Socially Constructive Interaction for Fostering Conceptual Change

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Abstract: In order to guide the design and assessment of successful intentional conceptual change at school, we examined third graders' learning processes using a series of lessons taught by a highly experienced teacher. The lesson unit consisted of 11 problems whose answers were to be predicted and discussed one at a time. All 21 students in the class successfully learned the target concept. Our analysis revealed that they started by confirming their rudimentary ideas taken from daily experiences, and then gradually developed theory-like concepts by repeatedly discussing their predictions to be confirmed with experiments. Toward the end of the unit, individual students could express their understanding in their own words, indicating that they successfully integrated their folk knowledge with scientific thinking. Further analysis of the dialogue contents indicated that some small-group discussions were effectively monitored and utilized by the rest of the class, to assure achievement of the entire class.

Introduction

This presentation aims to clarify the structures of successful classroom discussion that support learners in changing their folk knowledge into scientific understanding. It has been suggested that sequential cumulative discussion across students has strong positive effects in helping learners adaptively expand their understanding (e.g., Hatano and Inagaki, 1991; Schwartz and Martin, 2004; Miyake, 2008). However, the details of such classroom discussion have rarely been analyzed fully to explore whether a specific structure leads to adaptive conceptual change. In this paper, we report the results of our analysis of classroom discussions of 12 consecutive lessons of a third-grade class of 21 students, regarding their understanding of the physical identity of objects (the inability of two objects, like air and water, to share identical physical space). The lessons were conducted according to the framework of Hypothesis-Experiment-Instruction (HEI) (Hatano and Inagaki, 1991; Miyake, 2008). Overall, our analysis revealed that the students' discussion developed according to a specifiable structure, which we could formulate as a socially expanded version of two-person constructive interaction (Miyake, 2008). This analysis should help develop better CSCL systems for promoting collaborative learning in daily classroom practices.

Research Context: Hypothesis-Experiment-Instruction

In this section, we explain the framework of HEI, created by Itakura in 1963, and the target content of the "Air and Water" unit (Itakura, 2000) used as our research context. HEI is a strategy to teach basic scientific concepts. An HEI lesson consists of a set of strategic procedures for discussion and a problem. The students predict and discuss the answer to this problem, which is revealed as a result of a relevant experiment at the end of the discussion. An HEI unit consists of multiple problems, or experiments, carefully ordered to guide the development of scientific concepts underlying the problem set. To practice a unit, a teacher uses a problem sheet for each experiment, which explains the experiment and possible answers. Students are expected to integrate the results of the experiments in their own way to formulate individualized hypotheses, or rudimentary scientific concepts owned by individual students.

For a typical HEI problem, students follow the four steps (Itakura, 1997).

1) The teacher demonstrates the procedure of the experiment, and the students write their predictions of its outcome by choosing one of the alternatives. The results of the choices are made explicit when the teacher counts and writes on the blackboard the number of students who chose each alternative.
2) Students openly explain their choices to the class, so that all class members can hear the explanations. During this discussion, the students are allowed to express their ideas at will, including staying silent, and to change their choices if they wish to do so.
3) When this discussion naturally comes to an end, the experiment is conducted either by the teacher or by the students in small groups.
4) After the experiment, students write comments individually.

These four steps are repeated in a unit, in the order of the problems. All the HEI units were developed by Itakura and his core group, and have been tried out and refined by teachers in real classrooms.

The "Air and Water" Unit

The "Air and Water" unit consists of the 11 problems presented in Fig. 1, with explanations in Table 1.

