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Application of Inquiry-based Science Assessment Questions on Earth Science Content Domain (V)

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Abstract
This study incorporates inquiry-based questions in science assessment and analyzes student responses in purpose of evaluating scientific inquiry abilities of fifth and sixth grade students in Korea. It aims to assess students' performances on inquiry-based evaluation and to develop guidance on teaching for development of inquiry skills.
This study reports the result about an earth and universe domain. To fulfill the research goal, the study is carried out as followed.
The chosen research subjects were 1,198 fifth and sixth graders from seven elementary schools in Woolsan, Gyeongsangnam-Do, Korea. The assessment questions were devised by modifying and reinforcing the NAAA (National Assessment of Academic Ability) developed by NIER (National Institute for Educational Policy Research of Japan) to incorporate inquiry-based learning and correspond to 2007 amendment of national science education curriculum in Korea.
From this result, we could be concluded that the inquiry-based science assessment helped develop students' inquiry skills, and it was determined to be an adequate evaluation method for building scientific knowledge and concepts for students.
Key words: *Inquiry based assessment, Elementary student, Inquiry ability, Korea, Earth domain*

1. Introduction
This study devises inquiry-based science assessment questions based on the NAAA (National Assessment of Academic Ability) developed by NIER (National Institute for Educational Policy Research of Japan) to test inquiry skills of fifth and sixth graders in Korea in order to find a method of assessment that can heighten students' inquiry abilities [1-2]. Furthermore, the study analyzes percentage of correct answers and commonly chosen wrong answers to propose guidelines on building inquiry-based science questions. The study also provides different teaching approaches for building students' inquiry skills by gathering students' preconceptions and misconceptions on science from each question.

2. Research Methods

2.1 Research subjects and period
The research subjects selected for this study were 1,198 students, of who are 421 fifth graders and 777 sixth graders from seven elementary schools in Changwon, Jinju, Sacheon, Tongyeong, Hamyang, and Woolsan in the Province of Gyeongsamnam-do. The assessment was carried out and collected over two weeks period starting in mid-April. The aim of the assessment, the rules and guidelines on the assessment were delivered to teachers before the assessment. The assessment time was set to 40 minutes [1-2].

2.2 Assessment
The assessment used for this research was made by modifying and reinforcing the NAAA (National Assessment of Academic Ability) developed by NIER (National Institute for Educational Policy Research of Japan) accordingly to the level of 2007 amendment of science education curriculum of Korea [3]. The assessment is made of four to five questions in each of four subjects of physics/energy, matter, biology, and earth science/universe, totaling in nineteen questions. The assessment questions were first translated and modified, and then reviewed by teachers.
Each question has elements of fundamental inquiry skills and comprehensive inquiry skills, and questions were developed considering the connections between different questions to measure students' inquiry skills through inquiry activities. Question types were either multiple choices (4-

answer), short answers, short essays, or combined answer (multiple choice + short answer or short essay). Inquiry types and functions of each question are as listed in table 1.

Table 1. Framework for inquiry skill and inquiry function for earth and universe

Question No	Inquiry subject	Type	Inquiry function
Q 15	Position of the sun	Fundamental	measurement
Q 16	Introduction to compass	-	-
Q 17	Length of a shadow	Fundamental Comprehensive	Measurement Data transformation
Q 18	Weather and clouds	Fundamental Comprehensive	Inference
Q 19	Daily temperature change	-	-

3. Results and Analysis

3.1 Analysis of responses to the assessment questions

A. Percentage of correct answers

1) Overall percent correct

The percentages of correct answers to inquiry-based science assessment questions were analyzed by question type and material as in table 2.

Table 2. Percentages of correct answers to inquiry-based assessment questions

Correction ratio (%)	Sexual correction (%)				Year corrections(%)		
	Girl (N=559)		Boy (N=639)				
	5th grade	6th grade	5th grade	6th grade	5th grade	6th grade	Total (N=1198)
Earth and universe	31.68	32.84	33.32	34.24	22.89	26.90	25.66
	32.26		33.78				

Overall percentage of correct answers on the assessment was 40.16%. The percent correct of inquiry-based assessment questions were lower than that of the general schools' assessment.

2) Percent correct by class year

Percent correct per class year was 5.69% higher for 42.13% in sixth grade than the 36.44% in fifth grade, but percentages correct were higher in fifth grade for questions 6, 15, and 17.

3) Percent correct by gender

Overall inquiry skills appeared more superior in boys who scored 40.33% compared to girls who scored 39.98%, but girls performed more superior in subject of biology where girls scored 42.57% whereas boys scored 40.90%.

B. Relevance to the academic curriculum

The percentages of correct answers to inquiry-based assessment questions by material coverage of currently enforced 2007 amendment of science education curriculum are organized as in table 6. Of the 19 assessment questions, 7 questions (37%) were covered in fifth grade curriculum and 15 questions (80%) were covered in sixth grade curriculum. Rest of the questions came from materials not covered in the academic curriculum.

C. Case Study

Each assessment question was further examined for its percent correct and for its commonly chosen wrong answer based on the particular inquiry skill demanded by the question. First, the particular inquiry skill asked by each question is described, and then student responses are listed in tables. The percent correct and wrong answers on each question are then analyzed to quarry for possible preconceptions and misconceptions students have on each question.

