Development and validation of science process skills instrument in physics

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Abstract. Science process skills not only a learning approach but also as a result of learning. It is a basic skills in science and a tools of scientist to investigate the science phenomena. The focus of this research is to develop a valid and reliable of Science Process Skills Instrument (I-KPS). This research is Research and Development (R&D). The step of this research is theoretical construction, determination of assessment objectives, construction of items indicator, items construction, experts judgment, revising of instrument, the first field trial, revising of instrument, the second field trial, and finalization of instrument. The subject of field trail is 46 student of grade 10 of High School of 1 Bajeng, Gowa Regency. The instrument (I-KPS) specification are: (1) the type of item is essay test completed by scoring rubrics, (2) I-KPS could be assess science process skill for high school student, and (3) purpose of this I-KPS is cognitive test of science process skill. It is developed for measuring 6 (six) indicators of science process skills that is identification variable, hypothesizing, planning the experiment, predicting, communicating, and interpreting data. The content validity coefficient of I-KPS is 0.96. The result of empirical validation is 45 items are valid in topics of newton law, gravitational force, work and energy, momentum and impulse, and harmonic motion. The reliability coefficient of I-KPS is 0.935. The conclusion is I-KPS as valid and reliable instrument both theoretically and empirically.

Keywords: I-KPS; science process skills; test development; essay test; scoring rubrics

1. Introduction
Physics learning is not only design for students can understand the concept of physics but also can master the core competency of the 21st century. One of the Government's efforts to encourage it is through the application of Curriculum 2013 in Indonesia. This curriculum emphasizes the standard process on the scientific learning approach and formed the behavior of active and investigation learning. This approach requires learning designed through scientific method based on laboratorial activity. The learning activities of the laboratory are the basis of the formation of the scientific skills[1].

Besides the standar of learning process, Curriculum 2013 also emphasizes on assessment of learning achievement. The standar of assessment in this curriculum is required authentic assessment. It is an approach, procedures and instrument of assessment of process, and result in learning for assembling social and spiritual attitude, knowledge, and some of skills. The students get its starting from assignment like the real experiment or the activity that equal with the real world, and learning independently[2].
The learning activity in this curriculum 2013 emphasize in scientific learning that contains some activity such as observation, asking question, proposing answers, associating, communicating, and then testing those answers. Because of that, we need the corresponding instrument (authentic assessment) to evaluate the learning. The aspects of scientific learning integrate in science process approach and scientific method. Hence, the development of instrument to assess the science process must be executed[3].

Assessment of the science process skills that researchers observed in school right now has not been carried out in a comprehensive manner and was not use the assessment instrument to improve the quality of the science process skills. The instruments to measure the mastery level of the scientific approach or process skills approach have not been available in some schools. Whereas, the research of Akinbolala showed the countries implementing assessment exam practical work out performed those that do not do this assessment[4].

The development of science process skills of instruments have been developed at the high school level by various students, researchers and teachers in some countries. Some of them are: Ambarwati [5] who developed the instrument of science process skills on heat and thermodynamics material that using a multiple choice test. Suryani, et.al [6] who has measured for students of junior high schools also using the multiple choice test. Shahali [7] who also has developed the instrument of integrated science process skills using multiple choice tests. However, according to Lawson [8], the essay test has more advantages then objective test because very effectively assess the results of the complex study for example describes a causal relationship, interpretate of data, test of hypotheses, and create a graph.

The researches have perceived if developing the instrument of science process skills (I-KPS) is very important. The I-KPS would be developed in physics material on high school and to produce an instrument in essay test completed with scoring rubrics. Although the I-KPS has developed in limited physics topics, but all teachers and researchers to make the results of the development of I-KPS as reference in the development the valid and reliable of other topics.

2. Development methods
This research is development of science process skills instrument for students in the grade 10 to 12. Our overarching aim was to develop science process skills in knowledge domain. The type of item problems is essay completed with scoring rubrics. I-KPS is paper test for assessing 6 (six) indicators of both basic and integrated science process. It includes identification of variable, hypothesizing, planning the experiment, predicting, communicating, and interpreting of data.

The phase of the determination of the aspects of the science process skills is the process of preparation for developing the item of question. The process of drafting an instrument is started with the making of the problem in essay test and determination number of problem that would be to develop. Not all physics materials made of item of question on science process skills test. On the materials of gravity are not reserved for the indicators of identification of variables, hypothesizing, and planning the experiment. It caused difficulty to develop the problem that could be measure the knowledge aspects of the students. In addition, this material is not supported by a simple experiment at school and also Gravity chapter in schools only limited in theoretical. As well as the aspects of hypothesizing and planning the experiment for Work and Energy materials, there are not the problem items. Although on the indicator of identification of variables, there is item of problem because the experiment is not ril. This condition is only possible to give a question on identification of variabel.

