Mevlana International Journal of Education (MIJE) Vol. 2(3) **INVITED ARICLE**
Special Issue: Inquiry in Science Education & Argumentation Based Science Inquiry,
pp. 33- 42, 30 December, 2012 Available online at http://mije.mevlana.edu.tr/

Exploring changes found in lab reports of pre-service science teachers by adapting a group questioning strategy with using the science writing heuristic template

Myeong-Kyeong Shin*
Gyeongin National University of Education

Jeonghee Nam
Pusan National University

Article history

Received:
25.09. 2012

Received in revised form:
16. 10 2012-

Accepted:
19.12.2012

Key words:
Science writing,
Scientific practices,
Group questioning

Pre-service elementary teachers' view on how scientific practice works could be shown in their lab reports especially which were designed to write their testing questions, methods, claims and evidences. For better practice of scientific inquiry for the pre-service teachers, Science Writing Heuristic was used as a teaching method. Only adopting worksheet of SWH and following the steps may lead students to the proper experience of scientific inquiry, which might be hardly expected. The stage of making their own testable questions is essential and critical for the scientific practice as well. This study presumed that a group questioning strategy at this stage would be effective for better scientific inquiry. The purpose of this study is to demonstrate changes of scientific practices after adapting group questioning strategy in terms of scientific reasoning and consistency among elements of scientific practices including questions, methods, claims, and evidences based on pre-service teachers' lab reports on elementary level science activities. During the science teaching methods course for pre-service elementary science teachers, the activity of various subjects in elementary science textbooks were implemented. In this study, two classes were observed and participants' writings were collected; one used science writing form without and the other with group questioning strategy. During participants' practices with the form, participants were asked to write what they were curious about, what they did and was their evidences, and what they claimed through the activity. There were found to be more interactions among participants and more relevant and testable questions asked in a class with group questioning strategies. It was implicated that participant pre-service teachers acted similar with children in terms of scientific practices as well. Further it was discussed whether scientific practice in school science truly include testing students' own questions.

Ⅰ. Introduction

In our classroom of science, students' memorizing scientific words are frequently taking place still. We, however, believe in doing science is more like the skillful exercise of a repertoire of 'craft skills' than the following of an algorithm as Polanyi (1958) and Ravets (1971) asserted. In teaching children science, we are helping them to internalize the procedures and standards of scientific community. We are again assisting the child to construct for herself a mental representation of the scientific ways of working judging (Millar, 1989). It is because the training of scientists involves the process of coming to internalize these tacit canons of procedure and judgment.

* Correspondence: Gyeongin National University of Education, e-mail: mkshin@ginue.ac.kr

Early back in 1926, Bobbitt (1926) described the importance of training students not only to reproduce facts but, more importantly, to develop the power to think in relation to the world's activities. Here 'the training' means scientific inquiry or scientific practice where students develop their knowledge about the nature of science. It will be more important for their teachers to have such training in order to train students in that way.

What can science education suggest teachers to do in their classrooms in order to move toward providing students with 'scientific practice' through their classes? A recent work of Fulwiler (2007) throws us a thumb nail picture of how science writing can scaffold scientific inquiry to support learning. It is so sure that her point of view on science writing is somewhat different from the Science Writing Heuristic(SWH); she focused on writing about science and writing scientifically but the SWH as Hand (2000) proposed covered a scheme of scientific work with an emphasis on argumentation and inquiry organizers or scaffolding.

Argument-based inquiry writing using the SWH approach was proposed by Hand and Keys (1999) and incorporates the importance of language use in learning into scientific inquiry. Students are engaged into generating questions, designing procedures, collecting data, organizing and interpreting data, proposing claims, providing evidence, and doing their reflection on the whole process of inquiry and investigation. Students write their claims using their own words after experiment and communications.

With this science writing, students can learn and experience of scientific practice which consists of questioning, doing experiments, finding evidences and making claims. This type of science activity is quite student-oriented and open exploratory activity.

