Cognitive Development, Analytical Thinking and Learning Satisfaction of Second Grade Students Learned through Inquiry-based Learning

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Abstract

Science teaching needs to be able students having knowledge and understanding. Also, students have to develop their thinking skills, it should help students meet real science through inquiry-based pedagogical process. This study aims to (i) investigate effective teaching criterion through inquiry-based teaching at 80/80, (ii) find out effectiveness index of inquiry-based teaching, (iii) compare analytical thinking between before and after students had learned by inquiry-based learning activities, and (iv) study learning satisfaction of second grade students after they had learned through inquiry method. Participants of the study were 10 second grade students, sampled by purposive sampling technique. Research instruments comprised of 8-lesson plan, 20-item achievement test, 20-item analytical thinking test, and 15-item questionnaire on learning satisfaction. Data were gathered and analyzed by Wilcoxon Matched Pairs Singed–Ranks Test. Results revealed that inquiry-based learning activities had effective criterion at 84.46/82.50; effectiveness index of inquiry-based learning activities was 0.5200; post test score of achievement test higher than those pre test score at .05 statistical significance level; and students had learning satisfaction on inquiry-based learning activities at highest level. It can be concluded that inquiry-based learning activities promoted students in terms of both cognitive, analytical thinking, and learning satisfaction. It should be suggested in for pedagogical preparation and incorporate it into science curriculum.

Keywords: Inquiry-based leaning, Cognitive development, Analytical thing, Learning satisfaction

1. Introduction

In the context of changing world, we need to develop our children to learn science in terms of nature of science, scientific literacy, and science process skills. The pedagogical aspects need to have inquiring mind in science and make them to meet both scientific facts and creativity. The learning perspectives also have all been considered as an important of science education goals (AAAS, 1993; Bell and Lederman, 2003). Science education has a responsible importance in raising individual experiences and attitude towards science. School science is to enable students to observe their natural environment and to develop skills required to understand and explain both themselves and their environment (Marx, 2004).

In science education, inquiry-based learning allows students' learning by doing, is relied on Dewey's school life and on that students learn how to solve problems by themselves (Dewey, 1938). This method is a complex but realistic process in which students use their prior knowledge and scientific theories to generate new understandings of science (Yoshina and Harada, 2007). The idea of teaching science by inquiry method allows students to encourage, explore, and experiment

with their own concepts about science. In addition, Inquiry-based learning can be referred to diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work. It included the activities of students in which the develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (National Research Council, 1996).

The approaches challenges to instructional strategies based on reality of science teaching, it need to able helped students learn natural things that surround them. Teachers have to use instructional methods based on recitation and direct instruction. The inquiry teaching challenges science learning to develop new content knowledge, pedagogical techniques, approaches to assessment, and classroom management (Krajcik *et.al*., 1998). Inquiry-based learning requires students to collaborate with peers, think deeply about complex concepts, relate new science content to their lives, and self-regulate their behavior. It also can be bridged scientific and cultural ways of knowing to the meaning of lives and environment (Cuevas *et al*., 2005).

The National Academy of Sciences and National Research Council (1996) determined that inquiry-based learning should be leaded learners engaged by scientifically oriented questions, to have the ability to determine what data allows them to develop scientific explanations, to have students' ability to formulate their own explanations from obtained evidence, can expand their findings and relate those findings to similar situations, and be able to communicate their findings to others in class, to present at the entire class, or written laboratory reports. The inquiry-based learning can lead students open their windows of opportunities to explore and understand about natural world by themselves.

Traditional science classrooms are teacher centered with demonstrations and lectures, while inquiry-based classrooms are supported by the learners' real world experiences. (Colburn, 2007a). Also, traditional science instructional strategies limit the creativity of both students and teachers. As a result, science teachers need to employ alternative instructional and assessment strategies to improve student achievement (Ellis, 2001). Inquiry-based learning provides teachers with a way of assisting their students in the association of theories taught in the classroom with laboratory experiences. It is a realistic method of instructing science which allows students to establish connections between prior knowledge and scientific descriptions of the world when compared with traditional methods (Clymer and William, 2007). This study aims to (i) investigate effective teaching criterion through inquiry-based teaching at 80/80, (ii) find out effectiveness index of inquiry-based teaching, (iii) compare analytical thinking between before and after students had learned by inquiry-based learning activities, and (iv) study learning satisfaction of second grade students after they had learned through inquiry method. The results of study can engage students in terms of both cognitive, analytical thinking, and learning satisfaction.

