Characterizing scientific inquiry found in science core high schools (SCHS) in Republic of Korea

Caracterización de indagación científica encontrada en las escuelas secundarias con educación profundizada en ciencias en la República de Corea

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Abstract

The government of the Republic of Korea established a new type of school where students are provided with science research labs and field experiences in 2009. Rather than memorizing scientific knowledge and taking written tests without true understanding and applications the Science Core High School (SCHS) was designed to help students experience scientific inquiry and practice to enhance their scientific process skills and to develop better scientific minds. This study intended to find evidence of changes in the science classrooms in the SCHS as scientific practices are infused in teaching. The focus of the study was on identifying the characteristics of science teaching and learning in the newly built school system focusing on scientific inquiry.

Key words: *science education, Science Core High School, scientific inquiry, Republic of Korea*

Resumen

El gobierno de la República de Corea estableció en 2009 un nuevo tipo de escuela donde los estudiantes cuentan con laboratorios de investigación de la ciencia con la metodología de experimentación científica. En lugar de memorizar los conocimientos científicos y tomando pruebas escritas sin una verdadera comprensión y aplicaciones, las escuelas secundarias con educación profundizada en ciencias fueron diseñadas para ayudar a los estudiantes a experimentar, investigar y tener las prácticas científicas para mejorar sus habilidades indagativas y desarrollar mejor las capacidades científicas. Este estudio pretende encontrar evidencia de los cambios en las clases de ciencias en estas escuelas y sus influencias en las prácticas científicas en la enseñanza. El objetivo del estudio fue la identificación de las características de la enseñanza de las ciencias y el aprendizaje en el sistema escolar de nuevo tipo con énfasis en la indagación científica.

Palabras clave: *escuelas, educación profundizada, ciencias, indagación científica, República de Corea*

INTRODUCTION

The extent to which reform efforts framed by constructivism and promoted in the national standards documents have taken hold has been a topic of discussion in many countries. In Korea, Lee and Fraser (2000) argued, "while constructivist principles have been consistently emphasized in the science curriculum since 1982, actual practices in the classrooms in Korea have been dominated by teacher-centered, lecture-type instruction" (Lee & Fraser, 2000, p. 1). As evidence for this claim, in a study by Kim, Fisher, and Fraser (2000) investigating students' perceptions of their learning environment and teacher interpersonal behaviors in Korean science classrooms, 543 grade eight students rated the level of support they received from their teachers as relatively low. In addition, these same students reported a minimal amount of involvement in their class, as well as a limited amount of cooperation with other students (Campbell, et al, 2010).

The goals of inquiry, based on the National Science Education Standards (NSES), are summarized as: Through school science students should: (1) learn to do scientific inquiry, and (2) develop an understanding of scientific inquiry (National Research Council, 1996). The emphasis on scientific inquiry is also consistent with the Next Generation Science Standards, (National Research Council, 2013). In current school science practice, it is easily found that these two goals could be separately undertaken. As students perceive scientific knowledge to be the results or outcomes of doing science, they make efforts to memorize abstract science jargon without undergoing scientific practice or inquiry process. Understanding of scientific knowledge is, however, gained by using it. Better understanding scientific knowledge must involve students in participating in doing inquiry and scientific testing. Doing science is indeed correlated with cognitive processes that include scientific reasoning, students asking their own questions and formulating their own explanations. Students construct their own meaning through doing science. Such cognitive process and skills that involve scientific reasoning cannot be achieved by memorizing.

Unfortunately, school sciences in Korea have not been successful in involving students in their own inquiry where they are challenged with the cognitive processes involved with doing science. Recently, however, the Korean government has started to emphasize developing a strong science curriculum in high schools. The Science Core High Schools (SCHS), established in 2009, were designed to provide students with opportunities to practice authentic scientific inquiry. In Korea there are about 2282 high schools and 100 SCHSs. The proportion of SCHS is 4.4%. The SCHS is two year program for 11^{th} and 12^{th} graders that occurs in normal high schools nominated as SCHS. The government funded the development of the new science curriculum that included a special science program where students worked on scientific inquiry projects and studied history and philosophy of science as they were engaged in active science learning. The SCHS is a type of science immersion program in Korea.