Testing is an easy step of school science experiment. However in-depth analysis of science class during my observing elementary science classes, it is not easy to catch the scene describing students' own testing. Rather students follow the textbook experiments and fill out the worksheet. Mostly they copied the best students' answer in their group. For example, during my class observation of 4th graders, I found two students in a group were not writing the worksheet and wait. The experiment was simple observation of color changes. I asked them why you were not doing anything. They said they waited for the group leader finished writing answers in the form to copy them. In fact, the color changes were not done perfectly as textbooks said in that activity. The group leader wrote what she memorized from the textbook rather than what she saw. What school science is supposed to do in the name of scientific experiment may be hardly real. Scientific practices are at least not activities to let students follow the directions and ignore any mistake or errors. Rather it encourage students to define the different results and discuss them focusing on what they have known and newly found. In science practice, errors and wrong answers is a good starting point of authentic science doing.

It is easily found that Gagne’s view of the processes of science impacts on the science curriculum in Korea. He insisted that a child has to learn concept before learning principles and process skills before learning concepts. His view, however, is consistent with the early empiricist view that knowledge is inferred from experience (Finley, 1983). When we tried to move toward scientific practices in the light of available conceptual knowledge, the conceptual knowledge of researchers determines what constitutes a problem for a discipline, what hypotheses will be entertained, what experiments will be conducted, what data will be sought, and how observations will be organized and classified (Finley, 1983). The view of science as conceptually driven as the current Korean science curriculum emphasize on is rather consistent with the logical empiricist view of science as hypothetical deductive rather than inductive. And it connects to the SWH driven inquiry. In such open exploration context of science practice, Tytler and Peterson (2004) studied scientific reasoning of elementary students. They are characterizing the level of processing, dealing with competing knowledge claims and response to anomalous data which presented in elementary students' classroom dialogue. A large part of the program of science class tried to promote scientific reasoning. In order to achieve the purpose, teachers conceptualize and develop strategies for enhancing children's scientific reasoning. More importantly teachers needed to experiences representing scientific reasoning themselves.

In this study, the scientific reasoning of pre-service elementary teachers was explored when they worked with open exploratory activities by using group questioning strategy. A class of the 13 pre-service teachers in science teaching method course were compared before and after using group questioning strategies. Without this strategy, participants worked with the activities together and fulfilled the science writing form individually. With group questioning, there was only one difference that the instructor asked to make a group question rather than an individual one. The research questions of this study are followed:

1. How dose group questioning strategy affect scientific testability of their own questions and the coherence among the questions, claims and evidences?

2. What differences in nature of pre-service teachers' approach to exploration level of processing and response to anomalous data are found between pre and post group questioning strategies?

II. Research Concerns and Focus

Relevant Questioning and Making Claims in Scientific Inquiry

As the cognitive developmental research on students' scientific reasoning represented on their coordination of theory and evidence (Kuhn, Amsel, and O'Loughlin, 1988; Kuhn, 1997), children, until early adolescence, tend not to think of theory and evidence as separate entities. They argue that children's lack of ability to distinguish evidence from theory is a fundamental constraint on young' children's science conceptions (Tytler and Peterson, 2004).

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their works (NRC, 2000). Other than this, numerous definitions can be found in the educational literature.

Some advocates of more open-ended, student-centered inquiry would argue against a frame work for organizing and planning inquiry. Cuevas et al. (2005) proposed inquiry framework and its evaluation for elementary school students. They found it an important initial step for teachers and students. The purpose of the inquiry framework was to make the inquiry process explicit for students from backgrounds where science inquiry may not be encouraged or for those with limited experience of school science (Cuevas et al., 2005). The science writing in this study is a kind of inquiry framework which consisted of questioning including stating problem, test description, making claims with stating evidences, and writing their reflection.

In their report, they developed five steps of inquiry; questioning, planning, implementing, concluding, and reporting. In this study, questioning and concluding were exemplified for testing pre-service teachers' scientific inquiry before and after using group questioning strategy.

Nature of Approach to Exploration

Most concerns for the scientific inquiry are the theory-evidence relationship, How students coordinate these can be a critical indicator of scientific reasoning. The ability and tendency to generate hypotheses are major dimensions in exploratory behaviors (Tytler and Peterson, 2004). Tytler and Peterson (2004) created categories of Ad hoc explanation, inference searching, and hypothesis checking by focusing children's management of interactions between explanation, prediction, and evidences. Such management of these categories is an important aspect of scientific reasoning.