2. Materials and Methods

Participants: The participants of this study were ten second grade students, sampled by purposive sampling. They were studying in second semester, academic year 2008.

Research tools: Four types of research tools were created and employed: 16-hour inquiry-based learning lesson plan, 20-item achievement test, 20-item analytical thinking test, and 15-item leaning satisfaction on inquiry-based learning. The details of research tools construction were provided here.

1). inquiry-based learning lesson plan: researchers constructed learning activities based on inquiry and science education standards. Eight lesson plan, 16-hour learning activities were developed. Then, 3 experts seek a validity of lesson plan and provide suggestion delicately. Pilot study was allowed to conduct with 30 students of second grade students. Finally, the lesson plan was approved and prepared for experimentation.

2). Achievement test: researchers constructed 3-choice of 30-item achievement test. Then, 3 experts seek a validity of test. The index of congruency was calculated, its range was 0.67-1.00. Then, pilot study was allowed to conduct with 30 students of second grade students. The researchers selected 20 items which difficulty was .20-.80 and discrimination value (B) was 0.33-0.86. Reliability was also calculated and reported 0.88. Finally, achievement test was approved and prepared for experimentation in respectively.

3). Analytical thinking test: researchers constructed 3-choice of 30-item achievement test. Then, 3 experts seek a validity of test. The index of congruency was calculated, its range was 0.67-1.00. Then, pilot study was allowed to conduct with 30 students of second grade students. The researchers selected 20 items which difficulty was .27-.39 and discrimination value (r) was 0.24-0.40. Reliability (KR-20) was also calculated and reported 0.84. Finally, test was approved and prepared for experimentation in respectively.

4). Learning satisfaction questionnaire: researchers studied theories related learning satisfaction, 3-level of 20-item Likert scale was developed. Then, 3 experts seek a validity of test. The index of congruency was calculated, its range was 0.67-1.00. Then, pilot study was allowed to conduct with 30 students of second grade students. The researchers selected 15 items which discrimination value (r_{xy}) was 0.85-0.87. Reliability (Cronbach alpha coefficient) was also calculated and reported 0.87. Finally, questionnaire was approved and prepared for experimentation in respectively.

Procedure: In the research, one group pretest-posttest design was employed. Researchers clarified a purpose of this research for data collective cooperation with participants. Pretest is conducted, during 16 hours inquiry-based learning activities, researchers collected data to seek effective teaching criterion level of inquiry-based learning activities. Finally, posttest is followed. Data of cognitive and analytical thinking development were analyzed by Wilcoxon Matched Pairs Singed-Ranks Test.

Then, students response their learning satisfaction to this approach, the data have been defined and interpreted. The level of satisfaction to be consider with Likert's three-point rating scale. Each respondent is asked to rate each item on some response scale. They could rate each item on a 1-3 response scale where; 3 = agree, 2 = undecided, and 1 = disagree. Data were analyzed by mean and standard deviation.

Finally, the researcher analyzed collected data by using a computer program, checked the completeness of the data and then obtained data from responses to the questionnaire. Data were recorded; statistic values were calculated and interpreted by using the criteria as below:

Mean	Interpretation
2.50-3.00	High
1.50-2.49	Medium
1.00-1.49	Low

3. Results

3.1 Effective teaching criterion of inquiry-based teaching

Performance score of activities were measured during inquiry-based classroom, eight lesson plans were conducted and data were collected. Effective teaching criterion of process (E_1) was 84.46 and effective teaching criterion of outcome (E_2) was 82.50. It can be showed that the effective teaching criterion of inquiry based teaching for second grade students was 84.46/82.50 (see Table 1).