In this study, we had two research goals:

- Explore qualitatively the features of scientific inquiry found in classes.
- Rethink what school science inquiry means as related to the educational purpose of school science.

After reviewing the theoretical framework for involving students in scientific inquiry these goals will be developed in the methodology and further analyzed and discussed in the results.

THEORETICAL FRAMEWORK

In science education, characteristics and features of school scientific inquiry have been searched and explored in many ways by researchers. At the international symposium (Abd-El-Khalick et al. 2004), researchers in science education made a list of processes for describing science inquiry (Grandy & Duschl, 2007): posing questions, refining questions, evaluating questions, designing experiments, refining experiments, interpreting experiments, making observations, collecting data, representing data, analyzing data, relating data to hypotheses/models/theories, formulating hypotheses, comparing alternative theories/models with data, proving explanations, giving arguments for/against models and theories, comparing alternative models, making predictions, recording data, organizing data, discussing data, discussing theories/models, explaining and refining theories/models, writing about data, writing about theories/models, reading about data, and reading about theories/models.

This list interestingly included cognitive, social, and epistemological elements (Grandy & Duschl, 2007). For instance, writing about scientific theory is a cognitive task and at the same time it can ask students to make societal judgments (Norris 2005). It is because writing means that student authors need to possess delicate beliefs about the cognitive tasks of readers and at the same time ask students to make societal judgments. As students are making predictions, recording data, and organizing data, they may not concentrate on the writings. Therefore writing tasks need to require different points of view and the epistemological judgment and reasoning of students. In summary, judgment and reasoning should be included in school science connected to the real world. Whether authentic inquiry is feasible in school science classes is a question that is hardly answered. However, as explained in the "Inquiry and the National Science Education Standards: A Guide for Teaching and Learning" (NRC, 2000), teaching approaches and instructional features in scientific inquiry can be varied.

What experiences provided for learners through inquiry occur in school science? Grandy and Duschl (2007) presented a list similar to the above but focused on what learners should learn in school science inquiry. It involved learners being engaged with scientifically oriented questions, giving priority to evidence, formulating explanations and communicating and justifying their proposed explanations.

This list can be considered when designing immersion programs of long-term inquiry curriculum from the viewpoint of learner -centered classroom environments.

Considering the limitations of the physical environments in schools and the task of covering the whole national curriculum in Korea found in school science, it is a challenge to implement authentic inquiry in schools. Still we can try to find a way of overcoming such impediments and propose feasible ways of doing science. In that context, school scientific inquiry provides students with opportunities to formulate and evaluate explanations from evidence and actively participate in scientific practice and discourse (NRC, 1996, 2003; McNeill, 2011). Science for students is more than explaining concepts and facts; scientific understanding also includes thinking and reasoning. It is essential for students to provide concrete illustrations and experiential evidence to show authentic practice and reality of school scientific inquiry.

METHOD

Target Science Classes

During this study, thirteen Science Core High Schools were observed and videotaped from April to June of 2012. Fifteen classes were videotaped for this study: 8 from 10th, 6 from 11th, and 1 from 12th grades. The demographic information of the 15 classes is described in Table 1. Students in SCHS must take eight science courses including biology, chemistry, physics and earth science as well as science literacy, integrated science, and two out of physics experiment, chemistry experiment, biology experiment and earth science experiment.

Teaching strategies of fifteen classes in thirteen different SCHSs were as follows: three classes designing and inventing some devices (e.g. toy wagon using the principle of action and reaction law); five with active discourses by using student presentation and discussion; five with laboratory style investigation; one with a long term group investigation project; one with Prediction-Observation-Explanation (POE) teaching strategy where teachers allowed students to predict before observing something happening and explain after observing the actual demonstration (see Table 1).

Data Collection

Two researchers participated in observing and videotaping 15 classes. Two focus group discussions among students were videotaped. These videotaped classes were transcribed. After observation of classes, the researchers interviewed teachers and students to find their understanding of lesson goals and procedures. Lesson plans and students' work sheets were collected as well.

