SCISSORS, PAPER, STONE: HOW STUDENTS DEAL WITH CONCEPTUAL CONFLICTS IN AN INQUIRY-BASED ACTIVITY

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Abstract: One of the goals of inquiry-based teaching and learning of science is for students to learn the processes of inquiry and to apply these processes in new situations to construct new knowledge for themselves. Very often, students who are exposed to inquiry activities encounter conceptual conflicts that do not align with their pre-conceived ideas. How these conflicts are resolved provide different types of learning experiences for the learners. Interaction talk during hands-on science inquiry activities provides a good source of information on how students deal with conceptual conflicts and, in particular, how they apply inquiry skills to resolve these conflicts. The analysis of talk in interaction amongst a group of six grade five students in a Singapore school has surfaced at least three ways whereby students construct and shape their learning in an inquiry-based science activity through the ways they deal with conceptual conflicts: (a) domineering voices in a group can prematurely curtail alternative ideas and concepts in dealing with a conceptual conflict; (b) a peer expert in a group can scaffold learning for a student facing a conceptual conflict; and (c) learners draw on inquiry skills to resolve cognitive conflicts arising from anomalous results or behaviours during hands-on investigations.

Keywords: inquiry, conceptual conflicts, practical epistemology, talk- in-interaction

Introduction

"Eighteen point six."
"Eighteen point seven. Because just now I move back a little bit only!"
"…here eighteen point three lah." ('lah' is a common colloquial expression indicating the end of a statement)
"Take the middle one eighteen point four."
"Six"
"Four"
"Five"
"Scissors, paper, stone" (this is a game of chance where the winner gets to have the final say in a decision. This is a common game among children.)

The voices of six grade five students greet you as you step into Mrs L's science room about 22 minutes into her lesson on "Forces". The one girl and five boys were huddled around a hexagonal table covered with writing papers, pencil cases, two half-metre wooden rulers, a launching ramp and a test cart. About 14 minutes before you arrived, the students had already started working on a hands-on activity to find out the distance travelled by a test-cart as it zips across a piece of sandpaper, a piece of plastic transparency and a piece of A4-size writing paper. Did you hear wrongly? Scissors, paper, stone? In a science class where students were taking "objective" measurements of distance? Did not the worksheet handed in by the group indicate that they have obtained an average reading of 14.7 cm? Did the worksheet reflect how the students arrive at their reading? Did it provide information on how the students have constructed their learning in that one hour in the science room?

1. Theoretical Background

Traditional ways of teaching science are founded on the belief that there is a stable body of scientific knowledge [6] that need to be transmitted to students. Science is then delivered as a "rhetoric of conclusions" ([8], p. 1105) that have already been investigated, proven and accepted. Unlike traditional ways of teaching science, inquiry science is founded on the theory that scientific knowledge is tentative ([4]; [5]). Inquiry science views scientific knowledge as being continually debated and constructed through a process of asking questions, even of "established" laws and theories, of collecting evidence from investigations, of constructing explanations and meaning based on that evidence, and the documentation and presentation of the claims and evidence for debate and validation. School practitioners of inquiry science often use group-based hands-on investigative activities as a means to develop these inquiry skills, believing that such activities provide opportunities for students to acquire these skills.

It has been observed that students interacting on learning tasks such as inquiry activities often encounter cognitive conflicts that do not align with their pre-existing ideas [9]. How these conflicts are resolved provide different types of learning experiences for the learners, some of which may be productive and some non-productive towards inquiry. Neo-Vygotskyan theorists have also suggested that a fundamental medium of learning is in the social interaction, both formal and informal, amongst the participants of that learning [3]. In a group-based activity, the presence of other learners can have an influence on how the individual resolves the conflicts [2] and thus influence their learning experiences.

