk used to express agreement or dis agreement
Informative	Talk used to provide information.
Argumentational	Talk used to provide reasons and support their judgment
Hypothetical	Talk used to provide ideas or suggestions that could be used as bases for further investigation

Function of Talk	Description
External thinking	Talk used to express incomplete utterances
Intentional	Talk used to ask permission to talk or do to something
Reproductional	Talk used to read a text or repeat what has been said by another student
Compositional	Talk used to create or revise a written or spoken text
Expositional	Talk used to accompany a demonstration of a phenomenon or an experiment
Heuristic	Talk used to express having found out something
Experiential	Talk used to express personal experience
Affective	Talk used to express personal feeling or emotion
Imaginative	Talk used to express imaginative situations

The functional analysis of students' talk was conducted on the transcript of students talk when they were engaged in a small group work of solving a workout problem on simple machines. The problem that the teacher gave for all the groups in that class by writing it on the chalk board was:

A certain machine is used to lift a load of 400N when an effort of 80N is applied to a machine. The load is raised by 2m and the effort is moved by 20m.

Calculate:

A. The velocity ratio of the machine

B. The MA of the machine

C. The work output

D. The work input

E. Efficiency

Such a workout task is typical of the exercise teachers give to their students in these grade levels. These tasks, naturally, require students to follow certain rehearsed algorism leading to the write answer as far as student could pick the right formula and substitute the correct quantity in the formula. In Table 2, students' talk over their engagement with the given task was presented. The group members contributed to the talking while the group leader, Aziza, was doing most of the talking.

Table 2. Interaction dynamics among members of the group (lesson topic: efficiency)

Turns	Participants	Transcribed interaction	Functions of oral language	Modes of participation
1	Aziza	On whose exercise book do I show you the calculation?	Asking for permission	Domination from Aziza
2	Zehara	Let us do the first	Organizing	Initiation collaboration from Zehara
3	Aziza	Let us do together. Look attentively. I do not need you to joke! Velocity ratio is equal to distance moved by the effort over distance moved by the load. Is that not?	Organizing, asking for confirmation, describing relationship	Initiation collaboration from Aziza
4	Members	Yes	Responding	
5	Aziza	VR is not given. VR is equals to []	Providing information, initiating response	
8	Mita	I did not understand	Informing	
9	Aziza	How much is the distance moved by the effort?	Asking for information	
10	Members	Twenty	Response	
11	Aziza	You are given twenty meters, after that two meters. Meter will be cancelled by meter. Twenty divided by two is []	Providing information, asking for response, describing computation	Domination from Aziza
12	Members	Ten	Response	
13	Aziza	Ten. what is this? This is velocity ratio. Then, let us do (b). You are asked MA. MA is equal to []	Repeating, asking for response, providing information	
14	Zehara	Let me tell you the formula	Organizing, asking for permission	
15	Aziza	Load over E. Is that not? How much is the value of load you are given?	Providing information, asking for information, asking for con-	

			firmation, describing computation	
16	Members	Four hundred	Response	
17	Aziza	L_E []	Initiating for response	
18	Members	Eighty	Response	
19	Aziza	Newton is cancelled by Newton, zero is cancelled by zero. Forty divided by eight []	Describing computation, initiating response	Domination from Aziza
20	Members	Five	Response	
21	Aziza	Aziza: MA is equal to five. So, mechanical advantage is unit less	describing computation	Domination from Aziza
22	Lidia	Unit less!? Ok		
23	Aziza	Work input [moving to the next question] L times SL. Is that not? How much load are you given? Four hundred Newton. How much is the distance moved by the load?	Describing computation, asking for confirmation, asking for response	
24	Lidia	Two	Providing response	
25	Aziza	We can't cancel them because the units are different	Providing reason	
26	Members	Eight hundred	Response	
27	Lidia	Is that multiplication?	Asking for response	
28	Mita	It is eight hundred if they are added	Providing information	
29	Aziza	After that (D)	Organizing	
30	Zebiba	Not D, it is C	Showing disagreement	Sign of disagreement
31	Mita	I did not understand C. How did you do?	Providing information, asking for information	Initiating collaboration and support
32	Aziza	Work input is equal to effort times distance moved by the effort	Describing relationship, providing information,	

The effort is eighty. Is that not? How much is the distance?	asking for information, asking for confirmation

As can be seen in the interaction dynamics above, the students used their oral language for different purposes. They used their oral language for asking questions. Some of the questions required reactions from their peers in the form of confirmation (turn 3); some others required provision of some kind of known information (turn 23) and the rest required answers from other members of the group (turn 5). There were also questions posed for the purpose of asking permission to talk or do something (turn 14).

