Explore the participation of students of few words in dialogic collaborative problem solving

1. Introduction

Dialogic collaborative problem solving (CPS) is a process by which students solve problems by working together, mainly or wholly through productive peer talk. Previous studies have established that to best enable the success of a collaboration, there should be no significant difference among individual participations in CPS. Scholars have adopted various constructs to describe the similarity in individuals' modes of participation such as symmetry (Asterhan & Schwarz, 2009; Dillenbourg et al., 2016), verbal equity (Borge et al., 2018; Borge & Carroll, 2014), relational equity (Boaler, 2008), participation equity (Shah & Lewis, 2019) and participation inequity (Kapur et al., 2008; Shah & Lewis, 2019).

Participation equity describes students' relative degrees of access to the conversational floor (Shah & Lewis, 2019). Its presence or absence can affect whether a team can integrate the perspectives of its different team members. Participation inequity may lead to information loss, to dominance by a majority of the team members or to limitations on a team's potential to perform various tasks (Borge & Carroll, 2014; Woolley, Chabris, Pentland, Hashmi & Malone, 2010).

The individual participation rate reflects the aggregated degree of individual vocal engagement. In dialogic CPS, the participation rates of group members always vary a lot. Stephan and Mishler (1952) explored the distributions between individual rates of participation in small group interactions. These researchers found that the members' participation rates decreased exponentially with their participation ranks,

and that this decline was magnified as the group's size increased. Kapur et al. (2008) adopted the standard deviation of individual participation rates as an index of participation inequity. They found that this index tended to reach a plateau at a very early stage of group discussion.

It has also been intensively explored what factors might affect individual verbal participations. For example, academic status strongly affects participation patterns (Cohen & Lotan, 2014). Individuals of relatively higher academic status in their groups tended to speak more and to be better trusted by other members. Furthermore, reading ability is a strong indicator of perceived individual academic status among peers (Rosenholtz, 1985). Chizhik (2001) found open-ended tasks could enhance equity of participation than single-answer tasks because open-ended tasks offer multiple entry points and therefore mitigate the dominance of knowledgeable students. Students' uptake of collaborative roles is also important for equitable participation (Esmonde, 2009). Students' sense of respect for each member especially those who has low intellectual status (Boaler, 2008) would allow them to perform an equitable participation pattern.

The present study is based on a face-to-face small-sized dialogic CPS context and aims to explore the participations of students of few words in each group. In particular, there are two research questions that this study is going to address.

Research question 1: What kind of students spoke few words in dialogic CPS? This question aims to explore demographic and psychological features of students of few words in dialogic CPS.

Research question 2: How students of few words take turns in dialogic CPS? This question aims to investigate the approaches that students of few words access to the conversational floor and their intensions when actively taking the floor.

2. Method

2.1 Participants and procedures

This study was conducted in a primary school in a city of mainland China. Participants were 168 fourth graders from five classes (41% females, 59% males). The teachers helped organize the students into groups of four, balancing gender and prior mathematics grades. To ease the effect of task structure on individual participation modes, the present study designed three structured, open-response mathematical problems with various difficulties levels (featuring *ice cream*, a *snake* and a *bridge,* see the appendix for the translated English versions). Each group was given 30 minutes to collaboratively solve these three problems in a normal classroom setting. All problems were translated into English and could be found in the appendix.

Before the test, each student was asked to write down the names of his/her group members and give a score from 1 to 10 to indicate his/her willingness to collaborate with each member. After the test, students independently completed a questionnaire concerning their demographic information, mathematics learning enjoyment, mathematics self-concept, and social anxiety. Both measurements on self-concept and learning enjoyment used a four-point Likert scale adapted from TIMSS 2015 (1 = strongly agree, 2 = somewhat agree, 3 = somewhat disagree and 4 = strongly disagree).

The Cronbach's alpha was 0.882 and 0.734 respectively. Students were also asked to indicate the overall group performance, and his/her own performance in the group discussion immediately after finishing the task. Social anxiety was measured using the 10-item Chinese version of the Social Anxiety Scale for Children—Revised (La Greca & Stone, 1993). The students were asked to indicate the frequency of specific behaviours on a 3-point Likert scale (1 = always do this, 2 = sometimes do this, 3 = never do this). The Cronbach's alpha was 0.835.