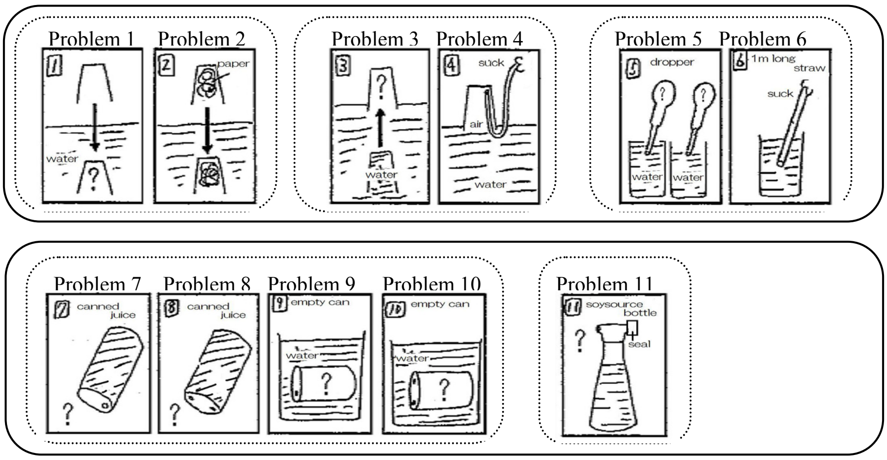

Figure 1. Depictions of the 11 Problems in the "Air and Water" HEI Unit.

Table 1: Wording of the 11 problems in the "Air and Water" HEI unit.

Problem 1. When an empty glass is pushed into water upside down, will the water come into the glass? Problem 2. If you place a crumpled piece of paper in the glass and do the same as in Problem 1, will the paper get wet?
Problem 3. An upside-down glass with water inside is in the water. When you lift it up through the surface of the water, what will happen to the water in the glass?
Problem 4. What will happen when you suck air through a straw from an upside-down glass in the water?
Problem 5. Which dropper sucks more water, one whose tip is deep in the water or one whose tip is shallow?
Problem 6. Can water be sucked through a 1m straw?
Problem 7. A can of juice has just one hole on top. When the can is turned upside down, will some juice come out of it?
Problem 8. Will some juice come out of a can that has two holes on its top and is turned upside down?
Problem 9. Suppose you put the can used in problem 8 deep into the water, keeping your finger tight on one of the holes. Will some water go into the can?
Problem 10: What will happen to the can in problem 9 if you let your finger go?
Problem 11: Will some soy sauce come out of its container if you put your finger onto the hole on its top?

These 11 problems can be classified into two subsets, Problem 1 (P1) to P6, and the rest. The first set includes problems whose answers are justifiable with daily experiences. Their answers are easy to imagine because the problems ask for direct sensing, as "visible" bubbles (P1, 2, 3, and 5) or "sense of mouth" (P4 and 6). In contrast, the situations of P7 to P10 are difficult to imagine because they do not often occur in the students' daily lives. These problems require learners to rely on their newly formed hypotheses, from predicting and observing the experiment results in the previous problems. The last problem, P11, can be answered by relying on either daily experiences or newly learned understanding, or both.

The problems in a unit are ordered so that answering the latter problems encourages active integration of the experiences gained through the preceding problems. The hypotheses required to answer the latter problems require higher-order abstractions of the experiences gained through the former problems. Miyake (2009) proposed a four-stage model of conceptual change (Table 2), where the concepts at both levels 1 and 2 could be formed based on individual experiences, while those at levels 3 and 4 require integration of different perspectives socially distributed among different individuals. According to this model, in the "Air and Water" unit, P1 to P6 can be answered with understanding at levels 1 and 2, while answering problems after P7 requires integration of different perspectives among learners.

Table 2: Four-stage model of conceptual change.

