Turn-taking patterns in dialogic collaborative problem solving

Liru Hu, Gaowei Chen
Faculty of Education, The University of Hong Kong, 999077, Hong Kong

Abstract

Turn-taking largely determines the social and temporal structure of collaborative talk. This study aims to identify turn-taking patterns in dialogic collaborative problem solving, whereby students solve a problem collaboratively, mainly or wholly through productive talk. There were 168 primary students assigned in 42 groups solving three structured open-response mathematical problems in 30 minutes. The present study mainly adopted the participation shift analysis framework and the latent profile analysis to detect underlying turn-taking patterns and understand how they might relate with group outcomes and individual characteristics. The preliminary analysis showed that turn-receiving was the dominant turn-taking pattern across group discussions. Turn-taking patterns were significantly related with the intensity of group interaction, but not group outcome. The turn-usurping shift was more likely to strengthen participation equity and promote more intense group interactions. In contrast, the turn-receiving shift tended to cause dominance of specific students but make group discussion more converged and thus efficient. As to individual level analysis, the present study identified four latent profiles of individuals who revealed distinctive turn-taking preferences: turn-receivers, turn-usurpers, turn-claimers, and turn-balancers. Turn-receivers and turn-usurpers showed contrast differences. Turn-receivers were most academically advantaged, highly confident, and made most contributions to group discussion; while turn-usurpers were most academically disadvantaged, unconfident, and participated least. Based on both group-level and individual level analysis, the present study further suggested that the participation of academically disadvantaged students was essential to balance participation and possibly bring in better group outcomes.

Keywords: turn-taking; collaborative problem solving; pattern; productive talk

1. Introduction

Turn-taking describes how floors flow among speakers, which largely determines the social and temporal structure of collaborative talk. Many existing studies constructed quantitative measurements to detect and illustrate possible underlying turn-taking patterns. Individual participation rate is a popular metric to characterize turn-taking in collaborative problem solving (CPS) contexts. It reflects aggregated individual degree of vocal engagement. Density in social network analysis is one commonly used metric to characterize the temporality of group cohesion (e.g., Martinez et al., 2007). Kapur et al. (2008) operationalized group participation inequity (PI) as the standard deviation of individual participation rates. Shannon information entropy (Shannon & Weaver, 1959) is another approach quantifying group-level turn-taking structure.

The framework of participation shift (P-shift) focuses on how turns shuffled among speakers (Gibson, 2003, 2005; Leenders et al., 2016). It differentiates speaker, target, and third party in human interactions, and further abstracts four categories of participation shifts (see Table 1).

Turn-receiving happens when the target takes the given floor from the speaker. Turn-claiming happens when one speaker addresses to the whole group and a third party responds to such open invitation. Turn-usurping happens when the third party usurps the target's floor that is assigned by the speaker. Turn-continuing refers that a speaker continuously occupies the floor when talking to multiple individuals in the process.

The P-shift framework could also be adopted to investigate individual turn-taking styles (Gibson, 2005). In the turn-receiving shift, the third party, also the target, is the agent to enable this shift. Therefore, the third party could be viewed as a turn-receiver. The third party in the turn-claiming shift, who actively claims the floor, could be characterized as a turn-claimer. Likewise, the third party in the turn-usurping shift, who usurps the floor, could

be taken as a turn-usurper. The speaker in the turn-continuing shift could thus be characterized as one turn-continuer.

This study mainly adopted the P-shift analysis framework to investigate patterns of turn-taking in dialogic CPS. Turn-continuing will not be considered given it does not involve the shuffling of speaker identity and seldom occurred in the present dialogic CPS context. Specifically, this study was going to address the following two questions:

Research question 1: What was the distribution of participation shifts in dialogic CPS and how did it relate with the intensity of group interaction and outcome of dialogic CPS?

Research Question 2: Were there underlying profiles arising from individual turn-taking preferences in dialogic CPS? What are the characteristics for different profiles?

2. Method

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; see the appendix for details). The teachers helped organise the students into groups of four, balancing gender and prior mathematics grades. Each group was given 30 minutes to collaboratively solve three structured, open-response mathematical problems in a normal classroom setting. All three problems were translated into English and could be found in the appendix.