In this paper, the discourse amongst the group of six students was analysed to examine how they construct and shape their learning in an inquiry-based science activity through the ways they deal with conceptual conflicts. As conflicts often manifest themselves as problem talk in an interactive discourse, applied Conversation Analysis (CA) was chosen as the key tool to interrogate and surface ways that students use to deal with the conflicts. Using an inductive perspective, the functional features of discourse such as turn taking and fact construction were examined. Trouble talk in several turns was identified. Incorporating content analysis into traditional CA techniques, what began to surface was the different ways that learners were co-constructing their learning. The applied CA approach has also been used by other researchers to examine what is embedded in educational theories and practices [1]. Sandoval [7], for instance, suggests that it may be more useful to look at students' talk in activities to uncover their epistemological ideas and beliefs than to use other methodologies like interviews. There is much in the dialogue of students' collaborative inquiry that does not show up in their interviews or constructed artefacts. Indeed, the conversational analysis of interaction talk amongst the six participants of this hands-on science inquiry activity provided a good source of information on how the students dealt with conceptual conflicts.

2. Method

The transcript used in this analysis was taken from an audio-recorded conversation amongst six grade five students in a Singapore primary school. The discourse took place in a one-hour lesson on 28 August 2007 in Mrs L's science room. This section of the audio-recording that was transcribed started 19:58 minutes into the lesson and ended at 26:04 minutes. The group of one female (S1) and five male students was working on a hands-on group activity to investigate the different distances a toy truck travelled across different types of surfaces. They were provided with an experimental kit that contained launching ramps, test-carts, steel balls and wooden rulers; materials that they could use for their investigation. A worksheet with open-ended questions about the experiment was also given to the students. One of the group's tasks was to document their readings in the form

of a table. They were to calculate the average of three readings for each of the materials they use in their investigation.

3. Analyses and Findings

An analysis of the discourse surfaced episodes which demonstrate how individuals in a group deal with information that conflict with their current knowledge, how each then negotiated with herself/himself and with the social community s/he is in to achieve resolution of that conflict at that point in time.

3.1 Domineering voice in resolving a conflict of ideas in group

When a conflict of ideas arose in a group activity, one way that was used in arriving at the resolution of the conflict was by the domineering opinion of a participant in the group. An example that illustrated this was found in the interaction recorded in excerpt 1 below.

Excerpt 1: I say cannot

38.	S4:	Don't play, don't play, stop it (2.0)
39.	S2:	Like that faster, like that, two at a time is faster
		((S2 had attached two launching ramps next to each other.))
40.	S3:	Yah two at a time(1.0)
41.	S3:	Transparency better
42.	S4:	Ro:ng, no playing, Ro:ng
43.	S3:	I love playing, what's wrong?
44.		( )
45.	S4:	Cannot wha:t↓=
46.	S2:	=Can, can , can, can like that
47.	S3:	Need to speed up the speed ah, huh?
48.	S2:	Both start second time altogether
49.	S4:	Cannot lah
50.	S1:	Later this o[ne go
51.	S4:	[Ya:h↑ canno:t, canno:t, I say cannot(.)
52.	S4:	Stop playi:ng, you one day don't play will die ah?
53.	S4:	Remove, you naughty boy

In this episode, two students from the group, S2 and S3 were trying out a two-ramp set-up to launch the test-carts. This set-up was a departure from the single-ramp set-up the group had used earlier. This alternative suggestion by S2 and S3 was viewed as horse-playing by S4. In both turns 38 and 42, S4 admonished S2 and S3 and asked them to stop "playing". On the contrary, S2 did not view this as "play". In response to S4, he provided a reasoned explanation in turn 39 on why he had set up the two ramps: that using two ramps will economise on the time taken to carry out the experiment.

Inspite of S2's explanation, S4 rejected S2's hypothesis (in turn 45) but did not provide any explanation for this rejection. In turn 48, S2 extended his explanation, reasoning that rolling a steel ball down each of the two ramps at the same time would mean two measurements could be made simultaneously, and thus was "faster" towards completion of their experiments. S4 once again rejected S2's explanation (in turn 49) without providing any counter-explanation. S4 was adamant that the set-up will not work. In turn 51, he emphasised this by repeating "cannot" three times, ending his talk with "I say cannot". No counter-explanations were necessary; his authority on the issue was final.

