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Comparative Study on Process Skills in the Elementary Science Curriculum and Textbooks between Indonesia and Japan

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Abstract

Enabling children to develop knowledge and ideas about nature by utilizing process skills has been a major objective of the elementary science in the Indonesian Curriculum 1994. The present research is carried out to investigate how the Indonesian and Japanese science curricula and textbooks set the process skills. The curricula were analyzed on the basis of substance of process skills. The textbooks were analyzed on the basis of basic skills and integrated skills involvement in their hands-on activity sections. Present research findings indicated that: (1) the objective of Indonesian Curriculum 1994 does not set the substance of process skills; (2) the objective of Japanese Curriculum 1998 sets the substance of process skills; (3) Indonesian textbooks primarily emphasize basic skills in all grade's levels; (4) Japanese textbooks emphasize basic skills in the 3rd grade and integrated skills in the 4th, 5th and 6th grades.

Key words : science elementary curriculum, textbooks, process skills, basic skills, integrated skills, Indonesia, Japan

I. INTRODUCTION

Process skills have long been identified as one of the basic goals of science education and became a part of well-established tradition of science teaching. **Esler** (2001) cited that modern elementary science curriculum emphasized two major goals, firstly, to enable children to develop process skills for doing science and secondly, to enable children to acquire appropriate science content or information. According to **Ostlund** (1992), one of the reasons to set process skills as the curriculum goal is that they emphasized the intellectual value rather than the value of memorizing scientific facts or principles. As a way of finding answers, process skills are effectively learned through conducting hands-on activities. **Helgeson** (1992) indicated that the most effective approach in teaching science is to integrate science process skills and science content using hands-on activities which focus on specific problem solving skills.

Process skills had been explicitly set as one of the curriculum objectives of Indonesian curriculum 1994. As one of the major objectives of curriculum, a number of researches had been conducted concerning their impacts upon science instructions both in the elementary and lower secondary classrooms. **Masjkur** (1999) indicated that process skills were less emphasized in the elementary; teachers lacked of knowledge in process skills; Observing and communicating skills were predominant in science classrooms. According to **Yulaelawati** (2000), science and technology education in Indonesia has some shortcomings concerning the curriculum 1994: the science textbooks

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本論文は，課程博士候補論文を構成する論文の一部として，以下の審査委員により審査を受けた。
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and instructions frequently brought about lecturing approach rather than activity-based approach.

According to study findings from the Third International Mathematics and Science Study (TIMSS) held by the International Association for the Evaluation of Educational Achievement (IEA) (1999), compared to Japan, elementary science instructions in Indonesia emphasize less on the utilization of laboratory equipment as experimenting activities were rarely performed in science lessons.

On the basis of the literature review, it was indicated that the shortcomings concerning process skills were related to their implementation in science classrooms as well as the teachers' perception and teaching strategies. As the research findings were primarily related to the outcome and impact of the curriculum implementation, it is considered necessary to firstly examine how the curricula itself set process skills as well as the curricula involvement with the substance of process skills. Then, to figure out the extent to which process skills had been implemented in the curriculum, it is necessary to examine textbooks as one of the curriculum materials.

Therefore, the present study is begun by exploring the substance of process skills followed by examining whether this substance is addressed in the curricula and the textbooks. Particularly, the present study sets the purposes to answer the following research questions:

1. What is the substance of process skills?
2. Do Indonesian and Japanese curriculum objectives set the substance of process skills?
3. To what extent do Indonesian and Japanese hands-on activities set the substance of process skills?

To clarify the extent to which process skills had been developed, it is necessary to design this research as a comparative study with other country where the curriculum is developed by the similar objectives and system. In terms of the curriculum objectives and textbook development system, Japan meets the requirement as Japanese curriculum objectives implicitly address the substance of process skills, and textbooks in Japan are mandatory and authorized by the central government.