3.2 Effective index of Inquiry-based learning

This study applies the Effectiveness Index (E.I.) methodology, developed to measure students' cognitive development. This method is for measuring change has been used in educational research by Hovland *et.al.*, (1949). It can measure involves comparing the actual change in a given outcome from baseline (P1) to follow-up (P2) to potential change (100-P1). The E.I. is thus computed as follows:

E.I. = [(P2-P1) / (100 – P1)] * 100

The numerator represents actual change, while the denominator represents the maximum change that could occur. The E.I. is useful in comparing program effects in two groups of similar size and with similar baseline prevalence of a desired program outcome, in which a larger EI suggests a larger program effect. Data were interpreted and calculated, It can be considered at 0.5205 (see Table 2).

3.3 Analytical thinking of second grade students

Researchers analyzed analytical thinking of second grade students who had learned through inquiry-based learning activities by Wilcoxon Matched Pairs Signed-Ranks Test (see Table 3). It can be summarized that posttest score had higher score than those pretest at .05 statistical significance level.

3.4 Learning satisfaction on inquiry-based learning

Respondents were asked to rate their satisfaction with various aspects of their feelings. Levels of learning satisfaction were recorded across a range of indicators. Respondents were all satisfied with the level of learning activities through inquiry-based learning at high level ($\overline{X}$ = 2.69) (see Table 4).

4. Discussion

The findings of this study can be discussed that effective teaching criterion for second grade students was 84.46/82.50. It seems to study that students had 84.46 percent of performance score and 82.50 percent of posttest score. It means that students can build new understanding through interactions with their environment. The cognitive aspects of students' experiences are schemas, these schemas are described as models from which students can infer and evaluate phenomena using prior knowledge (Piaget. 1970). The effectiveness index was 0.5205, students can gain their knowledge and experiences 52.05 percent of scientific conception after learned by inquiry method. It can be used and implied for science education in terms of teachers' teaching preparation. Teachers need to understand that these schemas include misconceptions of scientific concepts as well as accurate understanding. Student learning as construction based on explorations and interactions with peers and the environment. Based on learning theory, dynamic process is result from interactions with both individuals and the environment, intelligence as a creation from prior knowledge and new

understandings, and cognitive growth as autonomous which includes both social settings and the physical environment of the learning.

When science teachers implement inquiry-based methods, they need to take a cognitive approach to instruction (Colburn, 2007a). Science teachers should use constructivist approach as the basis for understanding inquiry-based methodology in which it is the way of understanding how we know information (Llewellyn, 2002). It can be understandable that students' prior knowledge and experiences are grown. Science classroom is also included students' experiences. Science teachers should address when establishing this type of learning environment, need to develop an understanding of the way in which students learn. In addition, science teachers should understand that constructivist theory can provide meaning to teaching and learning by beginning lessons with what students know and understand.

The result of analytical thinking comparison between pretest and posttest score can be considered that posttest score had higher than those pretest score at .05 statistical significance level. Mean score of pretest was 11.50 while posttest score was 15.80. Inquiry-based learning can improve students' analytical thinking by engaging students in science classrooms and laboratories (Colburn, 2007b). Science teachers need to promote the use of inquiry-based learning in order to show students the learning process and to develop each student's sense of curiosity. It helps students construct knowledge through real world problem-solving based on information gained during experimentation (Krajcik *et al*., 2000; Zion and Sadeh, 2007). Also, inquiry involves the creation of a constructivist learning environment.

Science teachers must facilitate learning rather than dissimilating learning. They should be accomplished by providing support, encouraging discussions among students, challenging students to guide and fully participate in students' learning, and promoting openness in students for new ideas. Also, science teachers need to cultivate a learning environment that allows students to engage in inquiry. This is accomplished by providing the necessary time for inquiry, establishing an inquiry learning environment, and supplying the essential materials and resources for inquiry.