Before the test, each student was asked to indicate their friendship with each group member. Group performance was indicated by both interaction intensity and group outcome. Interaction intensity was measured by the number of turns produced by one group to collaboratively solve problems. The group outcome was quantified as a total score for the solution quality based on the standard scoring criteria. After the test, students independently completed a questionnaire concerning their demographic information, Math learning enjoyment, Math learning self-concept and social anxiety. Sample questions of these three

instruments were in Table 2. Students were also asked to indicate the group performance, and his/her own performance in the group discussion immediately after finishing the task.

All transcripts of group discussions were coded according to the P-shift framework by two trained coders (see Table 3). They coded three groups together and achieved an initial inter-rater agreement of 0.692. All disagreements were negotiated and resolved. Then they independently coded all groups cooperatively. The present study mainly adopted latent profile analysis (LPA) (Gibson, 1959; Sterba, 2013), a person-based approach, to detect homogeneous latent profiles through the programming language of R (Rosenberg, Lissa, Beymer, Anderson, Schell, & Schmidt, 2019).

3. Results

3.1 Research question 1

On the average, one group produced 286 turns (SD = 116) within half an hour. Turn-receiving (M = 43%, SD = 10.3%) was the most common participation shift within groups, followed by turn-usurping (M = 29%, SD = 8.1%) and turn-claiming (M = 28%, SD = 7.5%). Furthermore, turn-receiving was negatively correlated with turn-claiming (r (42) = -0.632, p < .001) as well as turn-usurping (r (42) = -0.690, p < .001); while turn-claiming was not correlated with turn-usurping (see Fig.1).

Regarding group performance, turn-taking patterns only affected interaction intensity (see Fig. 1). It was also found that turn-usurping was positively related with interaction intensity (r (42) = 0.459, p < .01), and negatively related with participation inequity (r (42) = -0.534, p < .001) (see Fig.1). In contrast, turn-receiving was negatively related with interaction intensity (r (42) = -0.519, p < .001) and significantly positively related with participation inequity (r (42) = 0.616, p < .001).

Group outcome was not significantly correlated with the percentage of turn-claiming (r(39) = -0.173, p = 0.28), turn-receiving (r(39) = 0.002, p = 0.99), or turn-usurping (r(39) =

0.157, $p = 0.33$), with the lowest prior math grade in each group controlled. Yet, it was indicated that the correlation coefficient of turn-usurping and group outcome was relatively the largest. Meanwhile, interaction intensity was positively related group grade but did not achieve the significance level neither (r (39) = 0.186, $p = 0.25$).

3.2 Research question 2

The second research question aims to investigate subgroups of individuals who had similar turn-taking preferences. The latent profile analysis showed that the four-class model behaved best with relatively lowest AIC (AIC = 1241.02), BIC (BIC = 1297.25), biggest entropy of profiles (entropy = 0.86) and significant BLRT ($p < .05$). There were 20% of individuals belonging to Class 1 who strongly preferred usurping turns (see Fig. 2) and thus named as turn-usurpers. Individuals in Class 2 mainly received turns from previous speakers and counted for around 15%. They were named as turn receivers accordingly. Around half of individuals belonged to Class 3 (55%). Individuals of this class took turns in a relatively balanced approach and were thus labeled as turn-balancers. Likewise, there were also a few individuals (10%) belonging to Class 4 and were named as turn-claimers.

These four classes were significantly different regarding percentage of turns they took in group discussions, F (3, 164) = 37.38, $p < .001$. Turn-receivers contributed significantly higher percentage of turns in group talk (M = 35.06%, SD = 10.42%) than turn-balancers (M = 26.41%, SD = 6.66%), turn-claimers (M = 20.40%, SD = 7.80%) and turn-usurpers (M = 15.64%, SD = 5.79%). Self-assessment score was significantly different across four classes as well (F (3, 138) = 4.517, $p < .01$) with turn-usurpers (M = 5.52, SD = 2.35) significantly lower than turn balancers (M = 6.40, SD = 3.29).