The students also used their oral language to provide responses (turn 20), information (turn 10) and to show their confirmation (turn 4) to react to the questions they were asked. In the group interaction it is also observed that the leader of the group was frequently describing relationship between concepts. In doing so, she mainly used mathematical equations as indicated in turns 23 and 32. As the group work was a kind of numerical problems, the students were observed doing different mathematical operations and they used their oral language to communicate with each other how these operations were done (turns 19 and 33).

Another function of talk observed in the student-student interaction was managing the groupwork and controlling the students' behaviour (turns 2 and 3). The students also used their oral language for reflecting their agreement or disagreement (turn 30) even if their disputation was not targeted to the issue of the discussion. In only one case, the leader of the group used her talk with a sense of describing a reason for her claim (25).

The students were observed to repeat what had been said by others (turns 12 and 13). They were also observed using their oral language to read texts form their text book and initiate others to write texts. The following lines

of transcriptions that are taken from another lesson asserts such purposes of the students' talks.

14 Zehara: Write, simple machines are… [She reads] (Reading and initiating writing)
20 Zebiba: …write it. (Initiating writing)
23 Mita: Let me tell you the definition. Lever is… [reading from the textbook] (Reading)

After the overall analysis of the students' talks, eleven individual functions were identified. Among these functions, nine of them namely, Responsive, Organizational, Interrogative, Judgemental, Informative, Argumentational, Intentional, Reproductional and compositional. were similar to those identified by Kumpulainen & Wray (2002).

Two new functional categories which were labelled as 'computational' and 'relational' were identified as emerging from the analysis of the data. The Computational function included those talks that were talked simultaneously when the students were doing computation or calculation. For example, "*Meter by meter will be cancelled out*", "*Newton meter is cancelled by Newton meter*" were categorized under computational function. Under the 'relational' function, those talks which were used to describe relationship between concepts in the form of equations or formulas were grouped. Some examples of talks that served for the relational function include "*Velocity ratio is equal to distance moved by effort over distance moved by load*" and "*Work output is equal to L times* S_L".

One thing that we noticed regarding the students' talk was the relation of the talk to the point of the discussion and their contributions to the construction of knowledge. There were talks that directly or indirectly related to the issue of discussion but had very little contribution to the construction of knowledge. For example, talks that had Intentional, 'organizational' and 'compositional' functions were kinds of related but irrelevant talks. For example, talks like "*Let*

me write" and "*Let me tell you*" that had an Intentional function. Even though what students were going to write or tell to the group members were related to what they were discussing, their role in supporting students to make meaning is insignificant. Similar interpretation can be applied to talks that had 'organizational' and 'compositional' functions as well. On the other hand, there were talks that were both related to the issue of the groupwork and had relevance to the construction of knowledge even if their contributions were different.

The importance of talks to the students' learning varies from one functional category to another. For example, the purpose of 'reproductional' function was to read a text or repeat what has been said by another student. Talks that have this function is important to the students' learning because what has been read by the students may be used in the discussion in various ways such as to clarify ideas, remove confusions or start discussion. However, reading definitions of physics concepts from textbook is not equally important to students' learning as justifying claims or providing reasons which require high level of thinking.

