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INSECTA

Integrative Science Education and Teaching Activity Journal

Journal homepage : <https://jurnal.iainponorogo.ac.id/index.php/insecta>

Research Article

Developing Science Process Skills (SPS) Instruments for Vocational School Students Using CBT

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Article Info

Article history:

Received: September 24, 2020

Accepted: October 19, 2020

Published: November 27, 2020

Keywords:

Test Instrument

CBT

Science Process Skills

ABSTRACT

This study aimed to develop a Science Process Skills (SPS) instrument using CBT on heat matter. The method implemented was Borg & Gall Research and Development model. The preliminary stage data proved that instruments to measure SPS using CBT were required. In design & product development stage, instruments were validated by experts. Validation score of media was 84.5%, while matter score was 80%, and language score was 84%. The product testing stage was conducted at a vocational school in Lampung Province. The SPS instruments tested using CBT was done in 4 stages, i.e. the expert, the small group, the field and the instrument test stages. The results of the expert analysis test showed a percentage score of 85.25% or very eligible. The results of limited and field trials showed results of 86.5% and 81.5% or very interesting. The results of small group trials through students' responses were 86.5% while field trials were 81.5% or very interesting. The instruments test resulted 15 valid instruments of 20 prepared questions, the reliability (r_{11}) was 0.97 or very reliable. The discrimination power of 15 questions was categorized as good. The difficulty level showed that 7 questions were easy while 8 others were sufficient category

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INTRODUCTION

The results of the survey by the 2018 International Program of International Student Assessment (PISA) showed that the 78 participating countries in Indonesia rise 10 points from the previous score of 396, while the average score of OECD countries was 489 (OECD 2019). In 2015, Indonesia ranked 70th out of 72 participating countries with a score of 386, while the average score of OECD countries was 490. Indonesia in the survey was slightly better than Saudi Arabia, which was in the 71th position (OECD, 2019).

Three subjects tested in PISA, called reading, mathematics and science. The test used is diagnostic to provide useful information for improving the education system in Indonesia (Schleicher, 2019). A poor PISA score indicates the following: (1) Our students are used to solving routine problems. This means that students only usually solve problems that have been discussed in class. They struggle when they face new problems. (2) Students are weak in modeling real situations of mathematical problems and interpreting physics solutions into real situations. Whereas the scope of mathematics as the basis of physics demanded by the world is complete mathematical and physics skills: from modeling, finding solutions to physics problems, to interpreting initial problems. Students are generally accustomed to solely solving mathematical problems without interpreting real-world problems. This means that students focus only on the world of mathematics, but do not completely complete it with the experience of interacting between the real world and the world of mathematics. (3) The level of reasoning to summarize and analyze is still lacking. This means that the sophistication of reasoning that is demanded by the world is higher than that which runs in the practice of learning science process skills in Indonesia (Pratiwi, 2019).

The assessment used in PISA is based on higher order thinking skills. Part of the skills of higher order thinking is Science Process Skills (SPS). SPS is an approach that directs that finding knowledge requires a skill to observe, conduct experiments, interpretation data, communicate ideas and so on. To increase HOTS, it is necessary to use learning with a certain approach which is also HOTS-based and HOTS-based assessment instruments as well. For example, the combination of STEM learning with HOTS instruments which can improve students thinking skills (Rosidin et al., 2019) and the use of communication and collaboration skills assessment instruments combined with project-based learning (PjBL) can also improve studentsn thinking skills (Noviana et al., 2019).

The development of science in the 21st century affects all aspects of life and results in world changes. These changes have a broad impact, including the more open information and communication technology (ICT) from and throughout the world to penetrate the boundaries of distance, space and time. According to the results of a World Bank study, the most important factor determining the superiority of a megara is the ability to innovate, of course related to human resources (HR) whose contribution reaches 45%, then networking 25%, technology capability 20%, and finally the wealth of natural resources amounting to only contributing 10% to the progress of the country (Rosana et al., 2014). This data shows that the progress of a country is very dependent on the human resources of that country. Recepoglu & Ergun (2013) state that individuals who continue to conduct research, analyze, think critically and build information through interpretation can be said to have the qualifications expected in the 21st century, called humans who can keep up with developments in information and communication. These developments have made the impossible possible. The influence of information technology extends to various fields of life, including education.

