Test Instrument Development for Science Process Skills in Mechanic Wave Topic for Grade XI SMA Student

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Abstract. This research aims to studying the development of valid and reliable test instrument that can be used to measure the physics science process skill (SPS) of mechanic wave topic for student grade XI SMA. To know the aims has been obtained coefficient of content validity, coefficient of reliability, item difficulty level, and item distinguishing power of the instrument. The subject of this research is student grade XI of SMAN 2 Maros that consists of four classes as much as 87 peoples. Test instrument developed consists of 35 items in multiple choice form. Items have been validated content and validation empirically to determine the validity of the criteria. The steps for developing SPS test instrument are: inspect the syllabus and theory, determine the instrument dimensions and indicators, making the instrument grill, writing the test instrument items, determine content validity, empirically validation, and assembling the items of test instrument. The calculation result of content validity obtained internal consistency coefficient r = 0,771. Item validity of the instrument after empirical trial obtained 27 valid items and 8 invalid items from 35 item questions that developed. The instrument reliability coefficient obtained is r_i = 0,709. The item difficulty level consist of 0% easy items, 85,2% medium items, and 14,8% of items relatively difficult. The item distinguishing power consist of 55,6% very good items, 18,5% good items, 14,8% marginal items, and 11,1% of items are classified as poor.

Keywords: difficulty level, distinguishing power, reliability, science process skill, validity.

INTRODUCTION

Education is one of the factors determining the progress of a nation. Education plays a role in improving a quality human resources. Nowadays, education is carried out to prepare young people who have competing abilities, personalities and skills.

In fact, the quality of Indonesia's human resources is still low. Based on the 2017 World Economic Forum which ranked 130 countries on how well human resources are developed, Indonesia was ranked 65 (Adiyanto, 2017). In addition, based on the 2015 Program for International Student Assessment (PISA), the performance of Indonesian students was in 69th position out of 76 countries. With ratings for science, reading, and mathematics abilities respectively 62, 61 and 63 of 76 countries (Co-operation & OECD, 2016).

These data indicate that the scientific ability of Indonesian students is still low and must be improved, both by the government, schools, and teachers. At present, the government implements the 2013 curriculum with a scientific approach that demands the active involvement of students in the learning process. The steps of the scientific approach are adaptations of scientific steps in science. Based on Permendikbud No. 81 A Tahun 2013 Attachment IV, n.d., this approach consists of five learning experiences, namely: observing, asking, gathering information, associating, and communicating. The scientific approach involves science process skills and cognitive abilities in constructing concepts, laws, or principles (Hosnan, 2014, p. 36).

Science Process Skills (SPS) is used to find and develop existing concepts or deny previous findings (Ilmi, Desnita, Handoko, & Zelda, 2016, p. 2). SPS is a skill needed to acquire, develop and apply knowledge in the form of concepts, principles, and laws, both in the form of mental, physical, and social skills (Usmeldi, 2016, p. 238).

For students, SPS is one of the skills that need to be trained to gain knowledge by finding it themselves (Azizah, Wati, Mahtari, & others, 2017, p. 341). These skills make students able to analyze and make conclusions based on direct experience (Usmeldi, 2016, p. 238). SPS can be obtained from the activities of students starting from observation to conclusions. According to Sulaiman, Sentot, & Eny (2016, p. 123), SPS becomes an important part in scientific inquiry, trains students to be active in class, make decisions, and solve problems.

SPS consists of several types of skills proposed by several sources. According to Tawil & Liliasari (2014, p. 30), SPS consists of observing, classifying, interpreting, predicting, communicating, asking questions, submitting hypotheses, planning experiments/research, using tools/materials/sources, applying concepts, and carrying out experiments /investigation.

SPS is grouped into two levels, basic skills and integrated skills. The development of basic SPS will make students easier to develop integrated SPS. Basic skills consist of observing, asking questions, classifying, predicting, and measuring. Integrated skills consist of identifying names and defining variables, collecting data, creating table and graph data, explaining relationships between variables, interpreting data, manipulating materials, recording data, making hypotheses, designing experiments, and inviting and generalizing (Karamustafaoğlu, 2011, p. 26).

Physics learning requires students to be active and build their own knowledge, whether through the process of seeing, observing, or conducting experiments related to these natural symptoms. SPS have a positive influence on the mastery of students' physics concepts (Siswono, 2017, p. 88).