Even though most of the students' talks were both related and relevant to students' learning, a close analysis of the talks showed that they were not strong enough to promote the co-construction of knowledge. Even if the existence of different opinions or disagreements among the students are encouraged as they lead toward to the joint construction of knowledge through contrasting their perspectives using argumentation (Rojas-Drummond et al, 2013), the disagreements among the students in this study were neither targeted to the content of the lesson nor scaffolded properly by the teacher. The students were showing a kind of disagreement on what they were asked in the group task rather than on the main focus of the contents. Moreover, some functional categories in which their existence is an indicator of the existence of exploratory talk (Patterson, 2018) were observed rarely. For example, the 'Argumentational' function which is related to justification and reasoning was observed very minimally as compared to the other functional categories.

Modes of participation of students in the group work

The second feature of student-student interaction analysed in this study was concerned with how students participated in their groupwork. That was analysed based on the different modes of participation identified by Kumpulainen & Wray (2002) which include collaborative, tutoring, argumentative, individualistic, dominative, conflict and confusion. The description of the seven predetermined modes of participations were presented in Table 3 as stated by Kumpulainen & Wray (2002).

Table 3. Modes of participation in group interaction

Modes of participation	Description
Collaborative	Joint activity characterized by equal participation and meaning making
Tutoring	Student helping and assisting another student
Argumentative	Students are faced with cognitive /social conflicts which are resolved and justified in a rational way
Individualistic	Student(s) working on individual task with no sharing or joint meaning making
Domination	Student dominating the work, un equal participation
Conflict	Social and academic conflicts which are often unresolved
Confusion	Lack of shared understanding, student (s) do not understand the task or each other, often includes silent episodes

The students' participation during their group work was analysed in two ways. First, the kind of participation they made was identified based on the interaction dynamics of the group work. Second, the numbers of talk turns used by the members of the group was considered to analyse the proportion of their participation.

The analysis of the students' interaction with respect to their involvement in the group-work seemed to be similar in the three lessons. The group-work in general was dominated by one student (the leader of the group) which was evident by the higher number of talk-turns she used as shown in Table 4.

Table 4. Number of talk turns by members of the group in three lessons

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	Lesson 1		Lesson 2		Lesson 3		Total	
Members	N	%	N	%	N	%	N	%
Group-leader	21	56.8	19	47.5	9	37.5	49	48.5
Group-member 1	2	5.4	2	5.0	5	20.8	9	8.9
Group-member 2	2	5.4	4	10.0	2	8.3	8	7.9
Group-member 3	2	5.4	4	10.0	4	16.7	10	9.9
Group-member 4	3	8.1	1	2.5	4	16.7	8	7.9
Member together	7	18.9	10	25	0	0	17	16.8
Total	**37**		**40**		**24**		**101**	

As can be seen in Table 4 and the observation of classroom videos, variation was noticed in the participation of the students in their group-work across the lessons. Most of the group-work time was used by the group leader (48.5% on average) whereas, the other four members share on average about 8.6% individually. The leader used the dominant talk share for different purposes as exemplified in in Table 2 and used a greater number of talk-turns in the three lessons (Table 4). The other members of the group were involved in responding to the group leader's questions. Their responses were short and mainly numbers. More than 30% of the talk turns that shared by the group members (excluding the leader) were used to provide answers in the form of numbers which were either explicitly given in the questions or could be found using simple mathematical operations (example: turns 10, 12, 16, 18, 20, 24, 26 of Table 2). In addition, in most of their talks, the group leader preferred to say "*What are you given*?" than "*What are we given*?" when she asked the members to tell her the value of the given quantities indicating that the group leader considered herself as someone who perform more than the other members and acted as a tutor.

Regarding the number of talk turns, it was observed that the leader of the group used more talk turns: 56.8% in lesson-1, 47.5% in lesson-2 and 37.5% in lesson-3 to talk which in turn indicating the imbalance of the participation of members in the group-work. Although the group leader attempted to initiate the members to participate in the group-work, her intention seemed not to create collaboration among them for the co-construction of knowledge as the initiations were not more than asking easy questions which was incapable of encouraging them to contribute their ideas for the co-construction of knowledge. That is why many of the group members' talks were limited to a maximum of only two words as indicated in the turns 10, 16, 20, 24, 26, 34 of Table 2.