Data Analysis

The data analysis was conducted in three steps. In the first step, videotapes and their transcripts were examined. Discourse segments of student-student and students-teacher were extracted as well. The exemplary cases of showing active interactions were selected. Secondly, according to cognitive processes of inquiry (Chinn & Malhotra, 2002), each segment was analyzed and interpreted. Chinn & Malhotra (2002) categorized inquiry into authentic inquiry, simple experiment, simple observation, and simple illustration. They defined the cognitive process for each category and developed the framework to apply for analyzing textbooks. In the third step, exemplary cases were extracted to show essential features of school science inquiry.

Table 1. Summary of 15 class information from 13 SCHSs.

SCHS School Name Initial	Grade (number of observed classes)	Course Name	Features of Student Activity in Observed Classes	Activity Type
JA	11th (2)	Science Study	Student Science Long-term investigation	Group investigation project
KN	10th(1)	Science Literacy	POE, Student Inferences and Presentation	Prediction-Observation-Explanation(POE) /Student Inference and Presentation
SER	12th (1)	Chemistry Experiment	Experiment on measuring molecular weight using Ideal Gas Law	Laboratory style investigation
WA	10th (1)	Science Literacy	Experiment related to the topic of Health: antioxidants and reduction-oxidization Experiment	Laboratory style investigation
YJ	10th (1)	Science Literacy	Inventing 'Slowest moving slide'	Designing and Inventing
ICW	10th (1)	Integrated Science	Inventing 'Pendulum of Foucault'	Designing and Inventing
JI	11th (1)	Earth Science	-Big-Bang Theory -Student making film presentation on Big-Bang Theory	Student Presentation and Discussion
PCID	11th(1)	Biology	-Student Presentation and Discussion -Teacher Summary and Instruction	Student Presentation and Discussion
WJA	10th (1)	Science Literacy	Student Presentation on the topics of Advertisement and Caseins	Student Presentation and Discussion
BEJ	11th (2)	Chemistry Experiment '	Various student lab. Work	Laboratory style investigation
KR	10th (1)	Science Literacy	-Force and Momentum –Inventing a toy wagon which can make a longer trip	Designing and Inventing
BH	11th (1)	Earth Science	Student investigation and presentation on astronomy related topic	Student Presentation and Discussion
MS	10th (1)	Creative Science Experiencing	-Activity to make a water filtering machine -How to integrate music and physics	Laboratory style investigation

RESULTS

This study found four distinctive cases that demonstrated the cognitive processes of scientific inquiry: features of controlling variables-improving devices, designing studies, formulating explanations from observations, and reasoning to formulate explanations from evidence.

Case 1: Controlling variables-improving devices

Students in 10th grade class of SCHS KR took the course of "Science Literacy". Students, as found in the videotaped class, were asked to invent a "far going toy wagon" using the law of action–reaction in physics. Students tried to design a toy wagon which could move farther only with one finger push by using plastic straws, rubber bands and erasers (see Figure 1). The purpose of this class was mainly that students had a chance to design a science experiment including controlling variables. Students came up with numbers of strategies using different number of rubber bands, varying weight of erasers, and changing places of plastic straws. Controlling variables and the relationship between variables were considered including the height of placing rubber strings, how to set up erasers, and the placement of wagon on straws. In the school science classes, a full sequence of authentic inquiry was observed. Students formulated and structured their own questions, proceeded to experiments for solving their questions and they evaluated their explanations by identifying evidence. In the limited condition of full inquiry, partial features of inquiry activity were experienced. In this case, questions were provided for students, but the instruction was primarily learner-centered..