We see in this episode the power of the domineering voice in a group in prematurely putting to rest the deviant idea of the "naughty boy(s)". As this episode illustrated, sometimes learning and creativity could be curtailed by a domineering voice that provided no room for experimenting new ideas and no offer of any reasoned argument. This could run counter to the goals of scientific inquiry where questioning of norms is encouraged, where alternative ideas need not be discarded until they are put to the test and where

reasoned explanations contribute to the construction of knowledge for learners.

3.2 Peer expert's voice in resolving an individual's conceptual conflict

Excerpt 2 illustrated another way of resolving a conceptual conflict through interactive talk. In this case, the peer expert's voice is relied upon to achieve resolution of the conflict and in the process, help the learner construct his knowledge of a mathematical concept.

Excerpt 2: Thirty-four cannot divide by three

8.	S1:	Add together and divide IS? (0.5)
9.	S5:	Ok add.
10.	S4:	Ok, where's my pe- pencil? Where's my – [you took -
11.	S5:	[Eh:↑ over here
12.	S4:	Ok, ok
13.	S6 & others:	Ten point two
14.	S4:	Eh then how to do calculation here?
15.	S4:	Ok=
16.	S1:	=Next is thirty four.
17.	S1:	Later right, transparency? (0.5)
18.	S1:	Thirty four: ↑
19.	S6:	Wait, wait, take out sandpaper first (4.0) ((S6 directing this turn at S2 and S3 who are exploring the experimental set-up.))
20.	S1:	See?
21.	S4:	I told you already thirty four cannot divide by three what
22.	S1:	Got remainde::r↑
23.	S4:	O:k (1.5)
24.	S1:	Use decimal, use decimal lah. Forty over three (2.0)
25.	S2:	Size different one (1.0) these two (1.0) ((S2 and S3 are not participating in this calculation episode. They are a sub-group here exploring the equipment on the table and in the box. Here, they are discovering differently sized balls.))
26.	S1:	Continuous lah
27.	S6:	One point three three=
28.	S3:	=Like that test
29.	S4:	One point [three]
30.	S3:	[This] one not fair
31.	S1:	One point three three (0.2)
32.	S4:	Eleven point three [three
33.	S6:	[Eleven point three three (0.5)

There was indication of trouble in turn 14 when S4 asked "how to do calculation here?". S1 interpreted this as S4 having difficulties with the two-step process of deriving the average. S1's response in turn 16 was to ask S4 to first write down the number thirty-four which was the sum of the three readings. The next step posed another problem for S4. In turn 21, S4 said "I told you already thirty four cannot divide by three what". The conceptual conflict S4 was facing was reconciling how a non-multiple of three (in this case, the number thirty-four) could be divisible by three. S1 understood the problem that S4 raised and suggested that this conflict can be reconciled by using the concept of "remainder" in turn 22. S1 further suggested that instead of using remainder, a related but more appropriate concept to use was "decimal". S4 proceeded to do the division before encountering another problem – there was no "end" to the division when thirty four was divided by three. Once again, S1, the expert, assured him that this involved the concept of a recurring decimal, the non-technical term she used being "continuous" (in turn 26). Turn 32 showed the resolution of the conflict for S4 as he arrived at the final value of 11.33 for the average reading and this was confirmed by S6.

In contrast to the previous episode, this case illustrated how knowledge was constructed with the help of a peer expert. Instead of using a domineering voice to drown out a challenge posed by the learner ("I told you already thirty four cannot divide by three what"), the expert chose to reason with the learner and to scaffold the steps and the thinking in arriving at the final solution. It was interesting to note that S1, as a peer to S4, grasped very quickly the conceptual conflict that S4 faced without the need for much elaboration by S4. In turn 21, for example, "thirty-four cannot divide by three" was correctly interpreted by S1 as a problem dealing with a non-whole number answer. This evidence supported the idea that the close proximity of language and knowledge between peers could promote identification and resolution of conceptual conflicts. The reward was not only the completion of the task in this episode but also the successful transfer of learning by S4 to a subsequent similar task as evidenced in turns 133 and 135.