It was also noticed in Table 4 that the number of talk turns in the group discussion of the third lesson (topic: Types of simple machine) was lower relative to the other lessons. One of the reasons for the existence of small number of talk-turns in this lesson relative to the others was that the questions in the task were not numerical in which they did mostly during groupwork session. Except in this lesson, in all other lessons, the students were provided with numerical problems to be solved in groups. Moreover, the smaller time given to the group-work in this lesson restricted their discussion as they were forced to stop their group-work 5 minutes after they started. However, relatively longer time was given for the first two lessons (15 minutes for the first and 14 minutes for the second).

Types of students' talk in the group work

The third feature considered in the analysis of student-student interaction was the types of talks that the students made in the dialogue during group-work sessions. These talks are distinguished based on how participants in the dialogue orient each other's point of views as devised by Mercer (2000).

It was noticed in the previous sections that the participation of students in the group-work was mostly dominated by the leader of the group. Although, the group leader asked many questions to the group members, the purpose of

the questions was neither to create dialogue nor encourage argument among students. Her questions mainly required numerical responses like numerical values given in the questions and numerical values that could be found using simple mathematical computation. For the questions asked by the group leader, the group members did not need to discus, talk and critically think. They required only to see the given values in the question or to make simple mathematical operations. For example, in Table 2, while the leader's questions represented by turn 11 and turn 19 need only dividing numbers, those represented by turn 9 and turn 15 could be answered simply by reading the questions in the task.

It was also recognized that the domination of the group leader and the nature of the questions in the task led the other members of the group to be involved for only answering the group leader's easy questions. This in turn made the discussion to be closed in terms of providing opportunity for open discussion, demonstration of different points of view and the critical construction of knowledge. What was mainly observed in the group discussion seemed that the group leader took all the responsibility of doing the group-work tasks and the other members engage in listening her explanation and sometimes in answering questions in a supportive manner. This verified that more of the students' talk in the group-work was a type of 'cumulative' talk in which the participants of the talks build on each other's contributions and the information of their own was added in supportive and uncritical way as stated by Mercer (2000). One thing we noted about students' talk here is that because of the nature of the group task and the students' culture of doing group-works, the contribution of the members to the group discussion was limited to short talks usually not more than a single statement. Even if the discussion was not built by a significant contribution of ideas from the members, their support to what the group leader said was evident by their positive responses. In general, the overall examination of the data indicated that most of the students' talks in the discussion was tended to be more of cumulative than disputational.

Discussion

The three aspects of student-student interaction investigated in this study were purposes of students' talk, their participation in the group work, and the way student respond to point of views of others during interaction. Pre- defined codes outlined by Kumpulainen & Wray (2002) and Mercer (2000) were used in the analysis with allowance to the emerging codes.

With regard to the functions in which the students used their oral language, 9 of which identified according to Kumpulainen & Wray (2002) were observed and two more new functions: 'relational' and 'computational' were identifed as emerging functions from the data. The imaginative, affective, experiential, heuristic, expositional, external thinking and hypothetical functions from Kumpulainen & Wray's frameowork were not observed in the present study. The finding of this study is similar with that of the study by Ambrosino et al. (2015) that used the same analytical framework for the functional analysis of children's classroom discourse in that both studies missed the heuristic and hypothetical functions and revealed new emerging functions even if they served for different purposes in the respective studies. However, the number of functional categories identified in this study is lower.

The existence of the two newly emerged categories of functions was due to the nature of the group-work tasks given. As most of the groupwork tasks used in the lessons were numerical, students were describing relationship between variables in their interaction and making computation which resulted in the 'relational' and the 'computational' functions respectively. The existence of the small number of categories of functions as compared to those identified by Kumpulainen, & Wray (2002) and Ambrosino et al. (2015) might indicate that the students were not provided with an environment where they could make effective and sustained dialogue.

The second aspect of student-student interaction was concerned with how students were involved in the group-work. Many literatures acknowledge the value of fostering peer interaction in the context of collaborative group-work

as effective strategy to facilitate learning. Collaboration among peers help students establish shared understanding, divide workload and responsibilities (Rosen et al., 2019); help create opportunity to engage students in various beneficial behaviours like explaining, questioning, elaborating (Asterhan & Schwarz, 2009). However, in our study, the participation of students was characterized mostly by domination which was evidenced by the variance of the relative talk turns among the students as explained earlier.