Regarding individual characteristics, there was a significant difference in prior math grades across four profiles (F (3, 140) = 5.198, $p < .01$) with turn-usurpers (M = 93.02, SD =

12.00) significantly lower than both turn-receivers (M = 107.5, SD = 8.08) and turn-claimers (M = 105.16, SD = 12.02).

Chinese grade across four profiles was significantly different as well (F (3, 140) = 7.344, $p < .001$) with turn usurpers (M = 95.24, SD = 14.04) significantly lower than turn-receivers (M = 108.39, SD = 5.90) and turn-balancers (M = 102.75, SD = 8.86). Math self-concept across the four profiles was also significantly different (F (3, 142) = 5.043, $p < .01$). Turn usurpers (M = 2.73, SD = 0.70) had significantly lower math self-concept compared with turn-receivers (M = 3.26, SD = 0.61), turn-claimers (M = 3.10, SD = 0.62) and turn-balancers (M = 3.26, SD = 0.55).

4. Discussion

The present study addressed two main research questions. The first research question was to examine the distribution of micro participation shifts and how it related with group performance. The group-level analysis revealed that turn-receiving was the dominant participation shift in dialogic CPS. This finding confirmed the well-established "reciprocity" nature of human interaction (Blau, 1964; Sahlins, 1972). There is always an expected feedback from a target in human conversation. Turn-taking patterns identified in the present study, though significantly related with the intensity of group interaction, were far from enough to significantly predict group outcome. This strengthened previous findings that intense social interactions do not necessarily lead to high-quality group performance (Choi & Kang, 2010; Heo et al., 2010). Rather, the quality of interactions also matters.

The turn-usurping shift was found helpful to balance member participation, complicate the structure of group discussion and increase interaction intensity, yet not necessarily significantly related with group outcome though it had relatively largest correlation coefficient with group outcome compared to other types of participation shifts. In contrast, the reciprocal turn-receiving shift was not necessarily harmful for the final group

outcome but advantageous in speeding up the group decision process. These findings were not exactly consistent with previous studies that emphasize the beneficial effect of participation equity or entropy of discussion on group solution quality (Kapur et al., 2008; Stevens, 2012; Wiltshire et al., 2018).

The second research question aims to examine underlying profiles arising from individual turn-taking preferences in dialogic CPS and characteristics for different profiles. The present study revealed four latent profiles of students: turn-balancers, turn-usurpers, turn-receivers, and turn-claimers. Turn-usurpers actively fought for most of their turns in discussion. Most of them were academically disadvantaged. They showed least math self-concept and also participated least. Turn-usurping tended to increase the chaos of participation, bring in new perspectives or indicate phase transitions. Since many studies have proved the group level chaos was beneficial to group outcome (Steven, 2012; Wilshire et al., 2018), though not exactly the case in the present study, the participation of academically disadvantaged students seemed essential to group outcome.

In contrast to turn-usurpers, turn-receivers showed high social status in terms of prior math/Chinese grades, self-concept and also occupied most turns in group discussions. This might indicate that turn-receivers were relatively popular addressees and thus were frequently nominated by their peers in group discussions. On the other hand, turn-receivers were relatively passive in taking turns compared with turn-claimers or turn-usurpers. Thus, they might be knowledgably advantaged but not facilitative leaders.

Appendix

Table 1 Background information of participants in the present study

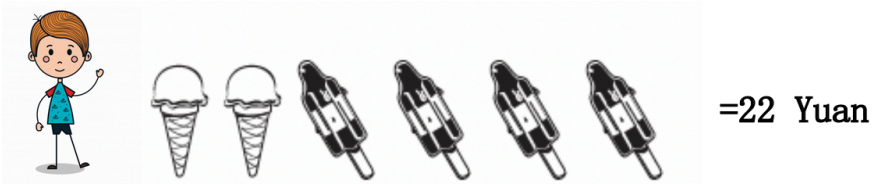
	N	Min.	Max.	*M*	*SD*
Age	168	8	12	10.50	0.57
Recent math grade[a]	144	11	120	100.97	13.78
Recent Chinese grade[a]	144	58	117.5	101.49	10.09
Mother's education level[b]	112	1	6	2.97	1.31