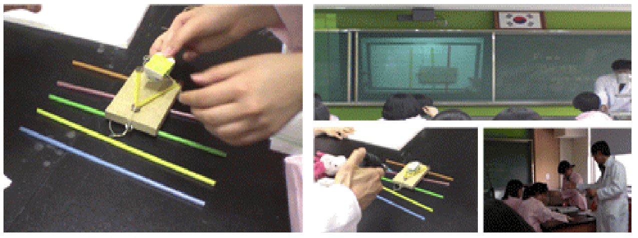


Figure 1. Students' activity of inventing 'far going' toy wagon

Case 2: Designing studies (defining variables, planning procedures, controlling variables, and planning measures)

This case took place in two class periods with 11th graders in SCHS JA participating in a group investigation project. This is a sort of independent science study or science immersion program. In one semester student group worked on their own science investigation topic for two hours every week. In the observed independent study group, students proposed to investigate on how to control the escape velocity of a variety of beads in a magnetic field. The escape velocity was dependent on the interactions and collisions of a variety of beads (including iron and glass beads). For example, given an initial velocity of an iron bead, the escape velocity was controlled by variables such as the: strength of magnets, diameter of iron beads and magnifying intensity. It was found that a group of three students designed their own study.

Figure 2. Students working on group investigation project

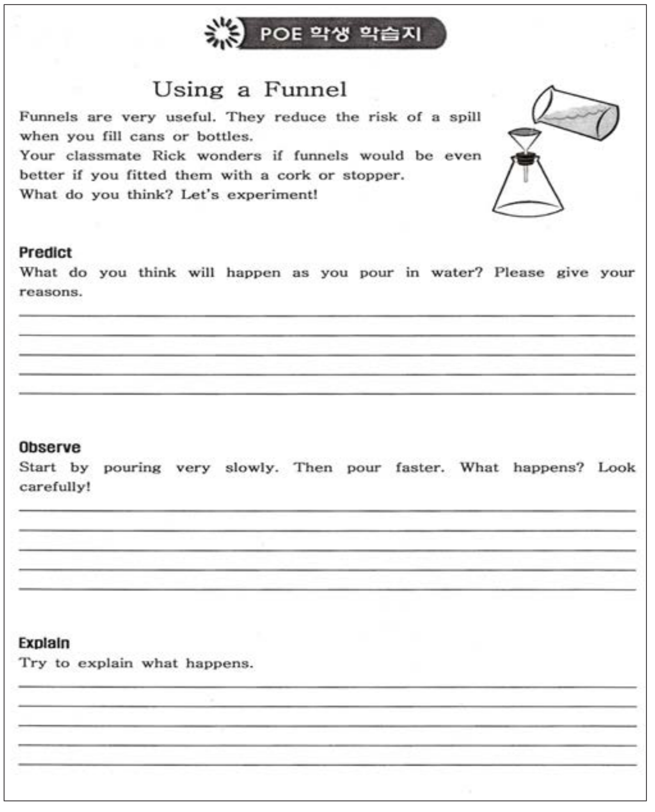
In this case, teachers did not tell the students the research question. Rather, the student groups made their own questions such as how to control escape velocity of moving beads in magnetic field. They tried to design the best experiment to solve their questions. They needed to define the variables related to their questions and make their own device. They interacted with each other in a group during the procedure of investigation. Students spent most of their time deciding distances and the time-duration of not-detecting laser light in order to calculate the escape velocity of beads. Students' exchange of ideas focusd on selecting critical variables for their own design of experimental devices in Figure 2.

Case 3: Formulating Explanations from Observations

This case was collected from a 11th 'Chemistry Experiment' class of SCHS BEJ during two consecutive periods. In this activity, students were asked to "design their own experiment using liquid nitrogen". Before starting this activity, a group of two students were assigned as a pre lab group and explained to the rest of students the purpose, contents, safety issues, and methods. The lab content found in this class were freezing roses, freezing a puffing snack, making liquid oxygen, twisting rubber balloons, and pouring liquid nitrogen into drinks.

Figure 3. Student works in chemistry experiment by using liquid nitrogen

Using liquid nitrogen, students observed a variety of phenomena and explained their observations. They tried to identify materials found during their experiments. When they explained something from their observations, it was found that they connected their observations with theoretical knowledge about phase change. Observational evidences from a simple experiment were simply matched with scientific knowledge and vice versa. This case showed two aspects of inquiry. First, students explained what they observed and linked to theory by means of active verbal interactions of students and teachers. During the interactions, they transferred their everyday words to scientific terms to explain their observations with scientific knowledge. Second, students tried to reason about the causes of what they observed and extended their investigation to explore various concepts, including differences between gases and liquids using appropriate materials.