Level of Processing and Response to Anomalous Data

Tytler and Peterson (2004) generated a framework to plot type of explanations brought by students. It included description of phenomena, pattern identification and explanations. The dimensions, as they viewed, describes characteristics of conceptual knowledge as it relates to evidence.

During the exploration, students easily meet with anomalous data. Thus how to deal with them is an important aspect of generating and evaluating knowledge claims in the light of evidence. It can lead us to understand how students practice theory -evidence coordination.

III. Research Method

Research context

This study occurred in the elementary science methods course for junior year students of teacher pre-service university. During the class, argument-based inquiry using the SWH was adapted for students activities. Before using group questioning strategies, students were asked to fill out their worksheet of the SWH template. It consists of seven sections to guide activities including beginning ideas, tests, observations, claims, evidence, reading, and reflection.

A lecturer provided materials and let students do their own inquiry from generating questions to claims. Most experiment materials were from elementary science textbooks. After proceeding 8 periods of adapting the SWH template without any specific strategies other than letting them use the template, a group questioning strategy was adopted. Before adopting a group questioning strategy, each student in a group made her own testing question with given experiment materials and equipment. A group questioning strategy is simple to encourage students to share their ideas and come up with one compromising testing question for a group work. Students worked as a group except questioning with a shared testing question but filled out the template individually. To illustrate the classes, all the students worked in a group for their inquiry and they came up with their test question through a group discussion. The SWH template was completed by an individual student. Therefore each group shared one question but methods, claims and reflections frequently were different among students even in the same group.

The SWH lab reports of participant students before adapting group questioning strategy were used as pre-treatment data and ones after utilizing the strategy as post data for this research. The treatment for this study is adapting a group questioning strategy. Before and after adapting the strategy were compared in terms of the SWH templates filled out by the participant students. Target classes of 'before' and 'after' were consecutive periods. Out of 40 enrolled students, 13 submitted both lab reports consecutively. Therefore the number of participants of this study is 13.

Target Tasks

For this study, the collected lab reports were regarding two target tasks from elementary science textbooks.

Pre-task: Sink or float

Salt, water, beakers, small pieces of candle, small weights of 100g, 1000g, and 50g and spring scales were provided for students. The materials can be used for testing relationship of weights in water according to density of water. Salt can be used for controlling density of water.

This test explained the buoyancy when a object is in water. Weight inside water is mainly governed not by original weights of objects but by their volume. One other factor for this study is spring scales. Each spring scale has its own range of measurement. Most of them in elementary school is ones ranged around 200g to 2000g. It must be checked before the test. Another factor can be surface tension force of water which will be very minor.

Post-task: Combustion of Candle:

Candles, lighters for lab, and different sized bottle with wide mouth were provided for students. What will be independent variables and dependent variables can judge the hypothesis of student group. Most cases are to use a big bottle and a small one and observing differences of duration of candle lights covered by two different sized bottles. It is very typical experiment in elementary level science.

IV. Results and Discussion

Brief description of differences observed in the Two Labs.

Both pre and post, students worked lab task of testing in groups of 5or 6 students. In post, students more interacted with each other than in pre. When students generated their own individual test question, they did not much attention on group work including interacting with their group members. They spent most of the time on searching the reference book for information. Their talks during the lab were mostly on private chatting talks. They did not have much attention on the test and experiment. One or two leader students in each group were only members working on the test. The rest of members in groups were just waiting for their finishing filling out the SWH template in order to copy them. This scene, interestingly, were frequently found in elementary students during my observation of elementary science classes.

Surprisingly when the lecturer told students to make a test question as one group question, the whole situation was changed. Instead of having private talks, students in groups conferred with the test questions and methods and their verbal interaction and engagement on the lab was even higher than the previous period. Each member of a group took participation on the task and was involved very sincerely.

