The Analysis of Verbal Interaction on the Process of Elementary Students' Hypothesis Generation Learning

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Abstract: The purpose of this study is to analyze the verbal interaction during elementary students' hypothesis generation learning. For this study, 32 6th graders were selected and were assorted into heterogeneous small-groups by achievement levels. The topics of hypothesis generation learning were developed by analyzing the current elementary school curriculum. Each group's verbal interactions were audio/video taped and transcribed. After coding the protocol and having student retrospective interview, types and frequency of verbal interaction were analyzed. The frequency of verbal interaction during observation was highest and that of questioning situation identification was lowest. Regarding to the quality of verbal interactions, low level interactions were significantly frequent during observation. On the other hand, hypothetical explicans generation revealed high frequency of high level interactions. The results revealed that elementary students can make high level verbal interactions through hypothesis generation learning.

Key words: hypothesis generation learning, verbal interaction, hypothetical explican

Ⅰ. Introduction

Enhancement of scientific thinking ability has been consistently emphasized as the goal of science teaching. This ability can be reinforced by generating hypotheses during science inquiry process(Kwon *et al.*, 2006). Social constructivism also highlights the importance of the verbal interaction, underlining active generation of the knowledge.

Generating hypothesis is considered as the most critical process of scientific inquiry (Kuhn *et al.*, 1988; Kwon, 1997; Lawson, 1995), and it has been discussed that this is closely related to not only students' science achievement, but also logical and creative thinking (Adsit and London, 1997; Lawson, 1995). Accordingly, hypothesis generation must be at the core of the science learning class.

Following the consensus that the hypothesis generating activity is one of the main components for quality science education, research on the hypothesis generation process has been activated (Kwon *et al.*, 2000; Hanson, 1958; Lawson, 1995). Researchers argue that hypothesis is generated by the abductive reasoning.

Hanson (1958) defined the abduction as the process of clarifying causes of the observed phenomena and stated that all scientific idea are gained by this process. Lawson (1995, 2000) exposited that the abduction is hypothesis generation process applying the similar experience in order to explain given questionable situation. Kwon *et al.* (2000) viewed hypothesis generation process in the aspect of abduction. Meanwhile, discussion, as the communication behavior, frequently appears in all sub-processes of scientists' knowledge generation. In the same context, discussion activities are known to play a pivotal role in exchanging information and opinions essential to generate scientific knowledge (Lee *at al.*, 2007).

However, previous studies verifying the effect of scientific knowledge generation learning program (Kang *et al*, 2006; Jeong *et al.*, 2005)

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**Received on 30 June 2012, Accepted on 3 September 2012
***This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MEST) (No. KRF 2012-0001734).

did not analyze the verbal interaction while focusing on each individual's thinking process. The frequency and level of verbal interaction during the laboratory class were often reported (Lee *at al.*, 2002; Lim and Noh, 2001), but the verbal interaction during hypothesis generation has not been conducted. This study, therefore, will analyze changes in the frequency and levels of verbal interaction patterns and their internal aspects while elementary students take part in hypothesis generation learning.

Ⅱ. Methods

1. Subjects

Thirty-two sixth graders were recruited from an elementary school in a metropolitan city and were assorted into heterogeneous 8 small-groups, each having 4 members, two boys and two girls. It is easy to cause the free riding effect when the group number exceeds five (Alexopoulou and Driver, 1996) while the group of four is known to be proper; it can facilitate effective exchange of opinion and collaboration (Jeong, 2002; Han and Noh, 2002). Sex ratio is referred as the variable of group verbal interaction, so the group members had the equal sex ratio. Cognitive levels of groups were equalized by comprising each group with students heterogeneous in achievement level.

2. Procedure

1) Task design

Tasks for hypothesis generation learning includes scientific inquiry contents proper to generate causal questions. Tasks are made up of ten sessions: orientation, two preliminary sessions (P1, P2) and main 8 sessions (M1~M8). Each session has teacher story board and student worksheet. Each task was validated the content by science education experts whether the content is related to the science curriculum. Student worksheets are made up of 5 directives: observation, question generation, questioning situation analysis, hypothetical explicans design and hypothesis generation learning.

2) Data acquisition

(1) Hypothesis generation learning audio/video recording

After tasks were once offered to students, teachers made no intervention in order to analyze inter-students verbal interaction. In each session, the whole interactions of two groups in turn were audio/video taped during 8 main sessions, i.e., each group activities were recorded two times. Students underwent interview within two days from the day audio/video-taped in order to profoundly understand the aspects of interactions during learning process.