Level 4	Scientific concept, created and shared in the scientific community
Level 3	Confirming explanation by integrating many ideas, including "textbook" scientific concepts
Level 2	Rules of thumb created by accumulating one's own (yet many) perspectives from different situations
Level 1[t]	Explanation or "theory" like folk concept based on one incidence

Hypotheses

Judging from the model in Table 2, we hypothesized that answering problems after P7 required level 3 and up collaborative integration of one's own multiple experiences and those of others. In order to test this hypothesis, we analyzed the predictions made before and after the discussion, accuracy of the predictions, and number of utterances made by the class as well as by each individual student during the discussion and after the experiments, for each of the 11 problems. More specifically, we tested whether the students' predictions of the experimental results for P1 to 6 were different from those for P7 to 11. While the prediction of correct answers tended to be high for P1 to P6 even before the discussion, it could be low for the earlier problems of the latter set (P7 and 8), and gradually increase toward P11. The predictions would also be more discrepant before and after the discussions for the latter set of problems. We also tested whether we could identify collaborative construction of abstracted concepts of level 3 and up in the discussion of the problem set of P7 to P11.

Data Analysis and Results

The Data

The data came from the "Air and Water" unit in an HEI class conducted in May and June of 2002. Twenty-one third graders participated in 12 lessons taught by a highly experienced HEI teacher, Yuko Saito, who voluntarily kept records of the students' answers and discussions using hand-written notes and voice recordings.

Figure 3 indicates the shift of predictions over the 11 problems. Each box corresponds to a problem in the unit, in order. In each box, the white bars indicate the number of choices made before discussion; the choices included the alternative answers of A, B, C, and D; the circled one (e.g., B for P1), is the correct answer. The black bars indicate the number of choices made after the discussion but before the experiment.

Predictions of Answers

For P1 to P4, the students tended to choose the correct alternative from the beginning and to stay with it after discussion (Fig. 3). For P5 and 6, they experienced a slight discrepancy between the two choices, but tended to choose the correct answer after discussion. This difference between P1 to P4 and P5 and 6 may be due to the ease of finding reliable reasons for choices: P1 to 4 could have been answered by remembering ordinary experiences at home (e.g., taking a bath). In P5 and 6, the problem situation shifted away from such familiar scenes to those using tools often found in a science class. With P7, the pattern suddenly changed, with no one choosing the correct answer even after discussion. The same phenomenon happened again for P8; however, with P9, the students recovered and were once again able to predict correctly how the experiment would turn out. They were shaken again on P10; however, they were all able to predict the correct answer to the last problem, P11. The overall pattern indicates that at the end of the unit, all the students in this class somehow successfully formed a rudimentary concept of physical identity, at least with regard to whether or not air and water could share the same physical space. The shift pattern matched what we hypothesized in Section 2.