II. SUBSTANCE OF PROCESS SKILLS

Although process skills have been variously defined, the most widely accepted definitions are those cited in Science-A Process Approach (SAPA), given by the Commission on Science Education of the American Association for the Advancement of Science (AAAS) in 1965. SAPA consists of 14 skills that categorized into basic skills and integrated skills. The definition of process skills by AAAS are given as follow:

• **Basic skills**

(1) *Observing*: to observe and identify properties of an object by 5 senses or instruments
(2) *Using time/space relationships*: to describe object position or motion in relation to other object.
(3) *Classifying*: to classify and order objects by their similarities and differences.
(4) *Measuring*: to quantify an observation using proper measuring device.
(5) *Communicating*: to communicate or report by oral, writing or drawing graphs, diagrams, maps, etc.
(6) *Predicting*: to forecast future event based on observations or prior experience.
(7) *Inferring*: to explain an event based on an observation.
(8) *Using number*: to make decision by applying numbers and their mathematical relationships

• **Integrated skills**

(1) *Controlling variables*: to identify and control variables in order to manage an experiment.
(2) *Interpreting data*: to collect and use data to make prediction, inference, and hypothesis.
(3) *Formulating hypothesis*: to make educated guess based on evidence that can be tested through experiment.
(4) *Defining operationally*: to define terms in the context of their own experiences.
(5) *Experimenting*: to test a hypothesis by performing experiment.
(6) *Formulating models*: to create an abstract or concrete illustration of an object or event.

Basic skills involve lower thinking skills and are commonly developed in the lower grades. Principally, basic skills lay the foundation of integrated skills. Integrated skills involve higher-order thinking skills and are commonly developed in the higher grades.

Since firstly introduced, SAPA had been recited in various process-skills related research. For instance, **Rezba.,et.al.,** (2003) in *Learning and Assessing Science Process Skills*, utilized SAPA to develop and assess process skills-based hands-on activities. In addition, **Smith., et al.,** (1995) in *Science Process Assessment for Elementary Students*, developed the test to measure elementary children competence in 13 skills of SAPA. Principally, the definition and categorization of process skills that cited by Smith and Rezba were similar to SAPA by AAAS. The facts provide evidence that since firstly introduced by AAAS nearly 4 decades ago, SAPA defined by AAAS still up to date as one of the most significant references for research in process skills.

To determine the substance of process skills, the definitions of process skills by Gagne and Shaw are addressed. **Gagné** (1965) defined that "process skills attempt to establish the specific competencies in students which will make it possible for them to solve problems, to make discoveries, and more generally think critically about science". In addition, **Shaw** (1983) indicated that skills of interpreting data, controlling variables, defining operationally, and formulating hypothesis are incorporated in problem solving skills. He notified that basic skills are a prerequisite for problem solving proficiency. According to these definitions, the substance of process skills is determined as follows:

- Process skills are ways to solving problem.
- Integrated skills incorporate in problem solving.
- Basic skills are the prerequisite for integrated skills.

III. METHOD AND PROCEDURE

III. 1. Curriculum Objective Analysis

Objectives of the Indonesian curriculum 1994 and Japanese curriculum 1998 were analyzed on the basis of the substance of process skills. Firstly, the overall objectives of the curricula in both countries are scrutinized. Secondly, determining whether the objective relate to any particular process skills. Then, the identified objectives are recorded on Table 1, which is arranged in terms of Indonesian Curriculum 1994 and Japanese Curriculum 1998. Final analysis is conducted to judge whether the objectives set or do not set the substance of process skills.

III. 2. Analysis of Hands-on Activities in Textbooks

Hands-on activities in the textbooks were analyzed according to the following procedures. Firstly, the textbooks are selected based on the prevailing criteria in the two countries. The criteria are: (1) textbooks were authorized by the central government, and (2) textbooks were published in year 2000 or after. Based on these criteria, Indonesian and Japanese textbooks are successively represented by "IPA untuk Sekolah Dasar kelas 3, 4, 5, 6: Erlangga (2003) " and "たのしい理科「3, 4上下, 5上下, 6上下」: 大日本図 (2002) ".

Secondly, the type of hands-on activities since the textbooks are delimitated as the textbooks present a variety of activities. Hands-on activities in Indonesia and Japan are successively represented by "Kegiatan" and "観察・実験". These hands-on activities are chosen based on the consideration that they are commonly used as the primary activities in the science classrooms. In the present study, the analysis of process skills in hands-on activities are focused on 13 skills instead of 14 skills, *as using number skill* more applicable in mathematics hands-on activities.