(2) Retrospective interview

Students underwent retrospective interview based on their worksheet and recording data. In this interview, students were elicited to explain whether the verbal interaction was beneficial to generate hypothesis, if then why they think so.

(3) Data analysis

First of all, students protocols were transcribed verbatim. Next, this extracted protocol was coded by the coding scheme (table 1) which was developed through literature review (Yang *et al.*, 2007; Lee *et al.*, 2002). The coding scheme is including types and levels of verbal interaction. Sub-categories of cognitive aspect were highly leveled when the verbal behavior induced deeper and more detailed interaction. Questions and answers were modified according to the levels of interactions, referring to the research results of Chang and Lee(2000) which qualitatively identified students' questions and answers in the peer questioning process. Sub-categories of the emotional aspect could be separated to positive and negative sides. Within emotional aspect's categories, bigger code number means more

Table 1

Types of Verbal Interaction in The Hypothesis Generation Learning

Type of interaction		code	Content
Cognitive aspect			156.994 mmEach aspect ordered from basic level to high level interaction
Question	Simple question	Q1	Asking the learning process Confirming the names of observed objects or laboratory equipment Repetitive questioning on the meanings of terms in worksheet
	Relative question	Q2	Asking how to solve the worksheet's problem or how to manipulate instruments Requestioning what peers said means.
	Extended question	Q3	Novel or Creative questions boosting up the thinking process or raising questions on the given phenomenon and peers' opinion
Answer	Simple answer	R1	Simple answers on the simple questions lacking the explanation
	Relative answer	R2	Answers on the relative questions checking the learning process
	Extended answer	R3	Explaning the answer on the extended questions Organizing the discussed contents using scientific concepts or interaction
Suggeting opinion	Repetition	MS1	Repetitive suggesting one's opinion
	Suggestion simple opinion	MS2	Reading out what has been written in worksheet without verbal interaction Suggestion one's opinion on the way how to manipulate instruments
	Suggestion extended opinion	MS3	Developing one's opinion through verbal interaction Comparing one's opinion to the interaction results
Receiving opinion	Repetition	RO1	Repeating peers' opinion
	Simple extension	RO2	Adding simple opinion to peers' opinion
	Complex extension	RO3	Articulationg one's opinion adding the explanation about peers' opinion or opposing others' opinion with reasons.
Emotional aspect			Each aspect ordered from positive mood to negative mood
Behavioral participation	Voluntariness	P1	Voluntarily participating to the learning process
	Elicitation	P2	Eliciting peers to participate in the class
	Command	P3	Commanding peers
	Interception	P4	Disturbing peers' activity or interrupting
	Disregard	P5	Disregarding peers' response
Group atmosphere	Praise	A1	Praising one's group or group members
	Self satisfaction	A2	Praising oneself
	Self-confidence deficit	A3	Relying on teachers to solve problems
	Dissatisfaction	A4	Showing dissatisfaction on peers
Response to peers' opinion	Acceptance	RA1	Accepting peers' opinion without one's own opinion
	Reject	RA2	Rejecting others' idea without reasons

negative interaction.

In this study, overall phases and characteristics of verbal interaction were analyzed, rather analyzing that of one particular group(Chang and Lederman, 1994) because this study is aiming to identify the characteristics of students verbal interaction during hypothesis generation learning.

Ⅲ. Results and Discussion

1. Types of verbal interaction

1) Types of verbal interaction in overall learning process

32 elementary students were grouped of 4, so 8 groups conducted learning activity for eight period. One group's verbal interaction per one period was transcribed according to the coding scheme and the result of verbal interaction was modified to the frequency and percentile.