The indicators of science process skills are selected from some reason: (1) the indicators can be measured using paper based test, (2) the indicators can be assessed based on the knowledge aspect, (3) the indicator is the learning key of scientific process, and (4) the skills that would be known.

In this study there are two data collected that is data validation results from experts and field trial results. Data validation results experts collected by way of handing out sheets of validation of two experts. While the field trial results data were collected by means of distributed process skills science
instruments (I-KPS) developed to the test respondent. The answer of the subject test then researches given the scoring according to the rubrics.

The subject tests in field trial were the students of high school of 1 Bajeng, Gowa Regency. The number of tested in field trial 1 was administered to a sample of 36 students and 46 students in field trial 2. This sample of field trial was learned the topics to be test. We have chosen the grade 11 because they have passed the topics to be test. The researches have used the random of class in grade 11 for the effectively learning process in school.

The validity of items was calculated using the correlation between the each item and the total score. The researches used SPPS for windows series 22 to calculate the coefficient of correlation. Analysis of the validity is associated with the precision of a measurement tool to measure what must to be measured. A valid instrument will certainly generate the data valid science process skills anyway. Analysis of the validity of the items based on the correlation between item with a score total. The index of correlation between grain with a score total score can be seen on the Item-Total Statistics on the column Corrected Item-Total Correlation.

In this study, we have calculated the reliability of I-KPS using the consistency internal technique. This technique applied Alpha Cronbach formula because the type of test is essay. The reliability of instrument can be accepted if the alpha coefficient is within 0.77–0.99[9].

### Problem

The experiment of simple pendulum shown in figure below. The pendulum bob is oscillation harmonic. The student want to measure the time period from pendulum with the length of rope is $\ell$ and 0.75 $\ell$. In the same mass and the place of experiment, write down (a) the fixed variable, (b) manipulated variable, and (c) response variable.

### Solution

1. Fixed variable: mass and gravitational acceleration
2. Manipulated variable: length
3. Response variable: time period

### Criteria

1. Write down of fixed variable
2. Write down of manipulated variable
3. Write down of response variable
4. Write down more than one of fixed variable

### Scoring

| Score | No criterion is fulfilled | Only 1 criterion is fulfilled | Only 2 criteria are fulfilled | Only 3 criteria are fulfilled | All criteria are fulfilled |
|-------|----------------------------|-------------------------------|-------------------------------|-------------------------------|----------------------------|
| 0     |                            |                               |                               |                               |                            |
| 2     |                            |                               |                               |                               |                            |
| 3     |                            |                               |                               |                               |                            |
| 4     |                            |                               |                               |                               |                            |
| 5     |                            |                               |                               |                               |                            |

### Figure 1.

Sample test items and scoring rubrics for I-KPS
3. Result and discussion

The science process skills is an ability of students to deliver decision based on a systematic investigation on their own knowledge so that they will produce a proficiency in understanding the process of the events around them. It is one of the learning approaches in Curriculum 2013. This skills regardless of the cognitive process so that this research resulted the instruments of science process skills.

The instrument of I-KPS could be tested to students at least 10th grade or the students who have passed the material. Science process skills test is to do because it uses in the scientific approach in Curriculum 2013. This approach is certainly related to the investigation skills called scientific process skills. This scientific investigation is needed especially in physics. This research has developed the instrument using the physics material specifically. The I-KPS materials are consists of: Newton’s law of motion, gravity, momentum and impulse, work and energy, and simple harmonic motion. On the first draft, there are 77 items number of essay test. Researchers have developed the average 3 item every the indicator of science process skills on each physics materials. This is to anticipate the item drop when testing the theoretical validity as well as the validity of the empirical.

We also have developed the scoring rubrics and item problems. Scoring rubrics are developed by defining the lowest and highest score that may accrue to students. The minimum score is 0 and the maximum score is 5. Every aspect of the KPS has same in maximum and minimum score. However, the range of his score is adjusted to the length of the answer is needed. On the indicators identify the variable of his score was the first variation of 0, 2, 3, and 5 and secondly 0, 2, 3, 4, and 5. This is due to the ability of the learners asked i.e. ability to identify variable manipulation, control, and response. The first variation score is used if there is the possibility of one variable manipulation only. While the second variations score is used if there is a possibility of more than one variable manipulation.

The others indicator of science process skills such as planning the experiments and communicating of data requires measures as well as an assessment of the various aspects so that it can produce some variation of the score. Therefore, the variation of his score will be the same for each items of material that evolved. In contrast to other science process indicators such as hypothesizing, predicting, and interpretation of data, it has variations of the score appraisal which is quite diverse. It is based on the length of the answers and level of complexity of the problem.

After the rubrics and item problems are finished, the next step was theoretical validity. The content of validity is determined with panel concept. The panel was evaluated 77 test items and asked to identification of scoring rubrics that needed to fix. The two experts agreed with the correlation of content and indicators of I-KPS in 0,96 or 96%. This indicates that I-KPS was valid in terms of the content.