Thirdly, skills that notify in single hands-on activity are identified and classified on the basis of the definition of process skills. Every paragraph in a hands-on activity is carefully scrutinized, especially in the beginning and in the ending part of paragraphs where skills usually notified. Identification of integrated skills is carried out on the basis of the criteria of problem solving. Thus, the involvement of formulating hypothesis, controlling variables, experimenting, and interpreting data are applied to determine whether the integrated skills involve. Finally, the results are recorded on the checklist. (Table 2)

IV. RESULTS AND FINDINGS

IV. 1 Curricula Analysis

According to the overall objectives of Indonesian Curriculum 1994, science education is aimed at enabling Indonesian children (1) to understand science concepts and their correlation with everyday life, (2) to utilize process skills to develop knowledge and ideas about nature, (3) to be interested in recognizing and learning things and phenomena in nature, (4) to demonstrate curiosity, open-mindedness, critical thinking, self-awareness, responsibility, cooperativeness, independence, (5) to apply science concepts in explaining natural phenomena and solving problems in everyday life, (6) to utilize simple technology to solve problem within everyday life, (7) to cultivate a sense of love for nature as the result of awareness of the greatness of God.

According to the overall objectives of the Japanese Curriculum 1998 (elementary science course of study), science education is aimed to enable Japanese children to become familiar with nature and to carry out observation and experiments with identifying clear purpose, and to develop their problem-solving abilities and to nurture hearts and minds filled with a love of nature, and at the same time, to develop their understanding of natural phenomena, and scientific views and thinking. In order to contrast the objectives that relate to process skills between the two countries, the objectives are arranged in Table 1.

Table 1. Substance of Process Skills in the Curriculum

Indonesian Curriculum 1994	Japanese Curriculum 1998
developing children knowledge and ideas about the nature	conducting observation and experiments.
	developing children abilities in problem solving
	developing children scientific view and thinking

According to Table 1, the Indonesian curriculum 1994 implicitly sets process skills as the tool of developing knowledge. Consequently, from the perspective of the substance of process skills, the Indonesian Curriculum 1994 does not incorporate integrated skills On the other hand, Japanese curriculum 1998 explicitly sets process skills as the tool to problem solving. Consequently, from the perspective of the substance of process skills, the Japanese Curriculum 1998 incorporates basic and integrated skills. On the basis to the consideration on Table 1, it is concluded that:

The objective of Indonesian Curriculum 1994 does not set the substance of process skills in problem solving. On the other hand, the objective of Japanese Curriculum 1998 sets the substance of process skills in problem solving.

IV. 2. Textbooks Analysis

In order to describe the extent to which the Indonesian and Japanese textbooks set process skills, Table 2 is developed. In this table, process skills are arranged in terms of basic skills and integrated skills, while a number of skills are arranged in terms of grade and country. The Table 2 indicates that the Indonesian textbooks emphasize the basic skills in all grade's levels. On the other hand, the Japanese textbooks primarily emphasize basic skills in 3rd grade, while integrated skills are emphasized in the 4th, 5th and 6th grades. In general, both countries rarely involve process skills of classifying, predicting, time-space relationship, defining operationally and formulating models.

In order to provide statistical data for the result in Table 2, the statistical analysis by Fisher's Exact Test was conducted. For this purpose, the Table 2 is re-set into Table 3 by totaling number basic and integrated skills. Fisher's Exact Test in 4th, 5th and 6th grades provide p as less than 0.01. The statistical results support evidences that the textbooks' activities in Indonesia primarily emphasize basic skills while the textbooks' activities in Japan primarily emphasize integrated skills. The test does not show any significant results concerning 3rd grade.

In general, data in the Table 3 reveal findings as follows:

(1) Indonesian textbook activities in the 3rd grade tend to emphasize more basic skills than integrated skills.

(2) The Japanese textbook activities in the 3rd grade tend to emphasize more basic skills than integrated skills.

Table 2. Process Skills in the Textbooks.