Table 2 shows two aspects of verbal interaction; cognitive and emotional aspects. Verbal interaction in the cognitive aspect takes 66%. Examining the frequency of detailed types of verbal interactions in

Table 2

Frequency and Percentile of Verbal Interaction Types

Section	Type of Interaction		Frequency (percentile)						Percentage of Each Process (%)
			Observation	Question generation	Question composition phenomena identification	Hypothetical explicans generation	Hypothesis generation	Total	
Cognitive Aspect	Question	Q1	26	2	4	9	1	42	28.1
		Q2	15	1	1	11	0	28	
		Q3	9	3	0	10	0	22	
	Response	R1	24	2	6	11	0	43	20.2
		R2	5	0	0	5	6	16	
		R3	2	1	0	4	0	7	
	Making Suggestion	MS1	6	3	1	0	2	12	37.6
		MS2	32	13	11	16	10	82	
		MS3	4	3	0	9	13	29	
	Receiving Opinion	RO1	4	0	0	2	0	6	14.1
		RO2	9	2	0	1	0	12	
		RO3	13	4	1	9	1	28	
	the Total		149 (45.6)	34 (10.4)	24 (7.3)	87 (26.6)	33 (10.1)	327 (100)	100
Emotional Aspect	Behavioral Participation	P1	6	3	1	3	0	13	62.0
		P2	16	9	9	7	8	49	
		P3	7	5	2	7	5	26	
		P4	9	2	0	2	0	13	
		P5	3	1	0	1	0	5	
	Group Atmosphere	A1	3	0	0	2	1	6	21.6
		A2	3	0	0	0	0	3	
		A3	2	2	0	3	0	7	
		A4	6	3	3	4	5	21	
	Reaction to Peer Opinion	RA1	6	5	1	8	3	23	16.4
		RA2	1	0	2	2	0	5	
	the Total		62 (36.3)	30 (17.5)	18 (10.5)	39 (22.8)	22 (12.9)	171 (100)	100

cognitive aspects, the frequency of making suggestion(MS) reached up to 37.6%. questions were 28.1% and answers 20.2% respectively. This seems because making suggestion itself immediately triggers another suggestion or questions and questions require related answers. On the other hand, receiving opinions relevant to suggestion making gained only 14.1%.

Verbal interaction in the emotional aspect was 37%, relatively high-portioned when regarding the hypothesis generation learning is cognitive process. It is likely because students elicited or command peers' participation in order to solve the given problem during collaboration learning. It has been reported that goal structure in collaboration learning causes the increment of verbal interaction based on the students' inter-peer-reliance(Jonhson & Johnson, 1987; Webb *et al.*, 1995). Of verbal interactions in emotional aspect, behavioral participation showed 62.0%, which means group members actively cooperated in order to stir up the hypothesis generation.

(M4. observing pores and sweat after exercising)
A : (smelling one's sweat and observing peers' forehead) You have no sweat. (MS2)
B : (showing paper soap) you would be better wash out with this. (MS2)
C : Hey, backhand got wet. There are pores! (MS2)
(from next group) my pad got wet! (RO2)
C : The back of my neck also wet! (RO2)
D : (watching that A and B chatted) go ahead. (P3)
C : Please, present your idea on the number 1. (P2)
A : The body gets hot. (MS2)
B : Head, nose, hand, backhand, thigh, footpad, neck got wet. (MS3)
D : Sweat came out from the tiny pore on the skin. (MS3)

2) Types of verbal interaction in thinking processes

One remarkable result was that students had vigorous interactions during observation because observation consolidates the foundation of scientific knowledge generation at the next stage of scientific inquiry (Kwon *et al.*, 2005). When it comes to the sub-categories of interactions, making suggestion interactions were high-frequently appeared, ensuing questions and answers repetitively; students endeavored to make multilateral perception on phenomena.

(M6. Observing hydrogen generation apparatus and hydrogen bubble near the fire)
E : It's going up, right?
F : (no response.)
E : (To G in next group, watching the bubble popped up), Was there anything at first?
(G in next group) In the bubbles? Hydrogen was made!
—
E : Bubbles with hydrogen exploded when they were fired.
F : In addition, glass tubes with soapy water made bubbles, Bubbles went up and exploded.

Related to this, retrospective interview showed that students understood and represented what they observed through verbal interaction. This is likely that students could not perceive what they were observing because observation but verbal interaction helped them finally perceive the factual phenomenon. Especially, observation was continued after the class moved beyond the observation phase which ment the thinking process of hypothesis generation recurs in circulating manner (Kwon *et al.*, 2008).

When generating questions, the frequency of verbal interaction rapidly decreased, but verbal interaction in the aspect of group atmosphere and response to peers' opinion increased. This seems because students related their subjective opinion into making questions and peers responded to this.

The verbal interaction frequency in cognitive and emotional aspects was the lowest when

composing questions and identifying phenomena. This result might be because choosing one question of all generated questions and analyzing the question is a matter of one's decision making. Most students reported having conversation on disparate questioning situation hampered analyzing one's own questioning situation.