Father's education level[b]	112	1	6	3.39	1.28
Math self-concept[c]	146	1.44	4.00	3.16	0.62
Math enjoyment[c]	146	1.33	4.00	3.58	0.53
Social anxiety[d]	146	1.00	3.00	1.51	0.42

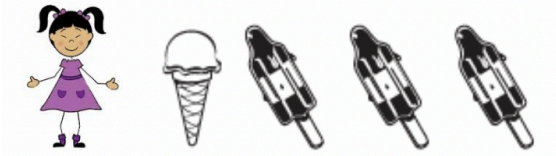
a. Full score is 120.
b. Educational level.1: Primary school or below; 2: Middle School; 3: High school or technical high school; 4: Junior college; 5: Undergraduate; 6: Graduate or above.
c. Four-point Likert Scale. Full score is four.
d. Three-point Likert Scale. Full score is three.

Table 2 Three mathematical problems set in the study

Ice Cream. Xiao Ming buys two ice creams and four popsicles. He spends 22 yuan in total. Xiao 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.



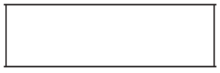
Xiao Ming



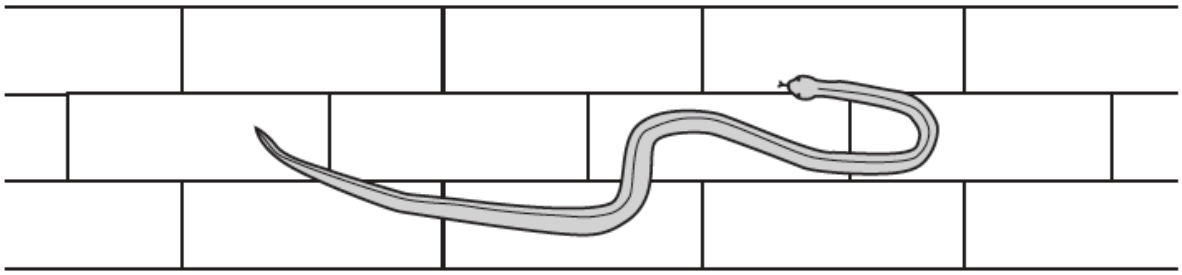
Xiao Lin

Answer: One ice cream cost _____ yuan.
One popsicle cost _____ 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 using as many approaches as you can and write out all of the solutions that you can think of.



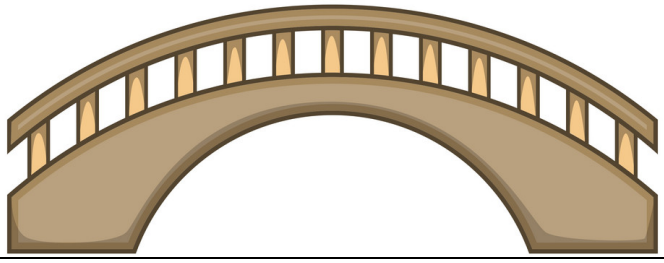
Answer: The straightened snake would occupy _____ stones.

Solution 1:

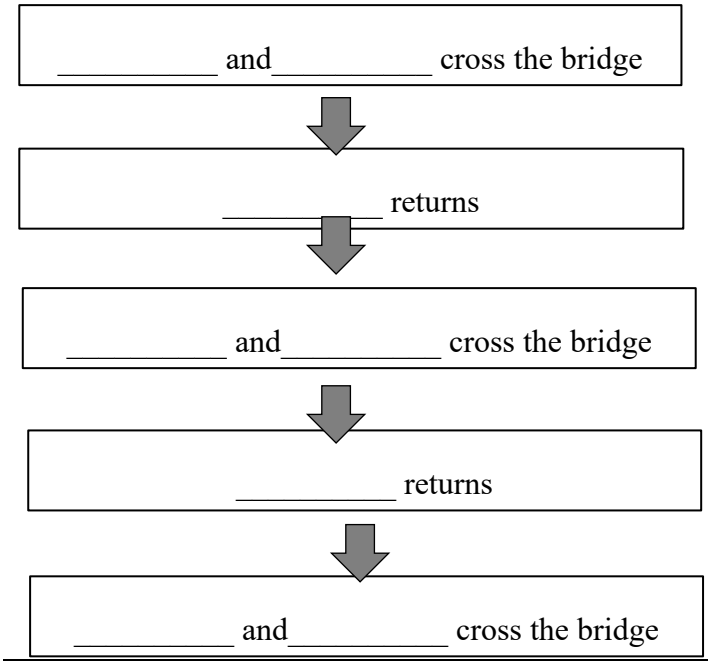
Solution 2:

Solution 3:

Bridge. Jia, Yi, Bing and Ding want to cross a bridge. It takes them 1 minute, 2 minutes, 5 minutes and 10 minutes, respectively. They have to use a flashlight because it is dark. However, they only have one flashlight, and the bridge can only support two people at most due to its limited loading capacity. They want to cross the bridge as quickly as possible. How quickly can they cross? Please help them plan their crossing and calculate the smallest amount of time it will take.



Your crossing plan is:



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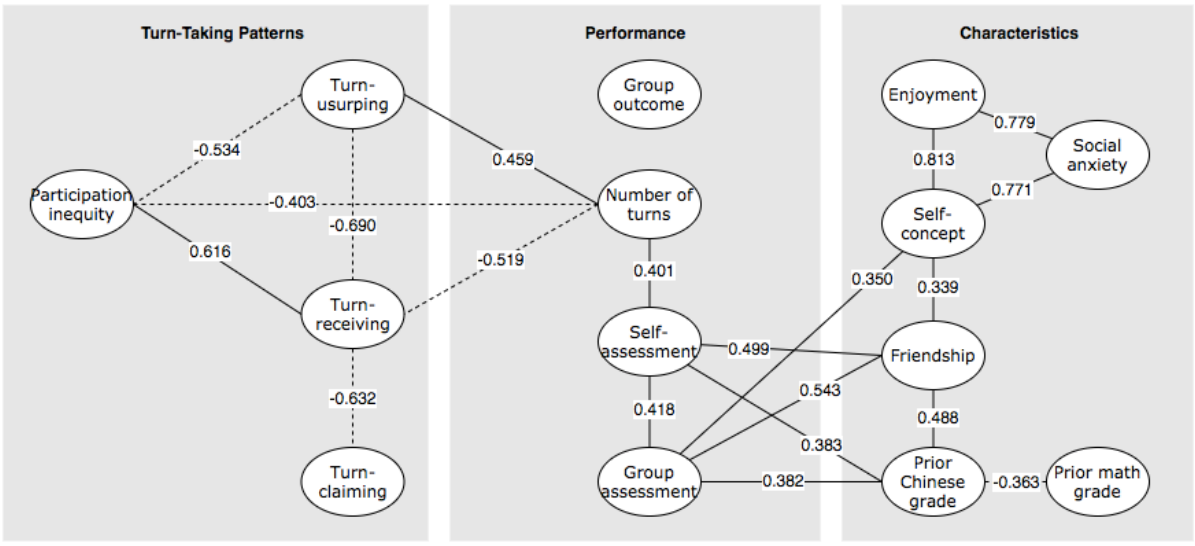


Figure 1. Significant correlations among major variables at group level (solid lines denote positive correlations; dashed lines denote negative correlations.)