Budiman (2017) states that one part of education is information technology, so technology development has a role in providing direction for the development of the world of education that can support the learning process. The use of technology in the learning process is known as e-learning. E-learning is learning that is structured with the aim of using an electronic or computer system so that it is able to support the learning process including its

evaluation (Allen, 2016). The development of ICT which has changed the face of the world in all fields cannot be separated from the field of education which continues to penetrate in various aspects. One of them is an assessment with a Computer based Test (CBT) which will leave the concept of Paper Based Test (PBT). CBT is a test that is carried out and carried out using computer media instead of paper media.

The results of the preliminary study through structured interviews with 5 teachers produced the following information 1) in the learning process that was carried out there were still many teachers who used the lecture method, 2) 50% of students were still inactive in learning activities including working on the practice questions given by teachers either in the learning process or when evaluating at the end of basic competencies, 3) in terms of the type of assessment instrument used, they mostly use the usual practice questions (LOTS-MOTS). The questions used have not used the science process skills approach of students. 4), the test instrument still uses a Paper Base Test (PBT), 5) 90% of students like computer-based tests (CBT).

Based on the background of the problem that has been described, the researcher has conducted research by developing a SPS test instrument using CBT with the research title "Development of Skills Test Instruments using CBT Science Process (SPS) for vocational students on Heat Matter".

METHODS

This study uses the research and development or Research and Development (R & D) model of Borg & Gall. Sugiyono (2015) states that Research and Development is a research method used to produce certain products. The research and development method used in this study refers to the Borg and Gall development model which has the steps (1) conducting preliminary research (pre-survey) to see potential and problems, (2) data collection, (3) developing types / forms initial product, (4) Conducting initial stage trials, (5) revising the main product, (6) conducting field trials, (7) revising operational products, (8) conducting operational field tests, (9) conducting field trials revision of the final product, (10) disseminating and implementing the product. The research method used with 3 simpler steps i.e : (1) preliminary stage, (2) product design and development, and (3) product testing

In this study only carried out until the seventh step, called revising operational products. The product developed by the researcher was a test instrument using CBT to facilitate students' science process skills in learning physics. Research steps for the development of the PPP test instrument as in the following table.

Table 1. Research steps for the development of the SPSS test instrument

Research Procedure	Explanation
1. Preliminary Research	Need analysis: a. Literature review b. Field observation.
2. Data Collection	Data collection: a. CBT based Instrument b. Calor matter.
3. First Product Design	Product and instrument design: a. Arranging lesson plans (syllabus, Worksheet, dan Lesson plan) b. Making SPS test instrument grid c. Making SPS test instrument d. Instrument product validation for CBT-based SPS test instruments

Research Procedure	Explanation
4. First Step Test	<ul style="list-style-type: none"> a. Expert test was carried out by two experts, namely learning design experts and material experts and linguists. b. The readability test was carried out on students who had taken the subject matter to be used in the study (selected students with low, medium, and high abilities) c. The limited group test is carried out on students who have not taken the subject matter to be used in the study (at least six students with low, medium, and high abilities were selected).
5. Revision of Initial Product	Initial product revisions are carried out based on early stage tests.
6. Field Trial	The main field test was carried out in the class that was the subject of the research trial.
7. Product Enhancement	The final revision was carried out by paying attention to the notes on the research trial.

The preliminary stage, the location and subjects of the research trials were carried out using purposive sampling technique, schools were selected based on the consideration of the researcher. The research location was carried out at Pringsewu Muhammadiyah Vocational School, students of class XI RPL. The subjects in the study were experts who tested the validity of the Science Program Skills (SPS) instrument which consisted of construct and content and language experts.

Data Analysis

The non-test instrument data analysis in this study used descriptive data analysis techniques. The non-test instrument was a questionnaire using a Likert scale. The Likert scale is used to measure the attitudes, opinions and perceptions of a person or group about a social phenomenon (Sugiyono, 2015). In this study using a scale of 1 to 5, with the highest score of 5 and the lowest score of 1 (Riduwan, 2009). The final value of an item is the percentage average value of the indicator from all validator answers. From the calculation of the score for each statement, a presentation of the overall answers of the respondents is sought using the formula:

$$P = \frac{\sum X}{\sum Xi} \times 100\%$$

Explanation:

P : Percentage

$\sum X$: The number of respondents' answers in one item

$\sum Xi$: The number of ideal values in the item (Asyhari & Silvia, 2016)