The third aspect of student-student interaction considered in this study dealt with the analysis of how students react to the perspectives of others during group discussion based on the categories outlined by Mercer (2000). The analysis showed that the interaction between students was dominated by a 'Cumulative' type of talk in which the group leader talked and the other students listen, respond to questions, repeat what the leader said or confirm what the leader was talking was right by saying 'yes' or 'ok'. Although, there were initiations of collaboration among students, the intention of the initiation was not only to bring ideas from different students and co-construct meaning but also observed in the interaction rarely. Rather the initiations were more of organizational and were intended to encourage the group members to work together. For example, talks like "*Let us do it together?"* and "*Shall we work on the next question?*" were used to encourage this kind of collaboration.

In our data, situation of exploratory talk which is the characteristic of dialogic teaching (Mercer, 2000; Mercer & Dawes, 2008) was not observed in any of the lessons. We recognize that the absence of exploratory talk and meaningful interaction among students were related to the nature of the questions, which were not demanding students to explicate their various ideas in the group-work tasks and the teacher interventions by way of scaffolding the debate (Van de Pol et al., 2010).

High quality of classroom interaction is associated with high level of scaffolding and support for learning and thinking on the part of the teacher

(Reznitskaya et al., 2009). This in turn implies that students' interaction is enhanced when the teacher created classroom environment where students actively engage in the classroom discussion. In such environment, teachers provide support for the development of knowledge and create meaningful talk by prompting students to justify their claims, explain their perspectives and evaluate the perspective of others. In this regard, the teacher plays key roles in creating conceptual development and participation through open questions, providing feedback, assisting students in explaining their point of views, creating opportunity to clarify their thinking (Gillies, 2014; Mortimer & Scott, 2003).

Scholars claimed that the teacher's questioning strategies and management of question and answer sequence were associated with the nature and extent of students' explanations in students dialogue (Webb et al., 2008; Mercer, 2005). To explore students' thinking, encourage them to elaborate their ideas and help them construct conceptual knowledge, teacher's questions have to be open and require higher order thinking (Chin, 2007). However, the teacher's oral questions that were frequently used to facilitate the discussion in this study were not effective enough to encourage students express their thoughts. Questions like "*What do you think*?", "*How do you do*?", "*What is your idea*" and "*What will happen if…*?" that are important to encourage exploratory talks (Swann, 2007) were not heard in the interaction.

The second factor that seemed to limit the students' exploratory talk was the nature of the groupwork task. The tasks that students perform are the most important aspect of the design of any teaching and learning environment (Herrington & Herrington, 2006). For effective collaborative group-work, the groupwork tasks need to be designed in a way that they create opportunity for the students to explain, question, compare and contrast perspectives, argue, elaborate and generate ideas (Hausmann, 2006; Asterhan & Schwarz, 2007). However, the questions in the groupwork task were not prepared in a way to initiate students to offer claims and suggestions through justification and reasoning that encourage exploratory talk (Mercer & Littleton, 2007; Mercer &

Dawes, 2008). It was also observed that the answers of some of the questions in the tasks were available in the textbook. This led the students to read from the textbook rather than discussing, arguing and forwarding their point of views about the questions.

Conclusions

As the research has demonstrated, the students were involved in group talks that have eleven different functions. Most of these talks had little significance to the co-construction of knowledge because of their low quality and low frequency of occurrences. The interaction among students during the group-work session was characterized by domination. The group members were recipients of what had been said by the group leader without questioning, which resulted in a cumulative type of talk. Exploratory talk which is a characteristic of dialogical teaching were not observed in the interaction of all lessons. It was also noticed that the poor preparation of group-work task and the ineffective teacher interventions were accounted for the existence of low quality and quantity of student talks, dominated classroom interaction and the absence of exploratory talks. The finding of the present study contributed to the literature by providing insight on how student-student interaction can influence the implementation of dialogic teaching in physics classrooms.

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