133.	S4:	Four four one divide by thre-=
135.	S4:	Point (0.8) seven. Fourteen point seven.

3.3 Inquirer's voice in resolving conceptual conflicts in the group

Very often, students who are exposed to hands-on investigations encounter anomalous results and behaviour, such as readings that do not fit a trend or readings that do not support students' pre-conceived ideas of a phenomenon. The steps taken to resolve these cognitive conflicts are therefore learning moments that could lead to acquisition and practice of science inquiry skills. Excerpt 3 below traced the paths the group took from a non-scientific way of resolving a measurement problem to finally using a scientific process to resolve the problem.

Excerpt 3: Second chance, second try

72.	S6:	Eighteen point six
73.	( )	Point three: ↑
74.	S6:	Eh, don't push back lah. No, no, no, [eighteen point six]
75.	S1:	[eighteen point six]
76.	S2:	Eighteen point seven
77.	S4:	No lah
78.	S2:	Because just now I move back a little bit only
79.	S4:	No lah, here eighteen point five leh °uncle°, here eighteen point five, here eighteen point three lah
80.	S6:	=Eighteen point six=
81.	S5:	=Take the middle one eighteen point four: (0.3)
82.	S1:	Si::x
83.	S4	Fo:ur
84.	S1 & S6:	Si::x
85.	( )	Fi[ve]
86.	S3:	[Sci]ssors paper stone
87.	S4:	°four°
88.	S3:	Scissors paper stone
89.	S4:	Second chance, second try

At the start of this turn, the group had just launched the test-cart onto a piece of transparency and was using a ruler to measure the distance travelled by the test-cart. S6 read the measurement off the ruler as 18.6 cm. S4 (in turn 79) and someone else in the group (in turn 73) did not agree with the reading and made a counter-claim that it should be 18.3. S2 in turn claimed that the reading should be 18.7, backing this up with the reasoning that he moved back (either the test-cart or the ruler) a little (turn 78). The group was now divided into three parties, each proposing a different reading of the measurement.

The problem in this interaction arose from how a measurement was to be taken. In negotiating a solution to this problem, the students went from insisting on the reasonableness of their reading (S2 in turn 78 and S4 in turn 79), to compromising by

taking a middle number (S5 and S4 suggested taking a number in between 18.6 and 18.3), to suggesting a game of chance ("scissors, paper, stone") and finally to a more scientific way of resolving this problem by repeating the experiment (in turn 89). While it took the group some time to arrive at the decision to use a more scientific approach to deal with an uncertainty over a measurement reading, this episode illustrated how the group was able to evaluate each alternative solution and finally rectify their disagreements by drawing on their common resource of inquiry skills.

4. Conclusion

The analysis of the talk in interaction amongst a group of six students had surfaced at least three ways whereby students construct and shape their learning in an inquiry-based science activity: domineering voices in a group can prematurely curtail alternative ideas and concepts, a peer expert in a group can scaffold learning for a student facing a conceptual conflict and learners draw on inquiry skills to resolve cognitive conflicts arising from anomalous results or behaviours during hands-on investigations. This finding has an important implication in our attempts to enact inquiry in the classroom. While a teacher can carefully plan and deliver an inquiry-based lesson, the extent of the learning experience of inquiry by the students may also depend on the social dynamics and interaction amongst the students. One of the ways that could reduce interactions that are unproductive towards inquiry is for teachers to make explicit some of the attitudes conducive to inquiry learning, for example, curiosity in exploring alternative ideas, suspending judgment, and using reasoning to present and challenge ideas and views.

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