Then look for the percentage of validation criteria both the feasibility and attractiveness of the instrument being developed. The validation criteria used can be seen in the following table:

Table 2. Interpretation of Eligibility Criteria

Interval	Kriteria
0% - 20%	Very Uneligible/Interesting
21% - 40%	Uneligible /Interesting
41% - 60%	Eligible enough/ Interesting
61% - 80%	Eligible/ Interesting
81% - 100%	Very Eligible/ Interesting

The product feasibility test (product validation) of the SPS test instrument was carried out by 2 experts, called 2 master lecturers of physics education. Expert judgment is carried out to examine the suitability of the items with the scope of teaching matter and the measured SPS indicators. The SPS test instrument is considered suitable for use if the assessment score is greater than 61% with appropriate criteria (Sudijono, 2011)

Field trials were carried out to see the reliability, distinguishing power, and level of difficulty of each test item. The validity of the items used the product moment correlation formula (Equation 1).

$$r_{xy} = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{(N\Sigma X^2 - (\Sigma X)^2)(N\Sigma Y^2 - (\Sigma Y)^2)}} \quad (1)$$

Where r_{xy} is the correlation coefficient between variables X and Y; X is the student's score for each item; Y is the student's total score; and N is the number of test takers. After obtaining the calculated r_{xy} value, the results are compared with the r critique of the product moment table at the significance level $\alpha = 5\%$. If $r_{xy} > r_{table}$, then the question is said to be valid.

Reliability test is done by using internal consistency method. Nunnally states that the reliability of the test is based on the homogeneity or correlation between the answer scores on each test item (Mujianto, 2017). Because the results of the test guideline review by the expert team provided a Likert scale score level, the reliability of the diagnostic test was measured using the Alpha Cronbach equation (Equation 2).

$$r_{11} = \left(\frac{n}{n-1} \right) \left(1 - \frac{\sum s_i^2}{s_t^2} \right) \quad (2)$$

In which r_{11} is the test reliability coefficient; k is the number of questions; S_i^2 is the number of variants of the item score; and S_t^2 is the number of variants of the total score. To determine the category of the test reliability coefficient used the criteria shown in Table 3 (Sugiyono, 2012).

Table 3. Reliability Coefficient Classification

Reliability Index	Reliability Criteria
$0,00 \leq r_{11} < 0,20$	Very low
$0,21 \leq r_{11} < 0,40$	Low
$0,41 \leq r_{11} < 0,60$	Medium or Enough
$0,61 \leq r_{11} < 0,80$	High
$0,81 \leq r_{11} < 1,00$	Very High

The analysis of the difficulty level of the test item is carried out by calculating the difficulty index using Equation 3.

$$TK = \frac{B}{JS} \quad (3)$$

With TK is the difficulty level (index of difficulty), B = The total score of students answering the test questions correctly for each question and JS = The total number of students taking the test. The difficulty index ranges from 0.00 to 1.00. Items with a difficulty index of 0.90 are very easy items and are not appropriate to be used as test instruments. Whereas the items with a difficulty index of 0.20 are very difficult items and need to be further explored what is the cause of the difficult questions, whether the items are difficult due to the grammar of the questions or problems with the content (Boopathiraj & Chellamani, 2013)

The analysis of the distinguishing power of the item is done by calculating the coefficient of distinguishing power using Equation 4.

$$DP = \frac{Ba}{Ja} - \frac{Bb}{Jb} = P_A - P_B \quad (4)$$

In which DP is the coefficient of discriminating power; Ba is the number of participants in the top group who answered the question correctly; Bb is the number of participants in the lower group who answered the question correctly; and N is the number of students who took the test. The distinguishing power value ranges from -1.00 to +1.00. The items are said to be good and can be used as an assessment instrument if I have a differentiating index of more than 0.20, while the items that have negative distinction cannot be used as an assessment instrument (Boopathiraj & Chellamani, 2013).

