Effectiveness of learning models for improving science process skills: A review study

Restiana¹,* and Djukri²

¹Biology Education, Postgraduate Program, Yogyakarta State University, Jl. Colombo No. 1, Yogyakarta, 55281, Indonesia
²Biology Education, Faculty of Mathematics and Natural Science, Yogyakarta State University, Jl. Colombo No. 1, Yogyakarta, 55281, Indonesia

*resti4300@gmail.com

Abstract. The 2013 curriculum implementation expects learning to produce output in the form of science process skills. Science process skills can be improved by applying appropriate learning models to learning activities. The research aims to analyze the types of learning models to improve science process skills. This research method is a meta-analysis by analyzing SINTA and SCOPUS indexed articles in the last 5 years qualitatively. Data analysis was performed by interpreting the same findings in the journal as a percentage. Research shows learning models that can improve science process skills include; practice based learning, guided-inquiry model, problem solving learning, guided-discovery model and project based learning. Of the various learning models, guided inquiry is more effective. Enhanced science process skills include basic skills and integrated skills.

1. Introduction
Science process skills (SPS) are used as a guide by students during the observation process to acquire new knowledge or develop existing knowledge. In Indonesia, this is reinforced by the existence of the Basic and Secondary Education Process Standards as stipulated in the Republic of Indonesia Minister of Education Regulation number 65 of 2016 stating that one of the learning objectives is skills that are elaborated on each education unit [1]. The challenges of the 21st century require students to have a variety of skills to face, one of which is scientific process skills [2]. Implementation of the 2013 curriculum expects students to independently develop new ideas through the stages contained in SPS. All stages in SPS train students’ new skills [1].

The lack of students’ process skills has an impact on student learning achievement that is less than the maximum [3]. Learning designed by teachers is more oriented towards cognitive achievement, while the achievement of motoric aspects is less touched. That is because the government policy that only assesses the standard of education assessment in Indonesia uses the results of the national examination [4] which is used as one of the considerations for determining the graduation of students from the education unit program. Based on [5] during the learning process, students be involved in active investigations by asking questions, planning investigations, collecting data, using scientific knowledge to understand observational data, and communicating the findings.

According to Rezba [6] applied science process skills have various indicators such as; define variables, interpret data, control variables, formulate hypotheses, design and conduct experiments.
Integrated skills are usually applied at the high school level. SPS is a provision in the daily life of students, this is supported by Zulfiani’s opinion [7], SPS makes (1) students can find solutions to the problems faced, (2) students able to form their own concepts and ways of learning something, (3) students able to develop themselves, (4) help students who are still at the stage of the development of concrete thinking, and (5) students able to develop creativity.

The teacher does not act as a source of learning but as a facilitator and motivator for students in the learning process. The teacher is in charge of helping students improve science process skills through designed learning designs [8]. Teacher-centered learning does not have the ability to improve science process skills [9]. The teacher designs interactive learning by implementing student-centered learning and it is expected that students’ science process skills will develop [10]. One of the factors that influence the results of students' science process skills is the use of learning models. Selection of the appropriate learning model is expected to improve science process skills as a result of learning [11].

The form of learning that is described from beginning to end and is presented typically by the teacher is called a learning model [12]. Used as guidelines or teaching instructions that are designed to achieve a learning goal. The role of the learning model has a positive impact on learning development. Its varied uses will provide a difference in the learning process that students go through to achieve their goals[13].

Based on the description above, developing science process skills is done by applying appropriate learning models. In order to achieve the research objectives systematically, the following questions were designed:

1. What science process skills are enhanced through the application of learning models?
2. What learning models be applied to improve students' science process skills?
3. How is the learning model considered effective in improving science process skills?

2. Methods

2.1 Research Design

This research uses a meta-analysis method to obtain new findings from several articles reviewed on a particular topic. Meta-analysis is a method for combining data from the results of studies conducted on similar articles statistically and numerically to achieve goals [14].

2.2 Data Source

The articles reviewed are articles published from relevant articles websites with SINTA and SCOPUS indexes, such as: Jurnal Pendidikan Sains Indonesia, BIOEDUKATIKA, JPBI (Jurnal Pendidikan Biologi Indonesia), JPPI (Jurnal Penelitian dan Pembelajaran IPA), JPI (Jurnal Pendidikan Indonesia), UNNES JOURNAL, JPPS (Jurnal Penelitian Pendidikan Sains), Journal of Physics, Cakrawala Pendidikan, Jurnal Inovasi Pendidikan Kimia, Journal of Baltic Science Education dan Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, with keywords; learning models and science process skills.