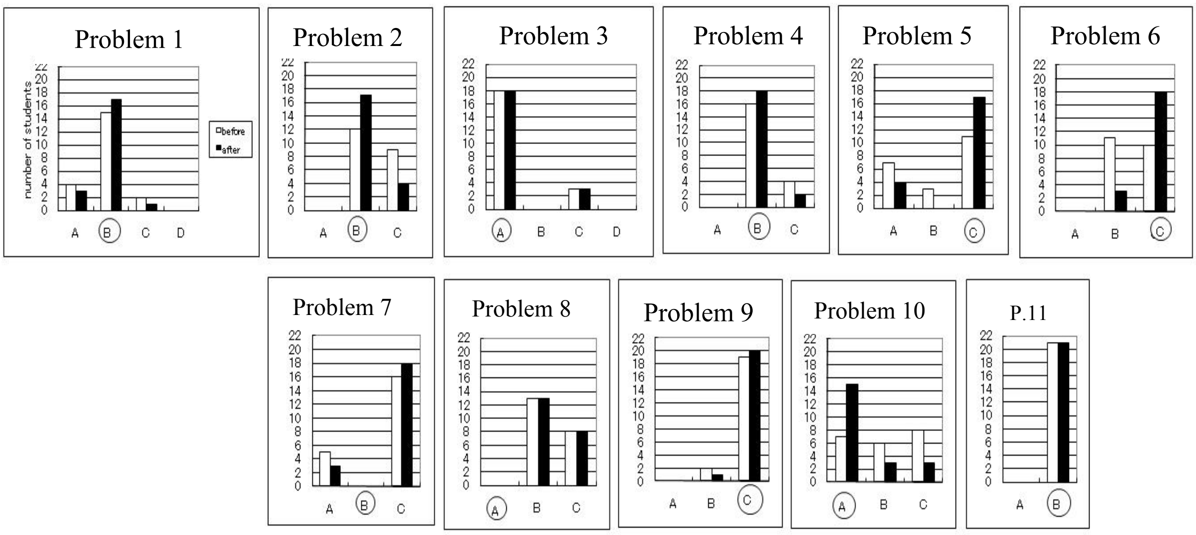

Fig. 2. Student's Choices of Alternative Answers for Each Problem in the "Air and Water" HEI Unit.

Shift Pattern of Predictions

If the shift pattern of predictions matched our hypothesis (1), we could expect to observe a corresponding trend in the number of level 3 and up utterances in our model in Fig. 2. We analyzed the contents of the student discussion to test this hypothesis. For an utterance to be classified as level 3 and up, it had to include expressions about the inability of air and water to share the same physical space (e.g., "The seal stops the air. When the air can't move, the water won't move, either" for P11). An utterance such as "I have tried such an experiment with a wash bowl in the bath" for P1 would not be level 3 or above. The correspondence rate of coding by two coders was 94%.

Figure 3 depicts the pattern we observed. The bars for each problem indicate the number of utterances at all levels. The black bars at the bottom indicate the number of level 3 and up utterances for each problem. As we hypothesized, for P1 to P6 the students did not talk much at level 3 or up, though some could express such understanding as early as P1. For P7, again as we expected, the number of level 3 and up utterances was close to zero, with only two students expressing such understanding. Thereafter, the number rose sharply for P8 but decreased toward the end of the unit, as the total number of utterances also decreased. This trend differed from our expectation, yet the level 3 and up utterances for P7 to 11 totaled 63, which was much higher than the total of 38 for P1 to 6. The average number of such utterances was 6.3 for P1 to P6, and 12.7 for P7 to P11.

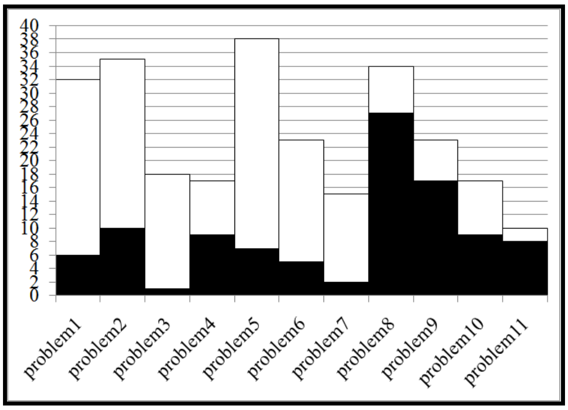

Figure. 3. Number of Students' Utterances during Discussion in the "Air and Water" HEI Unit.

This trend could be interpreted as indicating that most of the students succeeded in changing their folk theory (i.e., rule of thumb based on everyday experiences) into more scientific theory-like understanding by bridging two different types of problems. However, level 3 and up utterances existed even at P7 (though the owners did not make the correct prediction), and at P8 nobody could predict correctly even though many utterances were coded as level 3 and up. Thus, this quantitative whole-class analysis did not seem to provide enough information to confirm our hypotheses. To go one step further, we analyzed each student's utterances.

Coding of Discussion Patterns in Terms of Role Exchange

In order to identify a pattern among the discussions, we used the framework of constructive interaction developed and tested for a two-person joint problem. According to this framework, role exchange of task-doing (uttering ideas) and monitoring (listening) appears to be responsible for abstracting understanding (Shirouzu et al., 2002). It has been proposed that this mechanism happens socially to induce collaborative conceptual change (Miyake, 2008), or to help learners collaboratively change their folk theory into a scientific concept, as indicated in the model described above (Miyake, 2009). In order to test this idea, we coded the patterns of turn-taking during the discussion of the 12 lessons into two categories of role exchange: individual sequence and group dialogue, defined as follows.