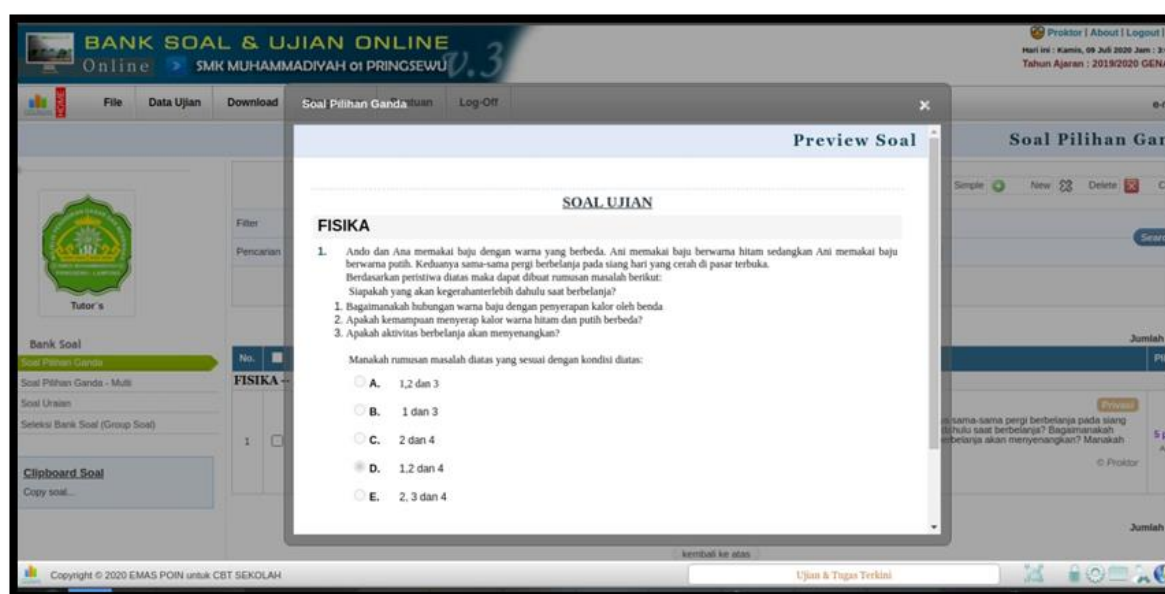
RESULTS AND DISCUSSION

The SPS instrument developed was in the form of multiple choices. Measurable aspects of process skills from the SPS assessment instrument are observing, predicting, measuring, classifying, communicating, and concluding (Table 4).

Table 4. Distribution of SPS Test Questions Based on SPS Aspects of Heat Matter

SPS Indicators	Numbers of Question
Asking question	1,2,3 and 4
Hypothesizing	5, 6, 7, 8, 9, 10, 11 and 12
Interpreting	13, 14, 15 and 16
Communicating	17, 18, 19 and 20

Table 4 shows the distribution of questions for each aspect of SPS. Measurable aspects of the SPS assessment instrument developed on heat consist of asking questions, hypothesizing, interpreting and communicating. Here is an example of a question on the indicator asking a question.

**Figure 1.** Display of SPS questions using CBT

The analysis of the validity (feasibility) of the SPS instrument according to experts (experts) obtained an average percentage score of the two experts of 82.83% in the very good category with details of the media aspects of 84.5%, the matter / content aspects of 80% and the language aspects of 84 % (Figure 2). The expert's (expert) assessment indicated that the PPP test instrument that was made was considered eligible in terms of construct, matter and language. According to (Arimbawa et al., 2017) content validity is important for test learning outcomes because a score is not even reflective of learning outcomes if the instrument is not able to comprehensively measure what students have learned. Validation is also important for the suitability of the instrument with the competence of learning outcomes, accurate matter content, and appropriate matter in terms of expertise (Wedyawati & Lisa, 2018). The results of media, matter and language validation can be seen as a whole in the following graph