The verbal interaction during hypothetical explican generation was the second best active. The frequency of 'questioning' and 'suggesting opinion' highly increased as they did in observation phase. It is likely that students having limited knowledge necessary for explican identification actively exchanged their opinions and information. In the next case, student K gained information on similar experience from L in order to explain questioning situation that sound occurs when salt is added to soda pop. K related his experience that beer can makes sound when it opens to the phenomenon that gas makes sound when it leaked. Student L also used 'unknown gas', the term that student K first referred when explaining the causal explicans. Student J tried to apply the concept 'dissolution' which was first used by J.

(M1. Observation of the phenomena that gas bubble leaked out when salt was added to pop soda.)
J : (looking into what K wrote) because salt was melted?
K : (no answer)
J : That's a good idea.
K : (to L) What did you write as the similar phenomenon?
L : Soda pop and beer can.
what is that leaking out from beer?
K : No, just call it 'unknown gas'.
L : Unknown gas?
K : We don't know what the gas is.
L : It sounds as soon as soda pop opened because carbondioxide leaked out.
J : Bubble temporarily emerges when the can lid got opened. When you open the cap of coke can, the same phenomenon occurs because they are samely carbonated drink. Carbon dioxide dissolves in the water.
K : To the opposite, only limited amount of salt get dissolved because all matters have the maximum limit to dissolve.
L : In addition, beer makes sound because it has a certain unknown gas.

Some students generated causal explicans having low relationship to the questioning situation as reported that elementary students hardly generated causal explicans about similar experience or just re-narrated one's similar experience(Kang *et al*, 2006). In retrospection, students stated that they thought by themselves rather consulted with peers when they made causal explicans. It means students gave up verbal interaction because verbal interaction was not effective to generate causal explicnas. Therefore, teachers need to employ a certain teaching strategy when they guide students the discussion and debate skill so that students clearly conduct discussion on causal explicans.

During hypothesis generation phase which is the last step of hypothesis generation learning, the verbal interaction seldom appeared. Next case is the protocol of ML. Student J, K and L elaborately generated hypothesis while assembling causal explicans that they made through verbal interaction. Student L generated the hypothesis by assembling two explicans 'carbondioxide leaks out' and 'salt is dissolved'. This is linear hypothesis with multiple explicans of the scientific hypothesis types (Jeong, 2007).

(ML. Observation on the abrupt leakage of gas when soda salt was added to soda pop.)
K : The reason bubble emerged is because salt push out the gas having been dissolved in the soda pop.
L : It sounds when salt gets added to soda pop because the carbondioxide leaked out.
J : When salt whole dissolved the bubble seldom went up.

L : (during class presentation) The reason soda pop makes sound when salt added is because carbon dioxide goes out while salt dissolved.

2. The level of verbal interactions

1) The verbal interaction level in overall learning processes

Intermediate-leveled interactions recorded 42%, higher high level(32%) and low level(36%) in the cognitive aspect. This can be regarded that students made bridge-stepped mediator communication proceeding toward the high level interaction through low level interaction.

2) The level alteration of verbal interactions in hypothesis generation learning

The result of level alteration reveals the discrepancies of verbal interaction level in the cognitive aspect along the hypothesis generation learning (Fig. 1). Verbal interaction level in emotional aspect was similar with that of cognitive aspect. Kang *et al*(2000) reported statements seemingly irrelevant to given task can make indirectly positive effect to the knowledge generation activities through releasing tension or formulating inter-peer intimacy. Verbal interaction in emotional aspect also functioned in this way. That is, emotional assessment followed peer's statement in cognitive aspect and this mediated ensuing discussion.

Table 3 shows the percentile of verbal interaction levels in individual steps of hypothesis generation learning.