2.2 Identification of students of few words

The present study adopted a two-step technique to identify students of few words. First, to ensure a certain amount of participation inequity within group members. The measurement of participation inequity was adopted by Kapur et al. (2008). It refers to the standard deviation of individual participation rates. Individual participate rate was operationalized as the percentage of turns the individual accessed in group discussions. In this step, we exclude groups whose participation inequity was in the fourth quantile. Second, the least speaking student in each of the left groups was labeled as "Least"; the most speaking one as "most"; and the left two students as "moderate".

2.3 Identification of turn-taking approaches

The analytical tool applied for this task is the participation-shift (P-shift) framework. This framework is focused on how turns shuffle among speakers (Leenders et al., 2016), and it describes 'the way in which people move themselves and one

another onto and off the floor' (Gibson, 2005, p.1,566). The participation-shift framework differentiates between the various speakers, targets and third parties in human interactions, and it further identifies four categories of participation shifts (see Table 1). Turn-receiving happens when a target takes the floor offered by a speaker. Turn-claiming happens when a speaker addresses the whole group, and a third party responds to this open invitation. Turn-usurping happens when a third party usurps the floor of the target who was assigned by the speaker. Turn-continuing occurs when a speaker continues to occupy the floor while talking to various other individuals. These participation shifts cover all possible micro turn-taking motifs, and they can thus describe how turns shift from one speaker to the next.

Table 1 Participation shifts as defined by Gibson (2003, 2005).

All transcripts of group discussions were coded according to the P-shift framework by two trained coders (see Table 3). They both coded three of the groups separately, and achieved an acceptable level of inter-rater agreement (*Kappa* = 0.692; Landis & Koch, 1977). All disagreements over coding were resolved through negotiation.

3. Results

3.1 Characteristics of students of few words (RQ1)

The present study identified 32 students speaking least from 42 groups. The average participation rate of them in a four-person group was 12.40% (SD = 4.38%), with a maximum of 19.13% and the minimum of 4.2%. One-way ANOVA revealed significant differences among three types of students in the turn-receiving participation

shift, turn-usurping participation shift, recent Chinese grade, recent mathematics grade, mathematics self-concept, gender, and subjective self-assessment (see Table 2). According to the post-hoc Tukey analysis, students speaking least participated in group discussions through usurping turns from others. They received significantly less turns from group members. Their recent mathematics and Chinese grades were also the lowest among the three types of students.

Table 2 Comparisons among students of various levels of verbal participation.

In addition, students speaking least showed lowest mathematics self-concept. They also reported more intense social anxiety compared with those speaking most. There was a similar percentage of female students in the "speaking least" and "speaking most" categories (44% and 47% respectively), while the percentage was relatively higher in the "speaking moderate" category (67%). However, the difference did not reach a significance level among pairwise post hoc tests.

3.2 Turn-taking patterns of students of few words (RQ2)

Research question one revealed that students speaking least significantly usurped turns to participate compared to students speaking more. This section further investigated specific intensions of students speaking less when they usurped a turn to contribute, and how their voice got responded by their peers in the group through scrutiny of three concrete groups. The three groups selected for this section represented three types of groups: discussed more and achieved a good solution (More-Good), discussed less and achieved a good solution (Less-Good), and discussed less and

achieved a bad solution (Less-Bad) (see Table 3).

Table 3. Characteristics of three selected groups

We further investigated whether relatively silent students interrupted others when they usurped a turn. It was found that the turn-usurping shifts seldom caused interruptions of last speakers with percentages of interruption all smaller than 10% across three groups.

Then, intentions of turn-usurping were identified through an open coding process based on existing coding schemes on talk moves (Hennessy et al., 2016; Michaels et al., 2010). Specific example excerpts of major turn-usurping intentions were illustrated in Table 4. In addition to the cognitive dimension, special functions of the turn-usurping shift were identified as well including regulating problem-solving and collaboration process, expressing emotions, and proposing actions.

Table 4 Major intentions of the turn-usurping shift on the basis of three example groups.

It was further found that *add on*, *new idea*, *disagree*, *agree, question* and *propose* were common intentions of turn-usurpings across three groups (see Fig. 1). In addition, the More-Good group showed a unique high percentage of *repeat.* A further investigation of this group revealed that students of this group had a very high level of collaboration. *Repeat* happened frequently when one student wrote down the solution while the other three kept informing him/her on what to write down. Meanwhile, the turn-usurping shifts in the Less-Bad group consisted a quite high percentage of *proposing* actions, expressing *emotions*, *regulating* collaboration and off-task.