Practicum activities provide opportunities for students to experience themselves, seek the truth of the theory, and draw conclusions. These activities develop SPS and foster the scientific attitude of students (Ilmi et al., 2016, p. 2). One of the physics materials whose concept requires practicum is mechanical waves. Students only imagine how the concept is without being directly involved in the practicum. Based on the results of Widiastutik's research (2014, p. 106), stationary wave practicum tools can train students' SPS with increase of 41.43%.

The test instrument is a measuring tool to obtain answers from students in the form of questions, statements, or assignments as the basis for determining the score. According to Kunandar (2013, p. 187), good multiple choice test requirements are: 1) having high validity and reliability; 2) having an adequate distinguishing power for each item; 3) the level of difficulty of the test based on the group to be tested; 4) easily administered. The multiple choice test form is a very appropriate form to develop a SPS test instrument that has many indicators, test material, and research subjects. Multiple choice questions are suitable for a large number of test participants, a short correction time, and a lot of material to be tested.

At present the evaluation instrument of science process skills in the form of observation sheets makes teachers have difficulty if they have to observe one by one the students when doing practical work (Azizah et al., 2017, p. 341). From the results of Susila's research (2012, pp. 5–6), there are several obstacles to physics teachers in Kab.Gianyar who assess the performance of students during practicum activities, such as difficult guidelines for instrument reporting to observe, the assessment component and the large number of students done by just one assessor, and the possibility of giving high scores or vice versa because the instrument has not fulfilled its validity and reliability requirements.

The validity means the accuracy of the instrument as a measuring instrument what should be measured. Valid instruments should be supported by theoretical and empirical validity. Instruments with theoretical validity are instruments whose criteria reflected what is measured rationally (theoretically). The theoretical validity of the test instrument should be eligible for the content validity and construct validity. The content and construct validity aims to determine the suitability between the questions and the teaching topic with the objectives to be measured or with the grids made (Sugiyono, 2014, p. 123).

Instrument reliability is a measure that states the level of reliability or consistency of an instrument (Jihad, 2013, p. 180). Instrument reliability is the level of consistency or determination of an instrument to measure by giving the same results (Suryabrata, 2013, p. 58).

The item difficulty level is an opportunity to answer correctly a problem at a certain level of ability. A good question is a matter that is not too easy or not too difficult (Arikunto, 2012, p. 245). Thus, a good question is a problem that has a level of difficulty that is not too easy and not too difficult (Arifin, 2012, p. 206).

Differentiator power of question is the ability of a question to differentiate between smart (highly capable) students and less intelligent (low-ability) students, usually expressed in an index (Arikunto, 2012, p. 247). Differentiator power index ranges from -1.00 to 1.00. The lower the differentiator power index is, the less able the problem distinguishes between smart students and less intelligent ones (Solichin, 2017, p. 197).

METHOD

This type of research is research and development that aims to develop a SPS test instrument. The testing phase of the SPS test instrument was conducted at SMAN 2 Maros. The research subjects were students of class XI MIA SMAN 2 Maros, which consisted of four classes with 87 students. The developed test instrument consists of 35 items that measure 8 aspects of SPS, the skill of observing, interpreting, communicating, asking questions, submitting hypotheses, planning experiments, using tools/materials, and applying concepts. The step of developing the SPS test instrument follows the step of developing the test instrument proposed by Djaali & Muljono (2008, p. 81).

Furthermore, the test is validated by using content validity to observe the internal consistency of the expert by using the Gregory test. If the value of internal consistency is $r \geq 0.75$, then the item is declared valid (Iskandar & Rizal, 2017, p. 16). After that, a field test was conducted on the respondents as equal to know the validity of the criteria of each item, using the point biserial coefficient equation (Arikunto, 2012, p. 93).

All valid items are then calculated for the reliability coefficient using KR-20 (Sugiyono, 2014, p. 132). Furthermore, the item calculated the difficulty level and the distinguishing power items.