The first field trial was conducted at Class of XI IPA 7 of SMA Negeri 1 Bajeng in the first semester of academic year 2017/2018. The test subject was 36 students. The number that invalid was 30 items and there were two indicators that invalid. These results are then discussed with experts to do some further revisions. Three items of test will then be included as an item for the second trial even though the question is invalid. It is aimed so that the every indicator there is a test item that represents. The selection process is based on the value of the coefficient correlation. The results yielded a third draft I-KPS. The revisions process was done on the scoring rubric. It is based on the findings answer the students in the first field trial.

The number of test item in field trial 2 was 46 items and the test subject was 46 students. The score of subject test was analyzed such as the validity and reliability, and the ordered on difficulty. Firstly, we discuss about the validity of the instrument. There was three test items that the correlation below from the minimal standards (0,291). All invalid test item is matter which measure aspects of ability of predicting. Invalid data can be caused by several factors. One of the reasons is a lack of effort of respondents to answer the questions[10]. It is not the cause of invalid item because the number 26, 27, and 28 as almost all respondents attempt to answer the question of items.

Item number that the index of correlation -0.104 very far from standard valid minimum so excluded from the data to the next analysis. While the item number 27 and 28 have a correlation index of 0.205
and 0.248. The second of these item validity coefficient is not satisfactory. But according to the guidelines of the U.S. Department of Labor, Employment and Training Administration in Aswar [11] coefficients validity 0.21 – 0.35 interpreted as grains of matter that can be useful. While the validity coefficient of 0.11 – 0.20 interpreted that their use depends on the circumstances.

The interpretation against to the decision-making of coefficient validity to accept of the test item needs to be accompanied by a variety of considerations concerning the objectives, the used of function items or the function of the score obtained. Because I-KPS intends to use to measure the science process skills based on the material, then the two items of the problem i.e. the item number 27 and 28 are included for the calculation of the next analysis. By entering both the item then the entire indicator and learning material has represented at least one item of every subject matter.

After analysis of the validity of the items, we have conducted an analysis of the reliability of the instrument. The results of the reliability of the new output can be seen on the Reliability Statistics on coulomb Cronbach's Alpha. The coefficient of reliability of I-KPS is 0.935. Reliability coefficient is larger than a standard minimum of 0.700 then concluded that an instrument of science process skills have been reliable.

Based on the analysis of each item is valid and reliable, so I-KPS may be used for measurement in the framework of the collection of data by researchers or practitioners. In addition to functioning as a measurement tool, instrument-making standards such as I-KPS will explain the function of science and introducing the scientific process steps in decision making or policy of rational scientific fact in the investigation in the daily life[12]. In addition to the analysis of the validity, we have conducted analysis the ordered on difficulty. The results of the analysis of the difficulty level of the item are not a good proportion. The amount of item the valid question has been previously analyzed with the number of rounds reserved as many as 45 items. The number of questions with a level of easy is 3, reserved with the levels of medium is 25 items, and questions with difficult levels of hard is 17 items.

Results proportion of reserved who mostly reside in the category of medium and hard to produce an expectation that science process skills students have not been high. This into consideration whether I-KPS too difficult or not yet a science process skills formation in high on the students. The strongest indication the science process skills still low on students. This is because it has not yet been student to do usual experimental learning. The author argues that way because, when the 2015 international TIMS reports result in science. In addition, research results gained the ability level of the science process skills still low even at the level of the student as a prospective teacher[13].

This summary of the study that I-KPS has valid and reliable instrument and can be distinguish the students who has skills in high and low of science process skills. The findings in this study is more than a half of subject tested who did not answer the question of item for the indicators planning the experiment. It is because the students also erred in putting together a planning of experiment. Lack the ability to plan an experiment can be caused by minimal knowledge about the function of the equipment and materials in the laboratory [14]. So the researchers assume that the ability to planing an experiment can be used as one of the important indicators in the assessment of the science process skills compared with the ability to write down the function of the apparatus in the experiment.

Therefore, the need for constantly drilled then the assessment process or evaluation are also carried out on an ongoing basis. Since the research I-KPS still constrained by some of the physics material, then it is recommended to do the development on the next subject matter.

4. Conclusions

The I-KPS is instrument to measure the science process skill of students in aspect of knowledge. The specifications of I-KPS are: (1) The indicators of science process skills that be assessed are identification of variable, hypothesizing, planning the experiment, predicting, communicating, and interpreting of data, (2) the format assessment is essay test and completed with scoring rubrics, (3) there is 45 of test item, (4) Item difficulty average is 0.38 each 17 items on hard level, 25 items on medium level, and 3 items on easy level, (5) the reliability coefficient of I-KPS is 0.935.
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