According to Colburn (2007b) and Llewellyn (2005), inquiry is a 5E process involving engagement, exploration, explanation, elaboration, and evaluation. During engagement phase, science teachers set stage for inquiry-based learning by hooking attention the students with inquiring mind. Exploration phase, science teachers incorporate inquiry-based laboratories and activities that include questions, hypotheses, cooperative interactions with other peers, and data collection. Explanation phase, inquiry students need to articulate their thoughts and experiences while constructing new meanings. Elaboration phase, the students should reinforce science concepts by expanding the data to real world experiences which will lead to additional inquiries. During the last phase, evaluation, students need to summarize relationships using higher order questions to make judgments, analyses, and evaluations of prior and newly attained knowledge.

Students need to include some the key aspects of inquiry-based classroom, new knowledge is incorporated through sensory stimuli by incorporating students' current and prior understandings. Students will be engaged and express their feeling how learning environment will be incorporated. They are continuously building and rebuilding understanding, need to reflect on their knowledge and experiences as well. Inquiry-based learning is a practical method for establishing the connections between prior knowledge and scientific descriptions of natural world. They should be provided with opportunities to appreciate and understand various forms of scientific inquiry.

5. Conclusion

The results of this study can be concluded that inquiry-based learning promote cognitive and analytical thinking developments, also learning satisfaction of second grade students were responded at high level. Teachers should play varied roles in supporting students' development of inquiry skills.

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Table 1. Showing score to calculate effective teaching criterion of inquiry-based classroom

No.	Lesson Plan 1 (30)	Lesson Plan 2 (30)	Lesson Plan 3 (30)	Lesson Plan 4 (30)	Lesson Plan 5 (30)	Lesson Plan 6 (30)	Lesson Plan 7 (30)	Lesson Plan 8 (30)	Formative score (240)	Pre-test (20)	Post-test (20)
1	26	25	25	25	25	25	24	25	200	11	15
2	25	25	24	26	25	26	25	25	201	12	16
3	26	24	25	25	24	25	25	25	200	13	16
4	24	26	27	24	26	26	25	25	203	12	17
5	26	26	25	24	25	25	26	25	202	14	16
6	25	26	25	26	25	25	27	25	203	12	18
7	26	24	26	25	25	26	25	24	201	12	15
8	25	25	25	27	25	25	26	26	204	12	17
9	26	25	26	26	25	25	26	26	205	14	17
10	27	26	25	25	27	26	25	26	207	15	18
Total	256	252	253	253	252	254	254	253	2027	127.00	165.00
Mean	25.60	25.20	25.30	25.30	25.20	25.40	25.40	25.30	25.34	12.70	16.50
S.D.	0.84	0.79	0.82	0.95	0.79	0.52	0.84	0.67	2.31	1.25	1.08
%	85.33	84.00	84.33	84.33	84.00	84.67	84.67	84.33	*84.46*		*82.50*

Table 2. Effective index of inquiry-based classroom

Summation between student multiplication and total score	Pretest score	Posttest score	E.I.
200	127	165	0.5205

Table 3. Comparisons of analytical thinking score between pretest and posttest

Variable		X	S.D.	Z	Asymp.Sig (2-tailed)
Analytical thinking	Pretest	11.50	0.85	2.816	0.0025
	Posttest	15.80	1.62		

Table 4. Students' learning satisfaction on inquiry-based teaching

Item	$\overline{x}$	S.D.	Level of response
I like to have teaching and learning activities based on inquiry	2.90	0.32	High
I prefer to do science with friends	2.80	0.42	High
I happy and proud with my learning outcomes	2.80	0.42	High
I feel better to have social acceptance when I do group work	2.70	0.48	High
I like to have learning participation and solve the problem with group	2.70	0.48	High
I like to have hands-on activities	2.60	0.52	High
I feel better when group members assigned me	2.50	0.53	High
I prefer, this activity allows me to do all step of assignment	2.60	0.52	High
I prefer to plan with others	2.50	0.53	High
I prefer to have assignment matching with student's aptitude	2.70	0.48	High
I like to have working studies	2.60	0.52	High
I feel good when I have to think and discuss with others	2.80	0.42	High
I like to investigate new information by employing constructivist theory	2.60	0.52	High
I feel good to inquire knowledge by self	2.80	0.42	High
I prefer learning activities that allow group investigation method	2.80	0.42	High
Total	2.69	0.47	High