Based on a capsule analysis of 13 students lab reports, the changes were quite visual. In pre, there was only one test question found. While students were encouraged to have their own individual question, one same dictated question for 13 students is even odd. In post, there were four different questions generated by the same students of pre. Considering using quite simple equipments and materials, four questions in post were big number. It is interpreted that all students in groups were involved in post.

More testable and more coherent

The list of questions found in 13 students in pre and post phase is the following.:

In pre phase,

"How does the spilled out water amount by an object change depending on the density of water?"

In post phase,

"Is the time duration of combustion of a candle linearly proportional to the size of bottles?"

" Amounts of air will affects on candle burning. "

"Is amount of air related to time of burning candle?"

"Does the number of candles in a bottle affect on their combustion time?"

In pre phase, one found question was in only one dictated form. In case of post, there were differently dictated questions were found as well with the similar meaning. It is an evidence to support that in pre students copied their question from each other. It came up with one type of question.

During the discussion on generating a group question in post, they needed to select the best one. Therefore they employed the rule for selecting the best question of ' whether it is testable or not?'. They were asked to make their own claims from the test. If they have a researchable but not tested by means of given materials and equipments, they would face the improper claims without any test data. For example, how much oxygen will be needed for a candle combustion is very researchable but with limited materials it can not be tested.

In pre phase, the question is not testable. It did not include independent and dependent variables.

In terms of coherence between questions and claims, none of reports in the pre, questions and claims were not coherent. The claims are supposed to respond to the questions. Students asked " Does the overflowed water amount by submerged objects is different from different densities of water?". Their claim was, however, 'Weights becomes smaller in denser water.'

In the post, most of students succeeded in making their questions coherent with claims.

Nature of exploration

The way students coordinated explanations with evidence is named as nature of exploration. Tytler and Peterson(2004) provided the categories for nature of exploration dimension with three levels: Level 1 is ad hoc exploration where no systematic observations or comparisons are made, or use of a guiding exploratory purpose. Exploration at this level interpretation that lies close to observable entities; Level 2 is inference searching. The inference could be about relations between variables, or about theoretical ideas; Level 3 is hypothesis checking. Explorations have a recognizable hypothesis driving them. Exploration at this level is theory led, but this level is theory led, but does not necessarily separate variables.

By this coding framework, the level of nature of exploration for 13 students was resulted in Table 1.

Table 1: Profile of levels of nature of exploration in pre and post phase

levels	pre-phase	post-phase
1. Ad hoc exploration	11	0
2. Inference searching	2	11
3.Hypothesis checking	0	2

In the lab reports of pre-phase, students had a random focus when exploring a given form of experiment and following the steps. How much water would be come out of the beaker during their exploration is only concern for them. They did not consider the range of spring weight scale for weights. All the reports indicated that measured weights has no consistent tendency when measuring the objects submerged in the water. It is interpreted that they might use the wrong range of spring scales. For instance, some spring scales ranges from 100g to 1000g or from 1000g to 3000g. The range is indicated on the device. They just did something randomly and followed what others did. It is just like observing flowers with some fascination as saying out loud 'Wow!

In their claims, they generated explanations for observed results without attempting to compare across the submerged matters of a candle and a iron piece with a similar volume. There were at least three set of independent-dependent variable relations in the pre-phase task. They are a comparison of weights of iron weights vs. candle piece in different densities of water, a comparison of weights of a object before and after submerged in water, and a comparison of amounts of overflowed water when objects submerging. Constantly, most students tried to describe the differences of weights of submerged objects in different densities of water.

In the post phase, students moved to inference searching. Yet there was no drastic change to hypothesis checking level. Students actively play with various independent variables and looked at features of combustion of candle. They put up with various questions. Even with a similar test question, there were found two different test methods. For instance, with a question of 'Is amount of air related with burning time? ', there were two test method: one used a big and a small bottle to check the time duration of candle burning in order to check relatively short or long. And the other used intentionally two different sized bottles. One is five time bigger volume than the other. They tried to check whether the exact proportion of time duration of one and the other is 5 vs 1. The transformation of data was quite differentiated among students. In pre, only one and identical form of data table was reveal in all lab reports. Students, in post, compared candle burning in pairs based on some factor of interest.