RESULT AND DISCUSSION

Based on the results of theoretical studies, all SPS indicators can be developed on mechanical wave topic. The indicators are: 1) observing skills can be presented in the form of observations of wave phenomena using the five senses; 2) interpreting can be presented in the form of tables and graphs of fast-moving relationships with rope tension and rope mass meeting; 3) asking questions and hypotheses can be made in the current and stationary wave events in the Melde experiment; 4) planning experiments and using tools / materials that students have experienced directly in the Melde experiment; 5) applying the concept of the concept of walking wave propagation ($v = \lambda f$) and stationary wave propagation ($v = \sqrt{F/\mu}$). While classifying and predicting has mechanical wave topic that answers these aspect indicators. Then the aspect of experimenting, the assessment cannot be conducted in the form of a written test because it is a domain of skills that requires a performance assessment test.

The researchers have choosen eight aspects of SPS that were developed as instrument dimensions and accompanied by indicators, as well as the SPS indicator developed by Tawil & Liliasari (2014, p. 30). The selection of indicators is based on the learning activities given to students. This is in line with Semiawan's opinion (Putri, 2017, p. 18), that scientists in the investigation are growing up to mastering certain abilities or physical and mental skills.

Other things that are taken into consideration are (1) indicators allow to be measured in the form of written tests, (2) indicators need to determine the success of scientific processes for students, according to Devi (2010, p. 31) the science process skills start from observing to submitting the question does not need to be a sequence that must be followed, and (3) indicators are adjusted to the scope of the material.

Dimensions and indicators of instruments that have been determined are then described in making instrument lattice. The researchers have made 35 items with an unequal number of questions for each aspect of SPS. This is because the preparation of the SPS questions is based on indicators of each aspect of the SPS that is not the same number. Each question indicator is represented by the items developed. The number of questions that are more for one aspect indicator of the SPS aims to anticipate the item drop when testing empirical validity.

In addition, the preparation of the SPS test instrument items considers the general characteristics of process skill measurement by Rustaman in Zamista & Kaniawati (2015, p. 2) for each item: 1) the concept must not be burdened by students, 2) it contains a number of information (pictures, diagrams, graphs, data in tables or descriptions, or original objects) that must be processed by students, 3) aspects to be measured must be clear and contain only one aspect, 4) images should be displayed to help present objects, analyze research, construct hypotheses, determine variables operationally, plan investigations and conduct experiments. Thus, the items of the SPS test instrument that are compiled are dominated by the presentation of objects / images.

Although it does not deny the existence of differences in learning styles of students in processing information, visual, auditory, and kinesthetic (DePorter in Hasyim, Muris, & Yani (2014, p. 53), this is also reinforced by the results of the study (Hasyim et al., 2014, p. 56) that there is no significant difference in SPS between students with audio-visual learning styles with students who have a kinesthetic learning style.

The results of the content validity analysis of both assessment experts of the SPS test instrument is r = 0.771 (high validity) After going through validation by experts, the matter was revised according to the advice of the expert until finally the question was worthy of being tested into the field. The first expert's suggestions and comments were to fix the *option* (the problem), language, or the appearance of the instrument, while from the second expert, the instrument must be corrected because there are still many errors in theory. The items of observation are still in the form of analytic questions s and the matter of planning the experiment / research, have not shown the form of planning. Suggestions and comments from the two experts are then used to revise the instruments developed.

Item validity test with r_{table} (5% significance level) has $r_{cal} \geq 0.2108$ declared valid. The results of the calculation show that there are 8 invalid items from 35 items made. The invalid items are points 2, 4. 8, 14, 18, 24, 29, and 30. Invalid items are items that are included in the indicator of observing, communicating, submitting hypotheses, asking questions, using tools / materials, and plan an experiment. The number of items declared valid is 27 items.

Furthermore, the calculation of the instrument reliability coefficient (r_i) for valid items is 0.709 and is in the high category. The reliability coefficient obtained shows that the SPS test instrument developed is consistent and reliable to use. Test results which consistently show that the instrument can be trusted or relied on (Suryabrata, 2013, p. 58).

The results of the instrument test data processing in determining the item difficulty level of each item showed that of the 27 valid items, none of the items were in the easy category, 23 items were in the medium category, and 4 items were in the difficult category. A good question is a matter that is not too easy or not too difficult (Arikunto, 2012, p. 245). So the number of questions with a good level of difficulty is 23 points. The instrument does not have an easy question, it shows students do not have a high SPS for every aspect of SPS. The difficult questions, namely points 25, 28, 34, and 35 which are questions about applying concepts, planning experiments, and using tools /materials.