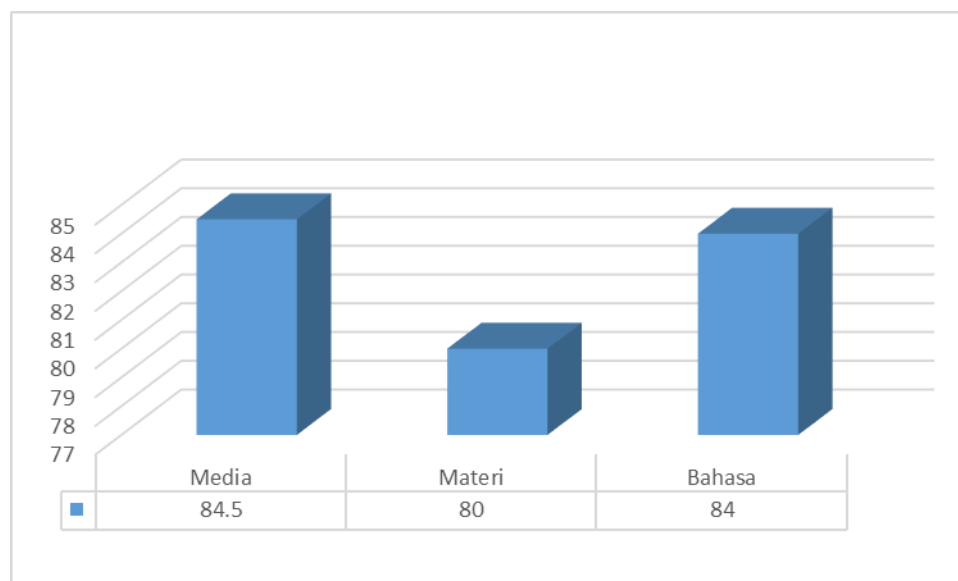


Figure 2. Validation Results for Product Development Experts

The finished product was validated and said to be eligible by the three experts, the instrument for CBT-based science process skills for vocational students on the heat matter was tested at Pringsewu 1 Muhammadiyah Senior High School. Testing of this instrument was carried out in three stages, called expert testing, small group testing and instrument testing. The results of the expert review test by educators are shown in the following table:

Table 5. Acquisition of Expert Review Tests

Indicators	Percentage	Criteria
Matter	86%	Very eligible
Presentation	85%	Very eligible
CBT	89%	Very eligible
Language	81%	Very eligible
Average	85,25%	Very eligible

Table 5 is the acquisition of results from the Expert Review Test by educators at the Muhammadiyah 1 Pringsewu SMKS. Then the researcher got a percentage of the feasibility value of each instrument assessment of the CBT-based science process skills using the Likert scale formula with a score of 86% in the matter category "very eligible", presentation with a percentage of 85% with the category "very eligible", 89% aspects of CBT criteria. "Eligible", and the percentage of 81% of the language aspect is in the category of "very eligible". So that the average assessment for all aspects of the CBT-based science process skills question instrument is 85.25% with the criteria "very eligible".

The small group trial was attended by 15 students who studied physics, especially heat matter at Pringsewu 1 Muhammadiyah Senior High School. The results of the small group trial are as follows:

Table 6. Data Acquisition for Small Group Trials

Indicators	Percentage	Criteria
Matter	87%	Very interesting
Presentation	85%	Very interesting
CBT	87%	Very interesting
Language	87%	Very interesting
Average	86,5%	Very interesting

Table 6. Explaining the questionnaire data obtained from the test results of small groups of students studying heat matter in class X physics at SMK Muhammadiyah 1 Pringsewu. The data obtained from small group trials on the matter aspect received a percentage of 87% in the "very interesting" category, the presentation aspect of the percentage of the assessment was 85% of the "very interesting" category, 87% of the percentage of the CBT aspect of the "very interesting" category, in the language aspect the percentage of the assessment was obtained. 87% of the category "very interesting". The average number of assessments obtained was 86.5% in the "very attractive" category.

This field test was conducted with 40 students studying physics, especially heat matter in several schools in Lampung. The results of the field test questionnaire recapitulation can be seen in the following table:

Table 7. Field Test Results

Indikator	Presentase	Kriteria
Matter	83%	Very interesting
Presentation	81%	Very interesting
CBT	80%	Very interesting
Language	82%	Very interesting
Average	81,5%	Very interesting

Table 7 describes the acquisition of results from field tests on students with an average percentage of 81.5% with the criteria "very interesting". With the acquisition for matter indicators of 83%, presentation of 81%, CBT of 80% and for language of 82% with very interesting categories.

After being declared eligible by the expert, the test was then tested on students who had studied the matter being tested, called 29 students of class XI SMK. The results of the field trial analysis were validity, distinguishing power, difficulty level, and reliability. Based on the analysis of the validity of SPS questions, valid and invalid questions were obtained (Table 5). Questions that have invalid criteria are discarded and not used because they have not been able to measure what will be measured.