Individual sequence Learners take turns to express their ideas in succession. Illustratively, utterances would move as A>R>F>C>H…. This is a linear successive role exchange in which a single person's verbalization is handed down sequentially to the next person. Though there is not much chance for constructive interaction among the speakers, this process assures an equal chance for all class members, and thus is sometimes preferred by teachers (CoREF, 2010).

Group dialogue Role exchange can happen socially, involving groups. In a class discussion, a small group of two to three students may engage in a positive discussion, exchanging roles of task-doing and monitoring among them for a while. Yet at the same time this group as a whole could be assuming the role of **task-doing** to the whole class, possibly working as a core or leading group of the lesson, whose discussion can be **monitored** by the other students in the class. When this group's discussion comes to a halt for some reason, a different group of students takes over the task-doing role by starting their own discussion to be monitored by the rest of the students. Such a shift of speakers exhibits a pattern, such as A>B>A>B followed by C>D>C>D, then by B>D>E>F>D>F.

Which pattern leads the class to a more successful conceptual change? If teachers' preferences are relevant, we would expect to observe more individual sequences in successful lessons such as those we analyze here. A prediction based on the rigid formulation of the constructive interaction framework also favors individual sequences because it requires each participant to experience both roles. Yet we can also expect group dialogues to lead to successful learning, as we observe a small group of selected class members engage in a long heated class discussion, which is monitored rather positively by the other members. If our analysis identifies this group-based pattern, this result may lead to new understanding of how to design and support such activities more positively than before.

Analysis of Role-exchange Patterns in Group Discussion

We analyzed the role-exchange pattern in discussions with the following two procedures.

Procedure 1 We counted the utterances of each individual student who participated in our data, to determine if any bias existed in the frequencies of role exchange. The students were assigned letters A to U based on the number of utterances, where the most frequent talker was A.

Procedure 2 For each of problems P7 to P10, we tabulated the shift to the task-doing role identified as a talker of her/his opinion. We also analyzed utterances relevant to conceptual change.

The data consisted of 263 utterances, 9 of which were uttered by the teacher. Because all her utterances were made in an effort to control the progress of the student discussion (e.g., "We don't have enough time. Let's experiment"), they were not coded, leaving 254 student utterances for this analysis.

Role-exchange Frequencies

Figure 4 lists the number of utterances for each student in the class, from the one who talked the most (top) to the one who talked the least (bottom). Students are identified alphabetically. Figure 5 indicates the order of students who talked for each problem. It is possible to identify the role exchange pattern (individual-based or group-based), with demographic information on whose comments were followed by whom, when, and how often. In order to identify the interaction patterns, we looked for sequences in which two to four persons iterated their utterances, and coded them as group dialogues (denoted with black cells in the graph). During these group-based exchanges, we assumed that some constructive interaction occurred among the members, by exchanging roles of task-doing and monitoring. This iterative pattern was identified not only by the orderly exchange of utterances but also by content continuity. Utterance numbers 17 to 26 of P8, skipping M's utterance at number 18, is such a case. The white cells indicate no apparent group dialogue, thus representing individual sequences.