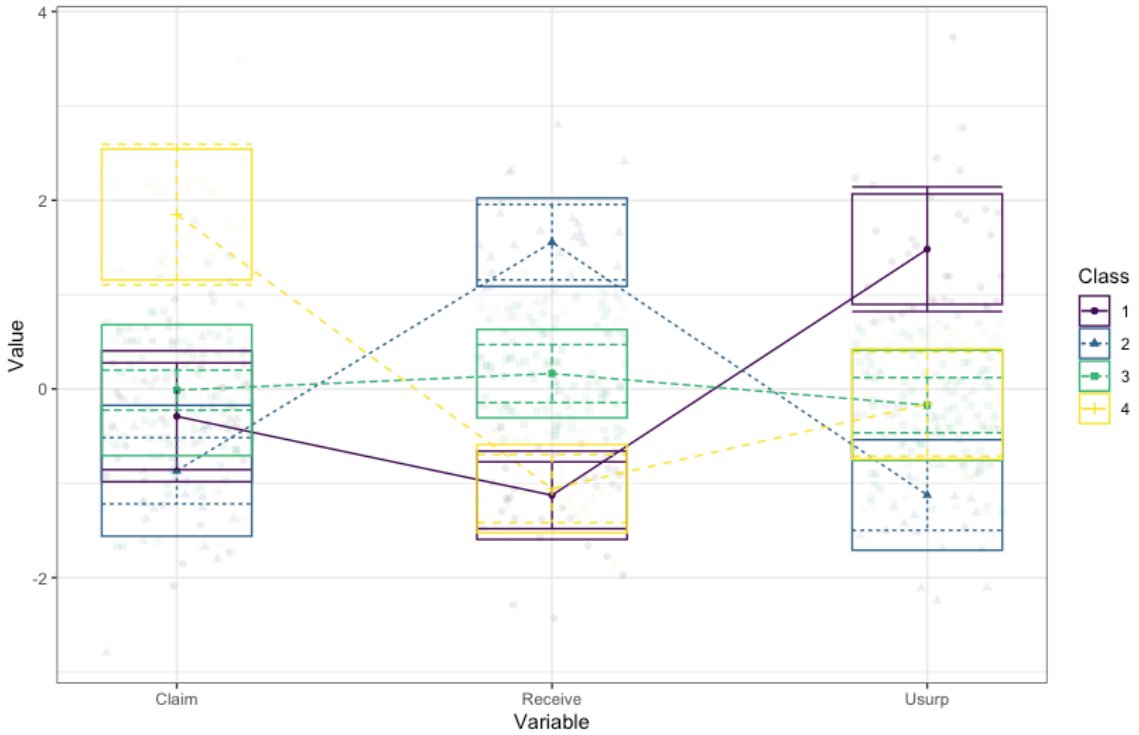
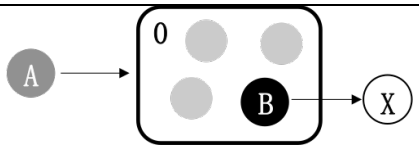
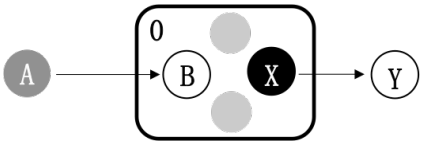
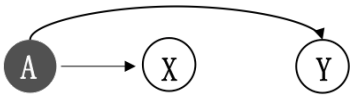


Figure 2. Four latent profiles among individuals concerning turn-taking preferences

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

P- shifts	Formula[a]	Illustrations	Descriptions
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 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 (speaker) (target) - (third party) (target of third party). The group is denoted as 0. X and Y represent someone other than neighboring speaker or target.

Table 2. Sample questions of social anxiety, math learning enjoyment, and math self-concept

Scales	Sample items
Social anxiety	I feel shy when there are all unknown kids around me
	I worried about how other kids would look at me
	I only talk with kids I am familiar with
Math learning enjoyment	I hope I don't need to learn math
	I like to do schoolwork related with numbers
	I like solving math problems
Math learning self-concept	I always do well in math
	I am very good at solving math problems
	Teacher told me that I am good at math

Table 3. A sample of data coding

Turn	Speaker	Target	Content	P-shift
42	Gan	Group	8 divides 2, equals 4	
43	Gu	Gan	Why? Their prices may not be the same.	Claim
44	Gan	Gu	8 divides 2, equals 4. Listen to me *(5-second pause)*, 8 yuan …	Receive
45	Xun	Gan	Gan, I wanna ask a question, … *(muffled sound, not clear)*	Usurp
46	Gan	Xun	It means 8 equals to one popsicle and one ice cream.	Receive
47	Gu	Group	It has begun. The teacher has pressed it for us. Then, how can we calculate the prices for one popsicle and one ice cream?	Usurp
48	Gan	Gu	One popsicle…	Claim
49	Si	Group	I think we can calculate like this.	Usurp
50	Gan	Si	Say it.	Claim
51	Si	Gan	2, 8, 16. That are two popsicles and two ice creams. Then 22-16 equals to two popsicles. Then divide 2. It is one popsicle.	Receive