Figure 1. Distribution of major intentions of turn-usurping shifts in three representative

groups.

Figures

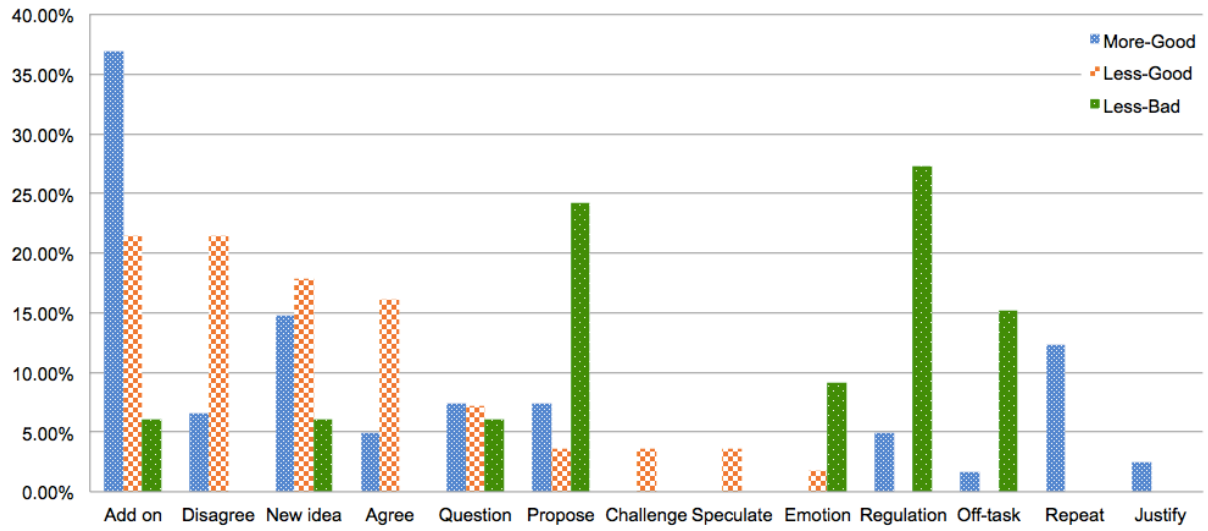
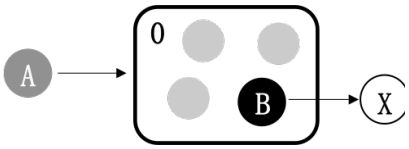
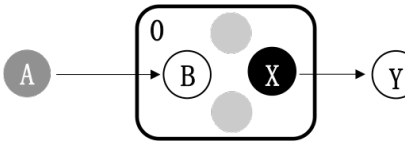
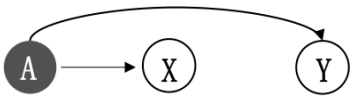


Figure 1. Distribution of major intentions of turn-usurping shifts in three representative groups.

Tables

Table 1 Participation shifts as defined by Gibson (2003, 2005)

Participation shift	Formula [a]	Illustration	Description
Turn-receiving	AB-BX		A talks to B, then B talks to X (X could be A or the group).
Turn-claiming	A0-BX		A talks to the group, then B talks to X (X could be A or the group).
Turn-usurping	AB-XY		A talks to B, then to X (X is not B or A) talks to Y (Y could be A, B or the group).
Turn-continuing	AB-AX		A talks to X (X could be the group), then A continues to talk to Y (Y could be the group).

a. The formula denotes the following: (speaker) (target) – (third party) (target of third party). The group is denoted as 0. X and Y represent people other than the neighbouring speaker and target.

Table 2 Comparisons among students of various levels of verbal participation.