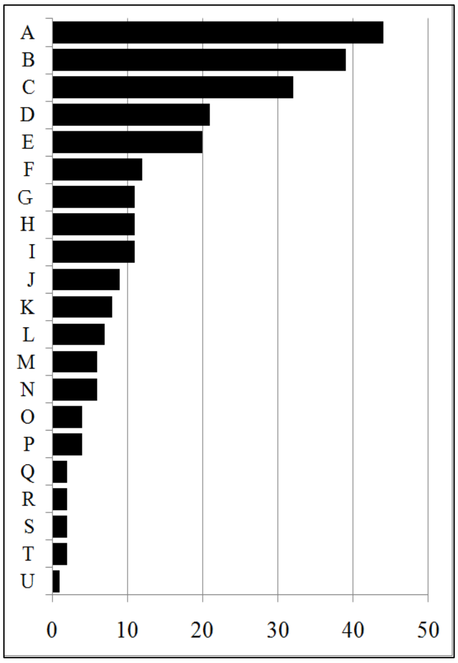

Figure. 4. Number of Utterances for Each Student.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	J	N	K	I	I	J	C	B	I	K	F
2	F	D	J	H	K	D	N	K	F	N	B
3	C	?	A	F	D	E	J	F	M	D	A
4	B	M	H	G	C	P	H	L	G	A	E
5	H	H	B	A	H	N	E	S	C	H	G
6	D	F	L	?	N	I	G	P	A	M	M
7	A	B	G	A	A	K	A	M	D	O	A
8	G	D	E	?	L	Q	B	D	C	I	F
9	E	E	A	A	B	C	D	J	A	L	A
10	B	A	L	D	D	K	P	C	C	T	F
11	U	T.U.	A	A	J	E	T	A	A	G	
12	F	B	B	H	E	G	J	E	C	E	
13	A	?	A	B	I	A	E	B	A	B	
14	B	E	E	A	K	O	B	A	C	C	
15	D	O	A	T.U.	O	B	T.U.	E	L	B	
16	B	P	E	all	H	C	A	B	?	A	
17	D	N	A	T.U.	R	T.U.		C	E		
18	B	R	E	S	A	J		M	C		
19	A	?		I	D	?		B	B		
20	B	C		A	B	A		A	A		
21	A	B		C	C	C		C	I		
22	B	D			B	T.U.		B	Q		
23	K	B			?	H		C	C		
24	C	C			A	D		A			
25	B	B			D	A		B			
26	C	C			C	T.U.		C			
27	B	D			A			I			
28	I	A			T.U.			F			
29	B	B			A			H			
30		C			E			E			
31		B			D			C			
32		C			L			B			
33		B			A			F			
34		?			B			A			
35		C			D						
36		F			C						
37		T.U.			G						
38					B						
39					J						
40					E						

Figure. 5. Role-exchange Patterns for Each Problem.

We infer from the data in Fig. 4 that if any group-based task-doing occurred, the chances were high that the group included students A, B, and C, and possibly D and E. The graph in Fig. 5 also indicates that during these 11 collaborative problem-solving lessons everyone talked; thus, every student played a task-doing role at least once.

In Fig. 5, the percentages of black cells in each column are lower for P1 to P6 (44.8% for P1, 35.1% for P2, 33.3% for P3, 23.8% for P4, 25% for P5, and 0% for P6) than for P8 to P11 (44.1%, 39.1%, 0%and 40%). This result may indicate that for this class, it was necessary for the students to accumulate different perspectives, or expressions based on individually different experiences in the former phase, in order to move on to more constructive group-based interaction regarding a focused sharable topic on which selected members exchanged roles, possibly leading them to raise their understanding (Shirouzu et al., 2002). This group dialogue could have worked as group-based ***task-doing***, whose discussion was ***monitored*** by the rest of the class members.