Item difficulty level which is relatively difficult corresponds to the opinion expressed by Karamustafaoğlu (2011, p. 26) that SPS consists of two levels, namely basic skills and integrated skills. The four items that are relatively difficult are integrated SPS. In addition, the eight invalid items are also integrated SPS.

This shows that students in SMAN 2 Maros are capable of basic skills but have not mastered integrated skills. Whereas high school students should master integrated SPS in the opinion of Akinbobola in Ulmiah, Andriani, & Fathurohman (2016, p. 2) that integrated process skills are more appropriate at the secondary and tertiary level. Correspondingly, the ability to formulate problems, construct hypotheses, and design an experiment are difficult job, and not every student is able to implement it (Sagala, 2010, p. 74).

Science process skills must be trained continuously for students during the learning process. This is in accordance with the demands of learning in the 2013 curriculum with a scientific approach to developing five scientific skills. Learning with a scientific approach has the following characteristics: 1) centering on students; 2) involving SPS in constructing concepts, laws or principles, 3) involving cognitive processes that stimulate intellectual development, especially higher-order thinking skills; 4) developing the character of students (Hosnan, 2014, p. 36).

Based on information from physics teachers at SMAN 2 Maros, students are rarely given practicum that trains students' SPS. They are accustomed to following an experimental plan that has been presented so that they are less able to plan experiments. In addition, the difficulty of students working on the problem of applying the concept because the implementation of the test is conducted when students are already in Class XII SMA so they forgeted the topic that has been learned in class XI.

Rarely doing the practicum also makes students less familiar with experimental tools and their functions. Based on the results of Jack's research (2013, p. 20), the completeness of the laboratory is very influential on students' SPS. Thus, training SPS must be supported by practical activities. This activity develops SPS and fosters the scientific attitude of students (Ilmi et al., 2016, p. 2).

This shows that students in class XI of SMAN 2 Maros should always be given learning that trains SPS. In line with the results of research on the development of SPS instruments by Zamista & Kaniawati, (2015, p. 5) that students are not used to working on SPS test questions and do not even know the aspects to be assessed. Based on the opinion of Tawil & Liliasari (2014, p. 10), the application of SPS in learning activities should be able to provide opportunities for students to demonstrate performance through a number of skills to process all the facts, concepts and principles.

Learning activities that are able to train and improve the SPS of students through a scientific approach can take the form of models Inquiry and Discovery Learning. The results of research by Ayuningtyas, Soegimin, & Supardi, (2017, p. 645) for Senior High School (SMA) with static fluid topic showed that the application of Guided Inquiry learning models was effective in improving SPS. The model Discovery Learning can develop students' SPS effectively by involving active students in investigating and discovering their own physics concepts (Lete, Sutopo, & Lia, 2016, p. 1028). SPS by using this model can be carried out well, especially in the skills of integrated SPS (Pratama, 2014, p. 143). Other research results by Astra & Rifa (2017, p. 188), the application of the model Guided Discovery Learning, can increase the SPS of students in class XI MIPA on temperature and heat topic for hypothesis ability, interpretation, and communication.

The results of processing instrument test data in determining the item distinguishing power are shown in **Table 1.** in below.

Table 1. Results of Item Distinguishing Power Calculation

Distinguishing Power	Item Number	Number	Percentage (%)
Significant	1, 3, 5, 6, 7, 11, 12, 15, 16, 17, 19, 20, 21, 23, 26, 32, 35	17	63.0
Not Significant	9, 10, 13, 22, 25, 27, 28, 31, 33, 34	10	37.0

Table 1 shows, there are 17 out of 27 valid items with significant distinguishing power. This means that the problem is able to distinguish between students who master SPS and students who have not mastered SPS. While the number of items that have insignificant distinguising power is 10 points. Categorization of item distinguishing power can be seen in **Table 2.**

Table 2. Categorizing Item Distinguishing Power

Category	Item	Number	Percentage (%)
Very good items	1, 3, 5, 6, 7, 12, 15, 16, 17, 19, 20, 21, 26, 32, 35	15	55.6
Reasonably good, but possibly subject to improvement	9, 10, 11, 22, 23	5	18.5
Marginal item, usually needing and being subject to improvement	13, 27, 31, 33	4	14.8
Poor item, to be reject or improved by revision	25, 28, 34	3	11.1

Table 2 above shows that out of 27 valid items, there are 15 items that are classified as very good, 5 items are classified as good, but possibly subject to improvement, 4 items are in marginal categories, usually needing and being subject to improvement, and 3 poor items to be reject or improved by revision. Items that are classified as significant consist of very good questions and some of the good questions, while the items that are classified as insignificant consist of several good questions, marginal questions, and poor questions. This shows consistency of the significance of distingushing and categorization of questions.