Variable	Least	Most	Moderate	*F*-Test	Significant pairwise post hoc tests[c]
percentage	12.40% (4.38%)	37.56% (4.19%)	24.95% (6.75%)	157.89***	Least<Moderate<Most
Claim	27.32% (12.04%)	23.75% (6.92%)	28.29% (9.47%)	2.4	
Receive	27.44% (13.53%)	55.85% (11.34%)	37.93% (14.20%)	37.33***	Least < Moderate < Most
Usurp	44.92% (14.57%)	19.89% (8.66%)	33.40% (13.08%)	31.92***	Least > Moderate > Most
Recent Chinese grade[a]	98.54 (9.68)	107.59 (6.68)	100.83 (11.16)	6.391**	Least < Most; Moderate < Most
Recent mathematics grade[a]	93.13 (12.25)	106.26 (7.73)	100.32 (11.65)	9.075***	Least < Moderate < Most
Mother's education level[b]	2.91 (1.48)	2.68 (1.09)	3.23 (1.35)	1.27	
Father's education level[b]	3.55 (1.57)	3.41 (1.18)	3.51 (1.34)	0.062	
Mathematics self-concept	2.68 (0.74)	3.32 (0.55)	3.15 (0.51)	8.84***	Least < Moderate; Least < Most
Mathematics enjoyment	3.33 (0.66)	3.63 (0.38)	3.58 (0.56)	2.43	
Social anxiety	1.64 (0.45)	1.37 (0.37)	1.53 (0.40)	2.98	Least > Most
Female	0.53 (0.51)	0.56 (0.50)	0.33 (0.47)	3.23*	
Willingness	7.01	7.08	6.92	0.054	

to collaborate	(1.80)	(2.07)	(2.27)		
Subjective self-assessment	5.96 (2.88)	7.63 (2.12)	6.34 (2.59)	3.26*	Least < Most
Subjective group assessment	6.92 (2.74)	7.56 (1.83)	8.00 (2.25)	1.93	

Note. $* p < .05$. $*** p < .001$.

[a] The maximum score is 120.

[b] Educational level. 1: Primary school or below; 2: middle school; 3: high school or technical high school; 4: junior college; 5: undergraduate; 6: graduate or above.

[c] Non-significant pairwise post hoc tests are not reported.

Table 3. Characteristics of three selected groups

Group	More-Good	Less-Good	Less-Bad
Number of turns	361	173	126
Group score	7.67	8.33	3.00
Number of turn-usurping	122	56	33
Average prior mathematics grade	105.50	94.75	107.33
(Average) prior mathematics grade of the student speaking least	98.5	96	NA
(Average) prior mathematics grade of the student speaking most	111	106	112

Table 4 Major intentions of the turn-usurping shift on the basis of three example groups.

Code	**Explain**	**Example**
Add on	Build new contributions upon others' or collective ideas.	Zhang (→Mei): You write down the third solution because you have the clearest train of thought. Could use the current… current number of stones…to get the probable... **Zhou** (→Zhang): Get the probable length of the snake Zhang (→Zhou): Should it be the probable number of stones?

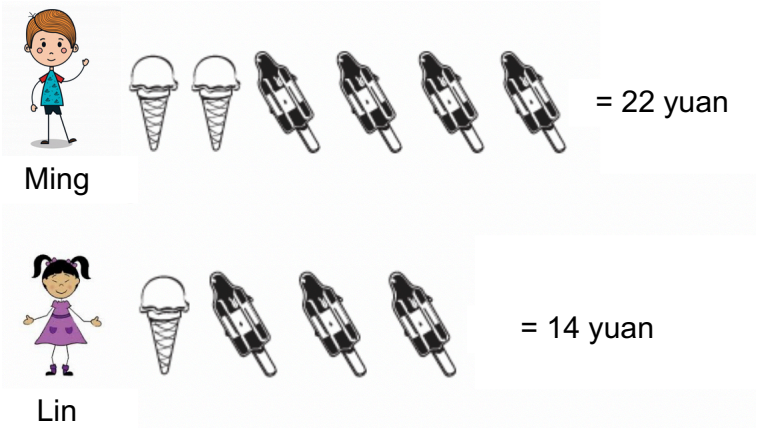
Question	Initiate a question to seek for new ideas, verification, elaborations, or explanations.	Zhang (→Group): we could use the red scarf. Fang (Zhang): The red scarf is too thick. **Mei** (→Group): Then how should we do? Zhang (Mei): We could use a soft staff.
New idea	Contribute to group knowledge such as proposing a new solution, viewpoint, suggestion, or plan.	Qiu (→Sun): They are the same! **Chen** (→Group): I feel that I also have a new idea. We could… could…could use the slowest Ding and fastest Jia. Therefore it is 11 minutes altogether, 11… *(being interrupted)*. Qiu (→Chen): No! They are all together!
Disagree	Disagree or partially disagree with other's or collective contributions.	Sun (→Chen): I think I have a different idea now. Send Ding first because he is the slowest. Isn't it right? **Qiu** (→Sun): But they use the same time and send the same people! Sun (→Qiu): Right, emm, send the slowest person, then the time spent should be less.
Agree	Agree with other's or collective contributions.	Sun (→Chen): Jia… Bing… There are four people. Bing is one of them. He has to cross the bridge as well. **Qiu** (→Sun): Yes. *(2-second pause)*. Sun (the group): We still have a few minutes left. Let's think again quickly.
Justify	Explain/justify contributions.	Mei (→Zhang): Jia returns in all cases? **Zhou** (→Mei): There is one flashlight delivered back and forth. Then Jia returns again and again. **Zhang** (→Mei): Because Jia only spends one minute, the smallest amount of time. Then Jia and... Mei (→Zhang): Jia and Yi *(3-second pause)*
Challenge	Challenge/confront other's view/assumption/argument.	Qiu (→Sun): Therefore, they spend the same time. **Chen** (→Qiu): But the case is Jia will cross the bridge before Ding. Qiu (→Chen): That would be okay if Jia slowed down and kept the same speed with Yi.
Speculate	Speculate/hypothesize/imagine different possibilities/theories based on previous contributions.	Qiu (→Chen): That would be okay if Jia slowed down and kept the same speed with Yi. Chen (→Qiu): In this case… Okay. **Sun** (→Chen): In addition, if Jia did not slow down, he would also arrive in 10 minutes of Yi.
Repeat	Simply repeat what has been said before.	Zhou (→Mei): Measure roughly the snake... Zhang (→Mei): Measure roughly the length of the snake **Zhou** (→Mei): The length of the snake