In the observation phase, low-leveled interaction percentage was two times of high-

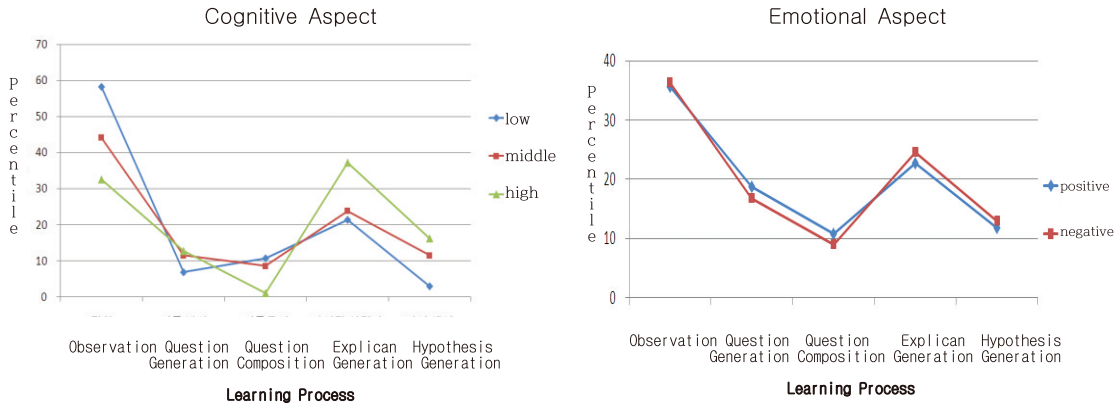

Fig. 1 *The Level Alteration of Verbal Interactions in Hypothesis Generation Learning*

Table 3
The Percentage of Verbal Interactions

Aspects	learning process	observation	question generating	question composition phenomena identification	generation of hypothetica explicans	hypothesis generation	the total
Cognitive	low	58	7	11	21	3	100
	middle	44	12	9	24	12	100
	high	33	13	1	37	16	100
Emotional	positive	36	19	11	23	12	100
	negative	36	17	9	25	13	100

leveled interaction (table 3).

Jang and Lee (2000) pointed the level of question students made is the main variable influencing to learning effect and quality of interaction. Table 2 shows the simple question and simple response are highly frequent, this supports their results. However, it is worthy to consider that this interaction occurred at the observation phase of hypothesis generation learning. This is categorized to fact question according to the study which categorized simple question into fact question, learning question, integration question. Fact question includes retrospection or identification on the information pertinent to learning contents. This means interaction collecting relevant information in order to perceive given phenomena precisely when students undergo observation phase.

Compared to observation phase's figure, in the question generating phase, high level interaction slightly decreased while low level interaction significantly dropped down until it gained just half portion of high level's percentage. This means interactional pattern altered from collecting and describing relevant information to understanding the property of phenomenon itself. Accepting peers' opinion was substituted to elaborating one's opinion based on the knowledge gained by observation.

At the stage of question composition and phenomena identification, low level interaction showed similar ratio with previous stage; it appeared more often than high level interaction. Verbal interactions in this process seldom emerged except simple suggestion making, reporting and posing ones' opinions in one direction.

When it comes to the hypothetical explicans generation process, high level interaction reached up to even three times higher than that of low level and this was the highest frequency of the whole hypothesis generation learning process. Low level interaction during observation in order to perceive phenomena successfully shifted to high-level communication in order to grasp the characteristics from similar experiencial situations.

Students' superficial conversation disappears and profound discussion occurs when they must solve the problems emerged during experiments (Kim *et al.*, 2006). When it comes to hypothesis generation learning, especially in the process of hypothetical explican generation, high level interaction is saliently increased. This process seems to require highly complicated thinking ability.

(M5. laying down dry ice in the water tank floor and blowing soapy bubbles so that the bubbles jump up or suspend)
O : I wonder (Q1)
M : What? (R1)
O : White thing like dry ice, making smoke (Q3)
M : Ah.... (thinking) (RA1)
N : Really..? (RO1)
M : You added in to your soapy bubbles right? (RO3)
M : It doesn't occur to me now though I listened before. Frozen Human making? (RO2)
N : Yah,, I know, the dead body. (RO2)
M : The dead bodies get frozen by it. (RO3)
M : Right, that's it. (P1)
O : What? (Q1)
M, N : Gas nitrogen. (R1)
O : Nitrogen? What nitrogen? (Q1)
M : nitrogen frozen.. yeh, liquid nitrogen. (R1)
M : liquid having the property of nitrogen? (Q3)
N : Condensing the nitrogen can make liquid nitrogen. (R3)
M : Condension. (RO1)
N : You didn' know it was liquid or gas. (A4)
M : you neither. (A4)
N : How can you contain it? (Q3)
M : You must contain it somewhere science room, the big refrigerator. (R3)
N : If it gets ignited then how? (Q3)
M : Have you ever seen cold fire? (RO3)
N : Though. (Q1)