Level of processing

The depth of processing is the extent to which students generated explanations that went beyond the data. In level of processing, Tytler and Peterson (2004) suggested three categories of description of phenomena, pattern identification, and explanations. Based on the pre and the post results, Table 2 was found after coding students' lab.

Table 2: Profile of levels of processing in pre and post phase

levels	pre-phase	post-phase
1. Description of phenomena	7	1
2. Pattern identification	6	10
3.Explanation	0	2

In the pre phase, students coded in level 1. Students focused on phenomena only. They tended to list or describe without comparison, and with minimal conceptual content. Even though they provided data table with various factors, they didn't use any for making their own claims. They seemed shared and copied the one data table. One identical observation data table is found in 13 lab reports. But 7 of them used it as describing phenomena. Six of them indicated the pattern identification in the pre. They identified patterns in the data. Still they only used one aspect of data set for finding patterns, while there were several potential patterns to be found. These six students' pattern identification statements was identical one from another.

In the post, most of students moved to level of pattern identification. They identify the generalized characteristics of combustion and relations between size of bottles and burning time duration. However the level of explanation was only two cases in the post. Mercan (2012) examined the epistemic beliefs about justification employed by 50 participants including physics undergraduate and graduate students and faculty in the context of solving a standard classical physics problem and a frontier physics problem. The situation of dealing with a frontier physics problem was quite similar to this study. The data of Mercan(2012) showed that seven justification modes emerged from the data and they were labeled as authoritative, rational, empirical, experiential, relativistic, religious, and modeling. The justification modes simply describe the ways that individuals justify knowledge in physics. It reported that the participants usually expressed more than one justification mode in a particular task context, and the frontier physics problem appeared to be more open to expressing multiple justification modes than the standard classical physics problem.

And in the context of the frontier physics problem the rational and empirical justification modes were used to support both the claim that the correct theory can be determined and the claim that it cannot be determined. In the pre-phase of this study, students did not try to even go into any explanation with justifying their findings and claims. They only described what they found. Drastically in post-phase, more students tried to explain or justify their own claims out of their findings. Yet even in the post-phase, students focused more on pattern identifying rather than going into the in-depth discussion with using more than one justification modes. The participants in this study is not quite competitive with ones of Mercan (2012)'s study. They used the level of elementary level science compared to undergraduate level of science of Mercan (2012).

Responses to anomalous data

Students' responses when confronted with evidence that contradicted their explanations were analyzed. As Tytler and Peterson (2004) proposed, in responses to anomalous data there can be two categories of non-acknowledgement and acknowledgement in preliminary sorting.

In the pre, 9 students of 13 ignored the anomalous data. But in the post, 12 of 13 acknowledged the anomalous data and 8 of 12 extended to explanation modification and proceeded to do their own re-test individually for the refinement of their claims and evidences. In the study of Lee et al. (2012), five science inquiry activities of using SWH forms and a total of 115 writings of the participant teacher at the elementary teacher preparation university in Korea were collected and analyzed. 115 pre-service teachers without any group questioning strategies like the situation of the pre-phase of this study were examined in terms of coordination of theory and evidences.

The most frequent type was showing consistency of theory and evidences. It was interpreted that, when theory in the inquiry questions were easily figured out by students, they tried to select supporting evidences out of data found. There were rarely found relations between activity topics and frequencies of coordination types but activity 1. And that active coordinating process itself was hardly found in the reports. It is quite similar to the pre phase of this study. The findings implicated that students should always neither collaborate nor their previously owned knowledge with experiment planning, data analysis and interpretation and making their own scientific claims when they come up with frontier or vague problems in the level of students .

V. Concluding Remarks

Group questioning strategy with the SWH in this study was effective on moving students towards more scientific inquiry. In terms of nature of exploration students revealed more inference searching than ad hoc observation, when adapting group questioning strategy. There were more frequent use of pattern identification than description of phenomena and more acknowledgements of anomalous data as well. Here ignoring anomalous data means their belief did not change. Unless belief in their own theories can be changed by an experiment, the theories are not part of science. With adopting the strategy, participant students had a chance to move toward experiencing theories as being part of science.