Propose	Propose specific actions like writing, being quite, thinking, or asking someone to talk.	Wang (→Hu): what is the unit price? **Xia** (→Wang): He is not clear about this. Please let me talk. Wang (→Xia): Okay. Group leader Wang, please express your viewpoints.
Regulation	Regulate problem-solving and collaboration process such as time management, and task/role assignment.	Xia (→Wang): I am number one, the group leader. Wang (→Xia): I am! **Liu** (→Xia): Wang is number one, the group leader. Xia (→Liu): You said let me be the group leader!
Emotion	Explicitly express one's feelings such as happiness, pride, discouragement, anger, impatience or disdain.	Wang (→Hu): Oh, member number two please talk. Okay… member number three please answer what is the unit price for an ice cream. Member number three! Hu (→Wang): What？ **Liu** (→Hu): She *(refers to Wang)* gets some problems with her brain. Hu (→Wang): I didn't hear it clearly. Please say it again.
Off-task	Talk off-task such as playful or idle talk.	Xia (→Wang): What to do next? **Liu** (→Hu): Why do you turn off the recorder? Wang (→Xia): Hello, I am member number one. May I ask you a question? What on earth is the answer for the first question that you feel?

Note. In the format of student1(→student2), student1 is the speaker, while student2 is the target. Highlighted speakers were students of few words who enabled a turn-usurping shift with the according intention.

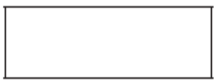
Appendix

Ice Cream. Ming buys two ice creams and four popsicles. He spends 22 yuan in total. Lin buys one ice cream and three popsicles. She spends 14 yuan in total. How much do one ice cream and one popsicle cost? Please write out your problem-solving process in detail.

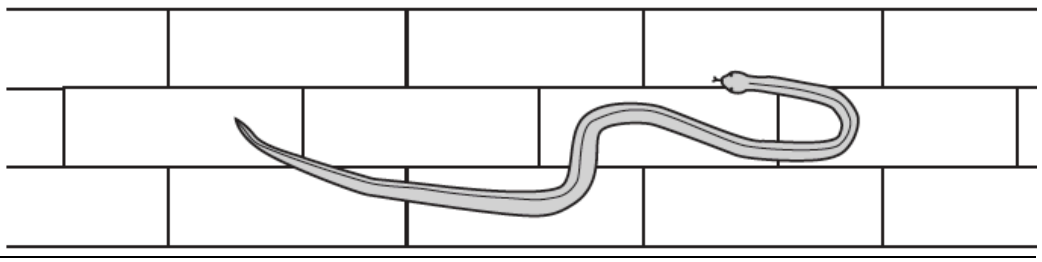


Answer: One ice cream costs _____ yuan.
One popsicle costs _____ yuan.
Your problem-solving process:

Snake. There is a snake on a pathway in a park. The pathway is made of stones, as shown below.



If we straightened the snake out to its full length, how many stones would it occupy? Please try to solve this problem by using as many approaches as you can, and write out all of the solutions that you can think of.



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