2.3 Data Collection

Articles are collected based on several categories: 1) the year of publication, namely the last five years, this aims to review the articles that are the latest research results. 2) learning models, variations of learning models that have been applied to improve science process skills. 3) article index, the articles reviewed are relevant articles indexed by SINTA and SCOPUS. The total articles reviewed were 20 articles.

2.4 Data Analysis

Data taken from the results, discussion, and conclusions of the articles reviewed. The data is then analyzed to get a percentage. The percentage results are obtained from the frequency results divided by
the number of articles multiplied by 100%. Frequency is the number of similar findings obtained from each article.

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\text{Percentage} = \frac{\text{Frequency}}{\text{Total article}} \times 100\% \tag{1}
\]

3. Results and Discussion

3.1 Measured Science Process Skills

The output of science process skills is in the form of a psychomotor domain, this is supported by Sanjaya (2010) which states that learning outcomes of behavior as learning outcomes are formulated in the form of abilities and competencies that can be measured or can be displayed through performance [15]. Rezba (2007) groups science process skills into two aspects, namely basic level skills and integrated level skills [6]. The two aspects measured based on the results of the journal review can be seen in the table 1.

| No. | Aspects of SPS | Frequency | Percentage |
|-----|----------------|-----------|------------|
| 1.  | Observe        | 14        | 70%        |
| 2.  | Classifying    | 10        | 50%        |
| 3.  | Predict        | 11        | 55%        |
| 4.  | Measure        | 7         | 35%        |
| 5.  | Conclude       | 12        | 60%        |
| 6.  | Communicate    | 12        | 60%        |
|     | Basic SPS      |           |            |
| 7.  | Controlling variables | 1 | 5% |
| 8.  | Data interpretation | 15 | 75% |
| 9.  | Hypothesis formulation | 12 | 60% |
| 10. | Defining variables | 2 | 10% |
| 11. | Design experiment | 10 | 50% |
| 12. | Conducting experiments | 8 | 40% |

|     | Integrated SPS |          |            |

Based on table 1, it is obtained that the measured science process skills include several indicators, namely observe, classifying, predict, measure, conclude and communicate as basic aspects and indicators of controlling variables, interpreting data, hypothesis formulation, defining variables, design experiments and conducting experiments as integrated aspects.

The percentage of basic aspects, namely observing aspects of 70%, classifying 50%, predicting 55%, measuring 35%, concluding 60%, communicating 60% with an average value of 55%. While the acquisition of the percentage of science process skills indicators integrated control variables 5%, interpretation of data 75%, formulation of hypotheses 60%, defining variables 10%, designing experiments 50%, conducting experiments 40% with an average of 40%. Data interpretation indicators get the highest percentage value, which means that these indicators are often measured in the application of learning models. Data interpretation is measured by performing various skills such as labeling a chart or diagram, producing the right theme and the information contained in it [16]. The ability of interpretation is the ability to record any observations of the relationship between observations, find patterns or regularity from a series of observations made [17].

Science process skills should be improved based on school level, in line with Rezba's (2007) opinion that the basic aspects are improved in elementary school students and the integrated aspects are improved in middle school students [6]. Having basic skills is needed to determine the mastery of integrated aspects of skills, because integrated skills are the result of increasing basic skills where the indicators are interrelated [18].
Based on figure 1, the results are obtained that the research sample is mostly done at the sample were senior high school, while based on the measurement table basic skills were higher than integrated skills. According to Rezba [6] science process skills should be adjusted to the level of education. Basic science process skills are improved for elementary schools and integrated science process skills are improved for secondary schools on the grounds that increasing science process skills adjusted to the level of education will achieve learning objectives according to Syamsuar Mochtar (1992), namely (1) fostering motivation and providing learning stimuli, (2) encouraging students' courage to ask questions and seek answers, (3) guiding students in various activities learning includes research activities and guiding students to interpret the results of research and report the results [19].