To analyze the distribution patterns of the black cells in Fig. 4, we must rely more on our observations and interpretation of constructive dialogues. With some caution, we made the following conclusions. Because P7 was a new problem for everyone, each student expressed her/his own ideas, resulting in a long sequence of individual sequences. During P8, after watching what happened to the juice in the can with one hole when it was turned upside-down, the same students appeared to be able to focus on selected aspects of the phenomenon, thus starting some group dialogue on such topics. Two such group discussions could have been highly positive, judging from the number of people involved and the length of the discussions. However, this group task did not seem to have worked fully to adaptively deepen the understanding of the members in the group or the rest of the class, because none of them correctly predicted the result of the experiment (Fig. 2). For P9, students A and C again engaged in group dialogue, as if they had picked up on their interaction for P7, providing a task-doing group for the class to monitor. Because most of the class members were able to answer P9 correctly, this group task-doing could have been effectively monitored by the class members; most of them understood the content of the discussion, and possibly integrated it to deepen their understanding. After this socially implemented constructive interaction between the core groups who were doing the task and the other members who were monitoring, each individual student was ready to express her/his own understanding in her/his own expressions, which led to sequential individual sequences (P10 column in Fig. 5).

Content Analysis of P7 to P10 Discussions

We examined the contents of utterances during the student discussions of P7 to P10, to confirm whether the contents would fit our interpretation of the Fig. 5 patterns.

Table 3: Excerpts of typical utterances during the discussion session of P7.

3	J	I want the juice to come out fast.
…	…	…
7	A	The can has only one hole so the air can't escape.
8	B	When I punched a small hole in a milk carton, the milk dripped out continuously.
…	…	…

(N.B. Numbers in the left-most column are orders of the utterances in this session. The letters in the second-to-the-left column denote students, as in Fig. 4.)

In this phase, as indicated in Table 3, students expressed their ideas independently, literally in the fashion of "one after the other." The third and eighth utterances appear to have been based on the speakers' daily experiences.

Table 4: Excerpts of group-based dialogues during the discussion session of P8.

1st Group-based dialogue

11	A	The juice in the can would block the air from coming in.
12	E	I think the air would enter from both holes and block the juice.
13	B	The air would enter from both holes and pass through the juice in the can.
14	A	Oh yes! The air will turn into bubbles and pass through the juice!
15	E	If the air blocks both holes, where can the juice come out from?
16	B	When the air enters into the can, the juice would come out. But I don't know how.

2nd Group-based dialogue

17	C	The air won't enter the can because it is filled with juice.
18	M	Oh! I got it!
19	B	C didn't listen to me. I said, "The air passes through the juice in the can."
20	A	The can has no space. It is filled with juice.

21	C	The can is filled with juice. So the air can't break into the can. Why do you think the air can enter the can?
22	B	The can has some space on top.
23	C	I don't think cans of juice have any space.
24	A	Yes, I think so, too.
25	B	Even a little space is enough for the air to enter.
26	C	The can is filled with juice. So the air will never break into the can!

In both of these group dialogues, the group members clearly shared a focus of discussion, taken not directly from their daily experiences but from their observation and interpretation of previous experiments(see Table4). Furthermore, we observed that while the first discussion tended to be about general movements of the air and the juice, the topic of the second discussion was more focused, with more vividly imagined details of the possible phenomena. Judging from this shift of content, we assumed that the students engaged in the second discussion already shared a basic understanding of the target scientific concept that air and water cannot share the same physical space. We also assumed that this discussion was monitored by the other class members, and that each of them compared and integrated the discussion expressions and their own thoughts. During this phase, the listeners monitored the discussion, while students A, B, C, and E expressed and assessed their own understanding.

Table 5: Excerpts of a group-based dialogue during the discussion session of P9.

5	C	Half of the air would escape from the can when it lies sideways.
6	A	I think that air tends to rise. So air won't escape from the hole punched on the lower side of the can.
7	D	What do you mean?
8	C	The can will be put deeply into the water. So I think we don't have to worry about the position of the hole.
9	A	The base of the can would push back the water.
10	C	When we tipped the glass in <Problem 2>, I remember, the glass was filled halfway with water.
11	A	The can with a hole doesn't have a wide mouth like the glass.
12	C	Small bubbles can pass through even a small hole of the can.
13	A	Anyway, I think the position of the can has nothing to do with the amount of water.
14	C	I think that all the air would escape from the can when it stands up. So half of the air would escape from the can when it lies sideways.