POE 학생 학습지

Using a Funnel

Funnels are very useful. They reduce the risk of a spill when you fill cans or bottles.
Your classmate Rick wonders if funnels would be even better if you fitted them with a cork or stopper.
What do you think? Let's experiment!

Predict
What do you think will happen as you pour in water? Please give your reasons.

Observe
Start by pouring very slowly. Then pour faster. What happens? Look carefully!

Explain
Try to explain what happens.

Figure 4. POE instruction working sheet(above) and students in action(below)

Case 4. Reasoning to formulate explanations from evidence

This case was collected from the POE (prediction-observation-explanation) teaching strategy used in the 12th grade class. The topic of this class was "understanding pressure: using funnel, both air and a column of water can exert pressure". This case demonstrated students' reasoning process following by the given working sheet in Figure 4. Whenever they predicted what happened, they actively participated in the discourses with their colleagues.

Even when they explained their own observations, they tried to use scientific terms including equilibrium, pressure, Boyle's law, and air pressure. It was found that by using observations as evidence, the students interacted very actively in making meaning out of their observations.

DISCUSSION AND CONCLUSIONS

This study found four distinctive cases to show cognitive processes of scientific inquiry in the classes of SCHS. These processes included: features of controlling variables-improving devices, designing studies, formulating explanations from observations, and reasoning to formulate explanations from evidence. These processes on scientific thinking are consistent with recommendation from the Next Generation Science Standards (National Research Council, 2013). In the four cases, it was commonly found that student-teachers and student-student interactions were active and features of scientific inquiry were clearly present. Each case of exemplary lessons showed parts of elements of authentic inquiry rather than demonstrating its full sequences. Further analyses of each class, describing what happening in real classes collectively, led to in-depth discussion on the purposes and directions for improved school science inquiry. The new school system of SCHS showed some possibilities for providing other normal schools with benchmarks of how to facilitate student inquiry in school science based on this study.

ACKNOWLDGEMENT

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2013R1A1A2065669) and the university research support of 2015 by the Gyeongin National University of Education.

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Received 26-02-2015 /Approved 02 -11- 2015

Una revisión sistemática sobre e-mentoring: tendencias y perspectivas

A systematic review of e-mentoring: trends and perspectives

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Resumen

La mentoría es una forma de apoyo que hace posible establecer relaciones de ayuda en muy diversos contextos, ya sean escolares o universitarios, de formación profesional e incluso en el ámbito de las organizaciones, en procesos de inducción a la profesión, de mejora y desarrollo profesional así como de desarrollo de competencias laborales específicas. Este artículo desarrolla una revisión sistemática con el objetivo de buscar información de manera ordenada, estructurada y metódica en torno a la mentoría electrónica para descubrir las tendencias y tópicos que la literatura científica muestra. La revisión se llevó a cabo desde una búsqueda sistemática, fundamentalmente en inglés, en la base ISI Web Of Science (WOS), empleando el descriptor "e-mentoring" y filtrando la búsqueda en función del criterio temporal (2009-2013) para los tipos de documento "article" en el área "Education and Educational Research". Se obtuvo un total de 20 artículos que cumplían los parámetros fijados. Los resultados se presentan desde dos parámetros. Por un lado, datos generales (autores, revistas, distribución por años y tópicos) y, en segundo lugar, se destacan los tópicos fundamentales. Esta investigación ha permitido apuntar hacia los beneficios, impacto y perspectivas de este tipo de programas.

Palabras clave: *e-mentoring, mentoría electrónica, tendencias, revisión sistemática, estado del arte*

Summary

Mentoring is a way to support that makes it possible to establish helping relationships in a variety of contexts, whether school or university, vocational training and even in the field of organizations, processes of induction into the profession, improvement and professional growth and development of specific competences. This article develops a systematic review in order to searching information in an orderly, structured and methodical way about the e-mentoring, to discover trends and topics that develops the scientific literature. The review was carried out from a systematic search in English, based on ISI Web of Science (WOS), using the descriptor "e-mentoring"