M : Stop it. (P4)
M : (pausing with silence) you, 4, why don't you say something? (P2)
O : Would you state your own thinking, 4? (P2)
M : Oil floats up because water and oil never mix one another. Oil is lighter than water so floats over water. (MS2)
O : I think the white gas emerges from the liquid nitrogen. Extremely cold nitrogen made vapor frozen. (MS3)
M : Why don't you? (P2)
N : Blown bubble did not disappeared but suspended because they were same in their ingredients. (MS2)

Above case showed that student O recalled the similar experience of going-up gas and managed to dredge up the gas's name through peer interaction. Meanwhile, student N actively explained and mobilized his own science knowledge. but the similar experience just ended repeating the questioning situation. It is because discussion was not got through on the floating soapy bubble. Retrospective interview revealed that student N generated the hypothetical explicans on her own. Accordingly, students having difficulty to generate hypothetical knowledge need to reinforce the verbal interaction skill so that they can generate highly explanatory explican.

In the hypothesis process of hypothesis generation, the level and type of verbal interaction appeared similar to question generation process. This is because both activities mainly encompass knowledge integration based on the questioning situation and similar experience situation. Most students skipped the verbal interaction during hypothesis generation, but a few students consulted with peers' opinion and developed one's hypothesis. According to the results of present study, low and intermediate level interaction showed frequently than that of high level in the verbal interaction during hypothesis generation learning process of elementary school students. This corresponds with the results of several research arguing that most experiment classes require only low level thinking and do not pique students' higher thinking ability like scientific inference (Yang *et al.*, 2006) or just superficial discussions occur in small-groups activities (Kang, 2001; Noh *et al.*, 2005). The further in-depth investigation, however, demonstrates quite different patterns. In the observation stage, low-level interactions occurred briskly and decreased smoothly. From the point of hypothetical explicans generation phase, high level interaction reversed. This can be accounted that early stages of hypothesis generation require amplifying the observational knowledge and simple external information while later stages must ensure higher level of thinking such as comparing, assembling acquired knowledge and formulating appropriate inference so that the inquiry results explain hypothetical knowledge more precisely.

Ⅳ. Conclusion and Implication

Analyzing the verbal interaction types so far, in cognitive aspects, the type of making suggestion showed high frequency and behavioral participation frequency was also higher than any other types in emotional aspect. This is because the interaction requiring more active behavioral participation functioned as the inducer allowing another interactions like fluently posing opinions and exchanging them based on the goal structure for the sake of hypothesis generation.

During hypothesis generation learning, observation phase took the half portion of whole verbal interactions and hypothetical explican generation phase followed. Opinion suggestion, questions, answers helped students perceive the questioning situation, experience situation, and explanation objects in the multiple aspects so that they succeeded in hypothesis generation. On the other hand, verbal interaction seldom appeared during question generation, question

composition, phenomenon identification and hypothesis generation. This steps seemed to proceed with individual's inner thinking.

Verbal interaction in emotional aspects had similar ratio in positive and negative atmosphere. The alteration resembled that of intermediate level interaction in the cognitive interaction, considering the similarity between intermediate interaction and whole interaction frequency, this can be concluded that interactions of emotional aspect mediated those of cognitive aspects.

On the other hand, in terms of interaction levels, observation mostly consisted of low-level interaction, but this pattern came reversed at the hypothetical explicans generation phase, showing high level interaction much more frequently than low level, which reflects interaction level's elaboration along the hypothesis generation learning process. In other words, students progressed to higher level thinking from the repetitive low level of interactions.

Although hypothesis generation is one of the most critical inquiry ability, it can be very difficult to students who are hardly curious or cannot recall relevant experiences. However, effective verbal interactions help students share the perceived phenomena and overcome the learning difficulty. Therefore, this study has following implication for current education.

First, educational strategy for observation and hypothesis generation when hypothesis generation learning program is employed into the educational practice. Students can further and develop these two processes with active interactions. Especially, students lacking the interaction during hypothetical explican generation produced low-relevant hypothetical explicans, so students will benefit when they have interactions during causal explican generation.

Second, teaching model on the question generation, question composition and phenomenon identification are required so that students can integrate their own thinking and develop their learning. Listening to peers' opinion after perception on the questioning situation can impede the progress of thinking.

Third, hypothesis generation showed low frequency but the interaction for hypothesis elaboration is necessary. Through verbal interaction during hypothesis elaboration, hypotheses can become more qualified and persuasive.

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