Again the students discussed concrete aspects of the problem situation (e.g., whether the can would be standing up or lying sideways, and the position of the hole)(see Table5). Such details were not explicitly expressed in the problem statements; therefore, the students created detailed, concrete images to clarify how much they understood. This activity also appears to help both the students who were discussing as task-doers and those who were listening as monitors, as they went back and forth between scientific abstract expressions (e.g., "air escapes" and "water fills") and concrete images (e.g., of the can, the juice, and the water), as if they were tying their scientific understanding to their daily life experiences.

Table 6: Excerpts of typical utterances during the discussion session of P10.

1	K	The can has two holes. So the water will replace the air that filled the can.
4	A	The air will escape from one hole, and the water will come in from the other hole.
14	J	The air will powerfully block the movement of the water.
17	B	The air will escape from the two holes. After the movement of the air, the water will come in from the two holes.

For P10, the students chose to express their understanding individually(see Table6). Not only students A and B, who served as core task-doers by phrasing and rephrasing their ideas, but also students K and J, who were relatively silent, verbally predicted (K) or made some causal-like expressions (e.g., student J's implication that air has power). Group-based dialogues that occurred in P8 and 9 discussions were monitored by these students, and possibly helped them integrate and abstract their own and others' ideas; as a result, their ideas came closer to scientific concepts.

Here we summarize our interpretation of the socially constructive interaction we observed in the protocol. During the P7 discussion, as we inferred from the role-exchange pattern in Fig. 5, students expressed their individual observations, because the problem situation was new and they did not share a common focus. When they moved on to P8, after exchanging different ideas expressed in various ways and observing the correct answer to the previous problem, some students (e.g., A) were able to express their rules of thumb rather abstractedly, in a top-down fashion (e.g., "Water cannot come out because there is air outside."). When such a statement was questioned by another student, a group dialogue or possibly constructive interaction between the two occurred; the rest of the class monitored this interaction as group task-doing. As the situation progressed, another student, who thought through concrete images of the juice in the can and of the water surrounding it, challenged the abstracted expression and asked for more concrete images. The result was more group task-doing, which was also monitored by the class. This monitorable constructive interaction between A and C, between the abstraction and the concrete images of the set of air-water exchange phenomena, helped each class member integrate the discussion with her/his own ideas toward the end of P9, leading them all to correct answers. For P10, all the students were able to express their individual understanding or concept in their own styles, rather sequentially. This pattern was the same as for P6 and P7, but the levels of the content according to the conceptual change model in Table 2 were different. The students' utterances contained more level 3 expressions during P10 discussion than during P6 and 7 discussions.

Discussion

In the discussion protocols of 21 third graders going through 11 carefully ordered HEI problems in an "Air and Water" unit, we observed successful socially constructive interaction among both individuals and small groups. We also found that the role exchange of task-doing as speakers and monitoring as listeners supported the entire class to raise each individual's understanding of the scientific concept, the target of the learning, as predicted from two-person constructive interaction studies. The 21 students in the class, in a facultative atmosphere where everybody felt free to talk, expressed diverse individual ideas on encountering new problems. The same students could also argue on a topic of focus after sharing some common experiences. When they argued about a selected topic, a small group of two to four members engaged in constructive interaction to form a task-doing group whose discussion was monitored by the class and sometimes integrated by some monitoring members. This group-based constructive interaction occurred several times, with different core members engaging in the task that was monitored by the rest of the class. The class exhibited high performance with everybody correctly answering the last question at the end of this highly social constructive interaction. This result indicated that such complex collaboration is an effective and enjoyable practice that promotes scientific conceptual change.

We plan to analyze similar sets of class discussion data taken from other units of HEI classes and other collaborative classes, in order to understand the conditions for successful discussion, in an effort to design better technological support for the promotion of intentional conceptual change, as well as collaborative learning skills.

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