PROCESS SKILLS	Type of skill	Number of Skill							
		Grade 3		Grade 4		Grade 5		Grade 6	
		I	J	I	J	I	J	I	J
BASIC SKILLS	1. Observing	3	19	25	13	29	8	24	4
	2. Classifying	–	–	1	–	–	1	1	1
	3. Inferring	–	1	10	–	18	–	1	–
	4. Prediction	–	–	–	5	–	–	–	–
	5. Measuring	–	9	4	4	1	8	1	–
	6. Communicating	3	2	3	12	8	2	6	1
	7. Time-Space relationship	–	1	–	3	–	–	–	–
INTEGRATED SKILLS	8. Defining operationally	–	–	–	–	–	–	–	–
	9. Formulating hypothesis	1	6	–	16	–	19	–	10
	10. Experimenting	1	6	–	16	–	19	–	10
	11. Identifying variables	1	6	–	16	–	19	–	10
	12. Interpretating data	1	6	–	16	–	19	–	10
	13. Formulating model	–	–	–	–	1	–	–	–

Table 3. Total Number of Process Skills

PS	G3		G4**		G5**		G6**	
	I	J	I	J	I	J	I	J
Basic skills	6	32	43	37	56	19	33	6
Integrated skills	4	24	0	64	1	76	0	40

** $p < 0.01$; * $p < 0.05$

(3) The Indonesian textbook activities in the 4th, 5th, and 6th grades emphasize more basic skills.

(4) Japanese textbook activities in the 4th, 5th, and 6th grades emphasize more on integrated skills.

According to findings (1)-(4), analysis on hands-on activities of the textbooks is summarized as follows:

Indonesian textbooks' activities in all grade's levels primarily emphasize basic skills. On the other hand, Japanese textbooks' activities in the 3rd grade emphasize more basic skills while the textbooks' activities in 4th, 5th and 6th grades emphasize more integrated skills.

V. DISCUSSION

The findings from hands-on activities of the textbook analysis had revealed that Indonesia emphasizes basic skills in all elementary grades' levels. In contrast, Japan emphasizes basic skills in the 3rd grade, while integrated skills are emphasized in the 4th, 5th and 6th grades. The different outcomes concerning process skills performance between the two countries is strongly considered as direct impact of the curriculum setting.

Although Indonesian Curriculum 1994 explicitly set process skills as the major objective, the process skills were primarily aimed as a way to knowledge accumulation instead of a way to problem solving. As process skills were not set in problem solving, the integrated skills, which incorporate in the problem solving, did not develop. In consequence, basic skills are predominant in every grade's levels.

As the objective of Japanese Curriculum 1998 set problem solving, consequently, the integrated skills that incorporate in problem solving are developed. Basic skills that lay foundation of integrated skills were predominant in the 3rd grade, while the integrated skills predominant in the 4th, 5th, and 6th grades. In fact, the Japanese Curriculum 1998 successfully set process skills as a way to solve problem.

To illustrate the difference between activities that set or not set problem solving, a sample of hands on activities concerning water properties are cited from Indonesian and Japanese science textbooks. For this purpose, Table 4 is constructed in terms of problem solving criteria. The criteria are: (1) set problem, (2) set hypothesis, (3) control variables, (4) experimenting and (5) interpret data.

According to Table 4, Indonesian textbook's activity was designed to verify whether the water expand or not expand when heating. The activity does not set the problem, hypothesis, or controlling variable. In contrast, Japanese textbook's set the problem as "does volume of water change if the temperature changes?" The problem setting provides the hypothesis to be tested. To test the hypothesis, the constant and the manipulated variables are determined (volume and temperature of water). The results of experiment provide the answer to the problem. (see detail of the activity at the appendix).

Table 4. Hands-on Activity Performance

Criteria	Indonesia (Process skills)	Japan (Problem solving)
(1) Set problem	—	Does volume of water change if temperature changes?
(2) Set hypothesis	—	Will volume of water change if temperature changes?
(3) Control variable	—	Volume of water (constant) and temperature (manipulate)
(4) Experimenting	Performing activity	Performing activity
(5) Interpret data	Water expand when heating	Volume of water will change if temperature changes

The findings from the present study have revealed that the Indonesian Curriculum 1994 has failed to develop integrated skills in the elementary science because the curriculum objective does not set process skills as a way to solve problem. In consequence, basic skills are predominant in all grade's levels.