Students' reports divided up similarly on the level of processing and nature of exploration. The same reports showing Ad hoc exploration was mostly indicated to description of phenomena as well as ignoring anomalous data. In the same manner, reports coded as inference searching revealed as pattern identification.

While nature of science cares for the expert views of science, individuals have their own belief systems regarding how scientific knowledge is constructed and evaluated in the boundary of personal epistemology. It suggests that individuals move through a unidimensional developmental sequence that reflects an evolving ability to coordinate the objective and subjective aspects of knowing -from a naive belief that knowledge is certain and directly accessible,- to a mature view of knowledge being justified by integrating and evaluating different opinions and multiple sources of data (Baxter -Magolda, 2004; King and Kitchener, 1994).

There should be more number of data to be collected in order to generalize the effects of group questioning strategy. Yet the finding of this research is quite positive.

Referring to Song (2010), 33 pre-service elementary teachers were analyzed in epistemological perspectives. They revealed mostly realist with naive inductivist view and positivism. They showed naive realist perspective in nature of science and used objective evidences to assist truth of scientific knowledge in epistemological aspects. It is interpreted as they don't view science experiments in school as testing their own questions. Based on this study, the approach of this study can drastically challenge pre-service teachers.

Acknowledgement

This work was supported by the National Research Foundation Grant funded by the Korean Government (NRF2012-045893).

References

Baxter-Magolda, M.B. (2004). Evolution of a constructivist conceptualization of epistemological reflection. Educational Psychologist, 39, 31–42.

Bobbitt, J.F.(1926). Curriculum investigations. Chicago: University of Chicago.

Cuevas, P., Lee, O., Hart, J. & Deaktor, R. (2005). Improving Science Inquiry with Elementary Students of Diverse Backgrounds. Journal of Research in Science Teaching. 42(3). 337-357.

Finley, F. N.(1983) Science Process, Journal of Research in Science Teaching, v20 n1 p47-54.

Fulwiler, B.R.(2007). Writing in science-how to scaffold instruction to support learning. Heinmann:Portsmouth, NH.(202p).

King, P.M., & Kitchener, K.S. (1994). Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults. San Francisco, CA: Jossey-Bass.

Kuhn, D. (1997). Developmental psychology and science education. Review of Educational Research, 67, 141–150.

Kuhn, D.,Amsel, E.,&O'Loughlin, M. (1988). The development of scientific thinking skills.
London: Academic Press.

Hand, B., Norton-Meier, L., Staker, J. and Bintz, J.(2006). When science and literacy meet in the secondary learning space: implementing the Science Writing Heuristic (SWH): University of Iowa, Draft Copy.

Lee, S.K., Lee, K.H., Choi, C.I. and Shin, M.K.(2012). Analyzing coordination of theroy and evidence presented in pre-service elementary teachers' science writing for inquiry activities. Journal of Korea Association of Science Education. 32(2), 201-209.

Mercan, F. Ç.(2012). Epistemic Beliefs about Justification Employed by Physics Students and Faculty in Two Different Problem Contexts, International Journal of Science Education. 34(9), 1411-1441.

Millar, R. (1989) -What is scientific method and can it be taught?(ch 3) In the book: Skills and Processes in Science Education: A Critical Analysis ,176p, Publisher: Routledge by Jerry Wellington (Editor)

NRC (National Research Council), 2000, Inquiry and the National Science Education Standards. Washington, DC: National Academy Press.

Polanyi, M.(1958) Personal Knowledge, London: Routledge and Kegan Paul.

Ravetz,J.R.(1971) Scientific knowledge and its social problems. Oxford:Oxford University Press.

Song, H.J. (2011). Effects of Naturalized Philosophy of Science Based Teaching-Learning Design on Pre-service Teachers' Epistemological Conceptions: Focused on Plate Tectonics. Ph.D. Thesis of Seoul National University.

Tytler, Russell and Peterson, Suzanne (2004). From try it and see to strategic exploration: characterizing young children's scientific reasoning. Journal of Research in Science Teaching, 41(1), 94-118.