1) Question 15. Position of the sun

> ※ Brian observed and recorded the position and length of shadow of a tree for a day at different sun positions on 20th of May. Three figures below are the recorded shadow of the tree. Answer the following questions (15~19).
>
> 15. Please select which of the following figures is correctly representing the position of the sun at 1 o'clock afternoon, and mark the answer choice number in your answer sheet. Also mark the position of the sun at this time.

The fundamental inquiry skill tested in this question was "measurement".
This question makes an inquiry on how to use a compass properly as well as on the ability to measure position of the sun using a compass. The question is composed of two parts asking for proper how-to use of a compass and an application of a compass on measuring sun position.
The percent correct of this question was only 7.8% as there were only very few students who were able to properly use a compass and write down the correct sun position. Fifth graders scored 8.3% whereas sixth graders scored only 7.6%, showing higher percent correct in fifth graders. For gender variations, boys scored higher than girls.
The most commonly chosen wrong answer was answer choice ②, selected by 34.9% of test-takers. This is because when compass usage was instructed, it was often guided to let north side of compass face the top direction. So, many students associated the compass in ②with north side facing top direction as proper use of a compass.

2) Question 16. Introduction to compass

> 16. Write down the name of a tool used in question 15 to record the position of the sun.

This question related to question 15 asks if students know the name of the tool used measure the position of the sun. It does not test for an inquiry function as it was in question 8, but the question was still included as necessary part of the inquiry-based assessment in the subject of earth science and universe.
The percent correct on this question was 82.3% as most students were aware of the term, "compass".

3) Question 17. Length of a shadow

> 17. Brian made observation records as below. Please select which of the following represents a graph of the shadow length of the tree, and write down the answer choice number in your answer sheet.

This questions tests for the fundamental inquiry skill, "measurement" and comprehensive inquiry skill, "data transformation".
The question asks if the responder understands that the length of a shadow becomes shorter as altitude of the sun rises and that shadow is not formed when there is no sunlight. The inquiry activity to be carried out in the question is measuring the shadow length against the altitude of sun.
The percent correct on this question was 35.5% which was lower than the overall percent correct.
Fifth graders scored bit higher than the sixth graders, and this shows that since the topic was not covered in both grades, the question is purely testing for student's inquiry ability regardless of material coverage.
Girls scored bit higher than the boys, and this shows that girls have slightly stronger inquiry skills in transforming data.

4) Question 18. Weather and clouds

> 18. Brian took a photo of the sky at 11 o'clock on the same day. Please select which of the followings is the photo taken by Brian considering that there were no shadow of the tree starting from 10 o'clock in the morning till noon. Write down the answer choice number in your answer sheet.

The fundamental inquiry skill tested in this question was "observation", and this question on relationship between the weather and clouds asks for the knowledge that the sun's shadow does not form when there are too much clouds.

The percent correct on this question was 38.4%, which was lower than the overall percent correct.
Sixth graders scored higher than fifth grade, and boys scored higher than girls.
The most commonly chosen wrong answers ②and ④were each selected by 21.7%, and this shows that students have trouble correlating the shape of an actual cloud with a shadow.
This questions shows that students have a misconception that shadows are not formed if there is a cloud regardless of the amount of formed cloud.
This topic is covered in chapter four of the first semester curriculum in third grade and it describes amount of cloud abstractly as “fewer clouds” or “more clouds”. As a follow-up, this topic should be covered again in older class year and give more specific description of the amount of cloud with examples of actual clouds.

5) Question 19. Daily temperature change

> 19. Brian took a record of temperature on a single day. Please select which of the following graph most accurately depicts daily temperature change considering the shape of a shadow on this particular day. Mark the answer choice in your answer sheet including explanation.

The fundamental inquiry ability tested in this question was “measurement” and the comprehensive inquiry ability tested was “data transformation”. It tests if the test-taker can understand and explain from measurement of daily change of temperature that temperature does not rise when there is no shadow because it means there is no sunlight.
The percent correct on this question was 2.4%, which is much lower than the overall percent correct.
The most commonly chosen wrong answer choice ①was selected by 38.1% of test-takers. Many of the students knew that the temperature slowly rises and falls back during the day, but were not able to reflect upon the given condition of the problem stating “considering the shape of shadow”. This is similar to question 17 where students failed to peruse the question statement before start solving it.
Also because question 17 and 18 were highly sequential as if they were one inquiry process, the low percent correct on the previous question may have caused the low percent correct on this particular question.

4. Conclusion and Proposals

This study develops inquiry-based assessment questions by modifying and reinforcing the NAAA by NIER of Japan to match 2007 amendment of science education curriculum of Korea. The assessment was given to fifth and sixth grade students, and the responses were collected for analysis. The percentages of correct answers and commonly chosen wrong answers from the assessment were ascertained, and students’ inquiry abilities were able to be determined.
The following conclusions were made from this study.
First, if the most ideal form of learning scientific knowledge is in making scientific inquiries, inquiry-based assessment would be the most appropriate assessment method for fulfilling the ultimate goal of science education as the inquiry-based assessment encourages students to naturally learn not only the scientific information and concept but also the inquiry skills.
Second, because this study targets only fifth and sixth graders who have yet to finish the coursework for completion of the education curriculum, the assessment in this study is limited in fully testing students’ inquiry abilities. The study should continue on until target students finish all the coursework to observe the change in their inquiry abilities.

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