Of the 3 items that have a poor distinguishing power, the items number 25, 28 and 34 are classified as valid so they do not need to be rejected, but need to be revised. The skills measured are the skills to apply concepts, plan experiments / research, and use tools / materials / sources. These three items are also quite difficult. This shows results that are in line with the calculation of the item difficulty level and item distinguishing power.

The result of distinguishing power also shows that the eight invalid questions do have an ugly distinguishing power so they must be discarded. So that there are results that are directly proportional between invalid questions with disproportionate levels of difficulty, and have a bad distinguishing power.

The significant amount of distinguishing power that is 10 out of 27 items or 37.0% could be due to the form of multiple choice questions. Non-significant questions means that they cannot be answered correctly by clever students but can be answered correctly by students who are less intelligent. This is likely to occur because the form of multiple choice questions has weaknesses, there are opportunities to guess the answer key from various possible answers (deceit) (Destiniar, Octaria, & Mulbasari, 2018, p. 22). That means, even though they don't know the answer, they can choose answers that are available randomly. There is also aspects of guessing but correct, students who have low abilities but answer the questions correctly with a high difficulty level (Yamtinah, 2015, p. 3).

Based on theoretical validation and empirical validation, the final SPS test instrument consists of 27 items. The quality of the instrument as a whole has, 1) high content validity (r = 0.771) and tested valid according to the expert; 2) high instrument reliability (r_i = 0.709) and reliable, 3) good difficulty level (85.2% proportional difficulty level), 4) adequate distinguishing power that is able to distinguish students who master SPS and not master SPS (63.0% questions with significant distinguishing power).

According to Sugiyono (2014, p. 123), valid instruments must have theoretical and empirical validity. As a result SPS test instrument for class XI SMAN 2 Maros on mechanical wave topic developed is suitable to be used as an assessment instrument for SPS students. Where instruments are valid and reliable, and can distinguish students who have high SPS and low SPS. However, that the number of items as many as 27 is not a reference in making SPS instruments in other topics.

CONCLUSION

The conclusions of the development of test instruments research are:

1. The content validity of the test of science process skills in mechanical wave topic for student grade XI SMA using the Gregory formula obtained internal consistency coefficients in the high category. While of the 35 items that were developed, there were 27 items that were declared valid and 8 items that were invalid.
2. The reliability of the science process skills test instrument for mechanical wave topic for student grade XI SMA has a Reliability Coefficient of $r_i = 0.709$.
3. From 27 items of scientific process skills test for mechanical wave topic for student grade XI SMA, there were 23 items with medium difficulty level, and 4 items were difficult.
4. From 27 items of science process skill test instrument for mechanical wave topic for student grade XI SMA, there are 15 items that have very good distinguishing power, 5 items are classified as good, 4 items are marginal, and 3 items are poor to be revised.

The recommendations of this research are:

1. SPS is a skill that must be trained continuously during the learning process, especially in strengthening the integrated SPS for students in based on the learning of the scientific approach of the 2013 Curriculum.
2. The testing phase of the SPS test instrument should be carried out over a period of time that is not long after giving the topic to be tested. So that students do not forget the topic that has been learned.
3. SPS test instruments should be tested twice, namely small group trials and extensive group trials. Invalid items in small group trials can be issued or repaired for retrying.
4. The SPS test instrument developed in this study is limited to one KD or the subject of mechanical wave topic in class XI. Then it is recommended for further researchers to develop a SPS test instrument on other topic or at another class level.

ACKNOWLEDGEMENT

The researcher wants to acknowledge her supervisors' Dr. Kaharuddin Arafah, M.Si and Dr. Hj. S. Salmiah Sari, M.Pd of Physics Education Department, Makassar State University, Makassar for their efforts to make this research a whole.

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