Therefore, to develop children knowledge and ideas about the nature through the implementation of basic skills and integrated skills, the present study strongly suggests to re-oriented and re-set the objective of Indonesian Curriculum 1994 from the process skills for accumulation of knowledge to process skills for solving problem.

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APPENDIX FEATURES OF HANDS-ON ACTIVITIES

KEGIATAN 10.5

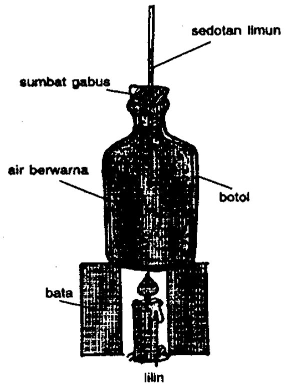
Alat dan bahan:

1. botol/labu erlenmeyer
2. dua buah batu bata
3. pipa plastik/sedotan limun
4. lilin
5. sumbat gabus.

Cara kerja:

Rangkailah botol/labu erlenmeyer dengan sumbat gabus yang dihubungkan dengan pipa plastik/sedotan limun. Isilah botol dengan air berwarna dengan cara membuka tutupnya dulu. Usahakan agar pemasangan sumbat botol dan pipa plastik/ sedotan limun agak rapat sehingga air tidak dapat keluar. Tekanlah sedotan sehingga berada kurang lebih 2 cm di bawah permukaan air.

Panaskan botol dengan lilin. Amatilah permukaan air di dalam selang plastik. Ternyata permukaan air berangsur-angsur bergerak ke atas setelah botol dipanaskan. Mengapa demikian? Diskusikan dan buatlah kesimpulanmu tentang percobaan di atas!

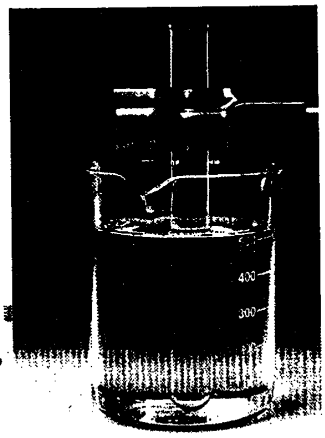


Keadaan air setelah mendapat panas cenderung menjadi ringan dan mengembang. Air di bagian bawah naik ke atas dan menekan air di atasnya sehingga permukaan air naik. Peristiwa tersebut menunjukkan bahwa air memuai apabila dipanaskan.

Air akan memuai jika dipanaskan.

2 水の温度とかさ

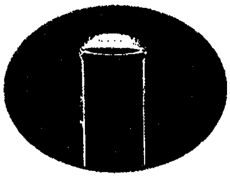
? 水も温度がかわると，かさがかわるだろうか。



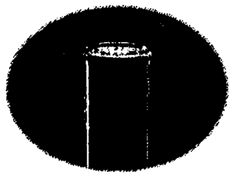
じっけん 1

❶しけんかんに水をいっぱい入れて，湯の中に立ててあたためる。水のかさがどうなるか調べる。

❷しけんかんに水をいっぱい入れて，つめたい水の中に立ててひやす。水のかさがどうなるか調べる。



あたためたとき



ひやしたとき

INDONESIA

Activity 10.5

Instrument & material

(1) bottle
(2) 2 paving blocks
(3) straw
(4) candle
(5) cork

Procedure

Set the instrument according to the given figure. Fill in the coloring water into the bottle. Then, insert the straw into the water through the cork (2cm beneath the water's surface), and capped them tightly to the bottle. Heat the bottle with a candle and observe the water level in the straw. In fact, the water level will gradually raise. Why? Discuss and make your conclusion.

Involve process skills of:

(1) Inferring
Why does the water level raise when it is heated?
(2) Communicating
Discuss and draw conclusion about this experiment.

JAPAN

Problem: does the volume of water change when the temperature is changed?
Hypothesis: the volume of water will change when the temperature is changed.
Control/Manipulate variables:
1. Fill the tube to the top with water. Place vertically in the beaker of hot water.
2. Fill the tube to the top with water. Place the tube vertically in the cold water in the beaker.
Interpret data: examine what will occur to the water in the tubes.

Involve process skills of:

(1) Set hypothesis
(2) Controlling variable
(3) Experimenting
(4) Interpreting data