Development of two-tier multiple choice instrument to measure science process skill

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Abstract. The science process skills of students are inseparable from learning. To measure the science process skills of students required an instrument of assessment that is easy and appropriate. This study aims to measure the ability of science process skills of students in secondary schools, using two-tier multiple choice instruments. Indicators of the science process skills used are interpreting data, predicting, asking questions, formulating hypotheses, planning experiments, using tools and materials, applying concepts, and communicating. This two-tier multiple choice assessment instrument consists of two tiers, where first-tier is a matter of knowledge that indicates science process skills and second-tier is the reason for the answer in the first-tier. This assessment instrument consisted of 18 questions, and was given to grade XI of Madiun 4th high school. The results of this study indicate the science process skills of students in SMA 4 Madiun included in the medium category with an average value of 37.12%.

1. Introduction
Science learning covers learning physics. In physics learning not only teaches about scientific knowledge, but physics learning provides students to develop scientific knowledge, scientific processes, and scientific attitudes. The scientific process is identical to the scientific activities that develop the science process skills carried out by students through various activities [1]. Physics part of natural science provides a variety of learning experiences and process skills to understand concepts related to daily life [2].

Science process skills can be divided into two, namely basic science process skills and integrated science process skills [3]. Basic science process skills include observing, measuring, deducing, predicting and classifying. Whereas integrated science process skills include controlling variables, interpreting data, formulating hypotheses, defining variables operationally, and designing experiments. Science process skills have been the foundation of science learning, student activities, and increased student responsibility for learning [4]. In addition, science process skills suitable for use in all fields of science that are important for students is how to learn to apply science in actual learning. One way to improve the quality of education is to improve the quality of learning and assessment quality. A good learning system will produce good quality, this can be seen from the results of the assessment. A good assessment system will encourage teachers to determine innovative and actual learning strategies. One of the assessments that is suitable for improving students’ science process skills is to use a two-tier multiple choice assessment instrument.

Two-tier multiple choice instruments can be used as instruments measuring science process skills [5]. Two-tier multiple choice instruments consist of two tiers. The first tier contains modified knowledge questions with indicators of science process skills, and the second tier contains the reasons...
for the answers in the first tier. Two-tier multiple choice has several advantages in addition to being used to measure science process skills, among others it can be used to test student understanding, it can be used to measure students' knowledge skills at a higher level [6]. In addition this instrument can be used to improve the assessment of learning and deeper thinking skills [7].

The two-tier multiple choice instrument design is a series of items that provide stimulus. This has been widely used in the world of education and testing of psychologists [8]. In general, teachers still do not fully understand two-tier multiple choice as an instrument of the assessment of science process skills. Scientific learning that has been done by the teacher cannot provide true information if it is not supported by the ability to measure it. Two-tier multiple instruments exist to get students used to solving problems using science process skills.

2. Methods
This research is a development study consisting of three stages, namely the initial stage, the development stage, and the evaluation stage. This research was carried out in Madiun 4 secondary school. Respondents in this study were class XI who had received 111 heat and temperature material. The data collection technique used in this study was through a test item consisting of 18 two-tier multiple choice questions. From the results of this data analysis we can find out the science process skills of students at the school.

The scoring technique in this study refers to the veracity of the options in the first tier and the correctness of the reasons for the answers in the second tier. The criteria for scoring are 0 - 3 [9].

| Table 1. Scoring Techniques of Two-tier Multiple Choice Assessment Instruments |
|---------------------------------------------------|
| Answer First-Tier | Answer Second-Tier | Score |
| True              | True              | 3     |
| True              | False             | 2     |
| False             | True              | 1     |
| False             | False             | 0     |

The data that has been obtained will be analyzed by the data interpretation technique percentage. Taking scores obtained are calculated using a formula and converted on a percentage scale. The formula used is:

\[
P(\%) = \frac{\sum \text{Score obtained (x)}}{\sum \text{Maximum Score (n)}} \times 100\% \tag{1}
\]

Presentation value obtained will be adjusted to the following table 2 below:

| Table 2. Scale of Science Process Skills Categories |
|---------------------------------------------------|
| Scala (%) | Interpretation |
| 0 <X ≤20  | Low            |
| 21 <X ≤40 | Medium         |
| 41 <X ≤60 | high           |

3. Result and Discussion
This study aims to measure the science process skills of students in secondary schools using a two-tier multiple-choice assessment instrument. Based on preliminary research and literature studies that have been carried out in secondary schools to improve the quality of learning, it is necessary to develop an assessment instrument that is not only to measure the ability of knowledge. But it can also measure the ability of students' process skills. In this study the instruments prepared were tested on 111 students in secondary schools.

The two-tier multiple-choice assessment instrument developed consisted of 18 questions. This research develops a two-tier multiple-choice assessment instrument combined with indicators of
science process skills. This instrument can also describe the science process skills possessed by students. The results of the analysis of science process skills are presented in Table 3.

**Table 3. Indicator Completeness of students’ science process skills**

| Indicators of SPS                  | SPS completeness (%) |
|-----------------------------------|----------------------|
| Interpret data                    | 40.39%               |
| Prediction                        | 49.25%               |
| Asking Question                   | 32.13%               |
| Formulating hypothesis            | 28.68%               |
| Plan an experiment                | 33.03%               |
| Using tools and materials         | 37.99%               |
| Applying concept                  | 32.73%               |
| Communicating                     | 42.79%               |

Table 3 shows achievement of the results of the analysis of the highest student science process skills lies in the Predict indicator with a percentage of 49.25%, Communicating at 42.79%, Interpreting Data at 40.39%, Using tools and materials at 37.99%, Applying the Concept at 32.73%, Planning an Experiment at 33.03%, Asking Questions at 32.13%, and Formulating a Hypothesis at 28.68%. Table 3 provides an overview of the achievement patterns of the student categories for each indicator. Data on the distribution of student categories for each indicator is shown in Figure 1.

**Figure 1. Data distribution of Student Science Process Skills categories**

Figure 1. Shows data distribution of Student Science Process Skills categories, which shows that the indicator that has the highest percentage is Predicting. Whereas in the other indicators, almost all of them are in the medium category. Science process skills are thinking skills that are used to create knowledge, reflect on problems, and formulate results [10]. Science process skills as mental and physical abilities and competencies as tools needed to effectively learn science and technology as well as cognitive and psychomotor skills used in problem solving, problem identification, data collection, transformation, interpretation and communication [11–13].

**4. Conclusion**

Learning activities, science process skills are very important for how to get the laws, concepts, and theories they receive. These science process skills need to be taught to students through scientific learning. But learning will be in vain if learning is not equipped with assessment. Therefore, we need
an assessment instrument that can measure science process skills. The way to make it happen is through this research. In this study using alternative two-tier multiple-choice instruments. The results of the analysis using a two-tier multiple choice instrument gave good results. However, it still needs to be improved and further developed to provide better results, so that it can be used as an appropriate instrument for measuring science process skills.

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