3.2 Learning Models that Improve Science Process Skills

3.2.1 Learning models. The results of review articles found that several learning models to improve science process skills are presented in the table 2.

| No. | Learning Models                      | Basic SPS | Integrated SPS |
|-----|--------------------------------------|-----------|---------------|
|     |                                      | 1 2 3 4 5 6 7 8 9 10 11 12 |     |
| 1.  | Inquiry 1                            | √          |               |
| 2.  | Inquiry 2                            | √          |               |
| 3.  | Inquiry 3                            | √          |               |
| 4.  | Inquiry 4                            | √          |               |
| 5.  | Inquiry 5                            | √          |               |
| 6.  | Guided Inquiry 1                     | √          |               |
| 7.  | Guided Inquiry 2                     | √          |               |
| 8.  | Guided Inquiry 3                     | √          |               |
| 9.  | Guided Inquiry 4                     | √          |               |
| 10. | Guided Inquiry 5                     | √          |               |
| 11. | Guided Inquiry 6                     | √          |               |
| 12. | Guided Inquiry 7                     | √          |               |
| 13. | Guided Inquiry 8                     | √          |               |
| 14. | Guided Inquiry 9                     | √          |               |
| 15. | Guided Inquiry 10                    | √          |               |
| 16. | Guided Inquiry 11                    | √          |               |
| 17. | Guided Discovery                     | √          |               |
| 18. | Practice based learning              | √          |               |
| 19. | Problem solving learning             | √          |               |
| 20. | Project based learning               | √          |               |
1. Observe
2. Classifying
3. Predict
4. Measure
5. Conclude
6. Communicate

Basic SPS

1. Observe
2. Classifying
3. Predict
4. Measure
5. Conclude
6. Communicate

Integrated SPS

7. Controlling variables
8. Data interpretation
9. Hypothesis formulation
10. Defining variables
11. Design an experiment
12. Conducting experiments

Based on table 2, learning models that have been used to improve science process skills, namely the inquiry-based learning model in articles [20], [21], [22], [23], and [24], including the guided inquiry model in articles [25], [26], [27], [16], [28], [29], [30], [9], [31], [10], and [32], the guided discovery learning model in articles [33] and [34], problem solving learning models in article [35] and project based learning models in article [36]. These learning models can improve science process skills because the basis of science learning consists of products, processes and attitudes that require students to make discovery and problem solving, this is supported by research [37]. Learning models implemented to develop science process skills generally involve investigative and problem-solving activities. Problem solving allows students to develop several skills including observation and rational thinking. This learning model trains students to analyze findings and solve problems. The inquiry process emphasizes useful learning, where students actively participate in learning activities and can carry out scientific processes in defining the concepts being studied. [37] Learning that involves the discovery and investigation of a concept independently and then solving problems can develop skills in the scientific process [34].

3.2.2 An effective learning model in increasing SPS. Based on table 2. Guide inquiry models measures all indicators of science processes both basic and integrated according to Rezba's grouping. [6] The learning process uses guided inquiry prioritizing direct student participation to gain knowledge that is not yet possessed. [29]. Therefore, in improving students' process skills, teachers can apply inquiry learning levels that are appropriate for students' scientific experience and competence which will then be raised to a higher level [38].

This finding is supported by research that has been conducted by [39] that the guided inquiry learning model is more effective at improving science process skills than the problem solving model, this is triggered because the problem solving learning model has several syntaxes that do not measure overall process skills, students only run provided trial procedure. Meanwhile the guided inquiry learning model has a syntax that measures science process skills such as students are given the opportunity to compile their own experiments to be better prepared to carry out experimental activities. Research [40] and [41] also provide results that guided inquiry is more effective at improving science process skills than the guided discovery model. Guided inquiry contains higher levels of mental processes, such as formulating problems on your own, designing experiments, conducting experiments, collecting and analyzing data, drawing conclusions independently. Meanwhile, guided discovery students find concepts based on materials or data that have been provided by the teacher.

The guided inquiry model influences student SPS because through a series of learning steps prepared by the teacher that involves students' senses to observe, propose hypotheses, control variables, collect data, process data and make conclusions from a problem being studied through experimental activities [42]. The syntax of the guided inquiry learning model includes: (1) orientation improves science process skills observing and questioning skills, (2) formulating problems improve questioning and communication skills, (3) hypothesizing improve predictive skills, formulating hypotheses and communicating (4) collecting data improves experimental design skills, observing, and classifying skills, (5) formulating hypotheses improves conceptualization and communication skills (6) formulating conclusions improving science process skills interpreting, applying concepts, classifying, communicating and concluding.
4. Conclusion
Science process skills measured in several articles are grouped into two, namely basic skills including indicators of observing, grouping, prediction, measurement, drawing conclusions and communication, while integrated skills include variables controlling indicators, interpreting data, formulating hypotheses, defining variables, designing experiments and doing experiments.

Science process skills are enhanced by applying several learning models such as project based learning, problem solving learning, practice based learning and inquiry including guided inquiry. The guided inquiry is the most effective in improving science process skills because its implementation involves the investigation of scientific problems so that it involves students who act actively and develop aspects of the science process skills possessed.

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