The results of the difficulty level of the SPS questions developed also varied, called questions in the difficult, medium, and easy categories. In addition, the criteria for distinguishing questions were obtained by questions with very good distinguishing power; questions with good distinguishing criteria; questions with sufficient distinguishing power criteria; and questions with poor discriminatory criteria. For questions that have poor

distinguishing criteria, the questions are not discarded but corrected. This is in accordance with the opinion of Kusairi (2013) that the index of item difference is not always a measure of the quality of the items, meaning that the low index of distinguishing power is not a measure of the low quality of the items. Apart from its validity, level of difficulty, and differentiation power, a test also needs to be seen on its consistency or reliability. The results of the reliability analysis of SPS questions show that the criteria for the reliability index of the questions are in the medium and good ranges. This shows that the SPS questions for the heat matter that are made have good consistency, meaning that a test is able to give the same results for the same subject at different times (Feyzioglu, 2012).

Table 8. Feasibility Test Results for SPS questions using CBT

Number of Question	Validity	Discrimination Power	Difficulty	Absorbtion			
1	0.16	Invalid	4.90	Good	0.97	Easy	96.55
2	0.37	Invalid	5.31	Good	1.00	Easy	93.10
3	0.12	Invalid	4.97	Good	0.97	Easy	96.55
4	0.49	Valid	3.66	Good	0.76	Easy	75.86
5	0.40	Valid	4.90	Good	0.79	Easy	79.31
6	0.83	Valid	1.59	Good	0.45	Medium	31.03
7	0.88	Valid	0.90	Good	0.32	Medium	24.14
8	0.75	Valid	2.48	Good	0.58	Medium	37.93
9	0.51	Valid	4.14	Good	1.42	Easy	58.62
10	0.73	Valid	1.59	Good	0.71	Easy	41.38
11	0.51	Valid	3.45	Good	0.61	Medium	37.93
12	-0.26	Invalid	2.07	Good	1.64	Easy	62.07
13	0.58	Valid	3.31	Good	0.52	Medium	44.83
14	0.44	Valid	4.69	Good	0.61	Medium	58.62
15	0.37	Valid	5.10	Good	0.86	Easy	86.21
16	0.81	Valid	0.62	Good	0.53	Medium	34.48
17	0.75	Valid	2.21	Good	0.50	Medium	48.28
18	0.37	Valid	4.28	Good	0.90	Easy	89.66
19	0.54	Valid	4.41	Good	0.79	Easy	79.31
20	0.27	Invalid	5.38	Good	1.00	Easy	86.21
Reliability	0.97	Very High					

Table 8 shows that the level of item reliability is very strong for multiple choice questions. However, if you look at the empirical validity test, there are 5 questions that are declared invalid. For questions like this, it was decided to discard and not use, called questions number 1, 2, 3, 12, and 20. Mediate for questions with valid criteria and good distinguishing power, then they are ready to use.

The results obtained after testing the instrument, called from the 20 questions given to students after being analyzed, there were 5 invalid questions and 15 valid questions. The reliable value of the instrument that has been tested is reliable (r11) of 0.97 with reliable information "Very High".

The results of the analysis of the difference power test carried out showed that all the questions were good. The result of the difficulty level test that has been analyzed from the question instrument, obtained Easy and sufficient criteria. There are 8 items with sufficient / Medium criteria, while for Easy criteria there are 7 items. The product after going through the validation process from several validators of media experts, matter experts, and linguists, so that by testing the product in which there are stages of expert review testing, small group testing, and testing of product instruments developed by researchers it is said to be "Very Eligible" and "Very Interesting" without having to be revised again. So that the advantages of the product developed in the form of an instrument for CBT-based science process skills for vocational students on heat matter, called: (1) The instrument for CBT-based science process skills is very practical to use because it is stored in the form of an application. (2) Enabling students to do or work on science process skills questions. (3) Using communicative language so that students can understand it. (4) It makes it easier for educators to correct questions, because the assessment on this instrument already includes the points obtained after students have done it.

Mediate the shortcomings of this CBT-based question instrument, called to make an instrument you must get special access from the CBT admin, and when making it you have to use an internet connection, and when using this application, you have to be connected to the internet too. In addition, the use of CBT in students is feared that there will be an increase in the level of cheating when working on questions, therefore educators should monitor carefully so that there is no cheating when working on questions using CBT. Overall, from the results of expert validation, expert review tests, small group product trials, field tests and instrument trials, satisfactory results were obtained and were declared very eligible and interesting to use and apply the instrument for CBT-based science process skills questions to students.

CONCLUSION

Based on research objectives that the quality of the development of instruments for CBT-based science process skills for vocational high school students on the overall heat matter according to media experts, matter experts, and linguists, as well as from the responses of educators with an ideal percentage of 84.5% each with very eligible criteria, 80% eligible, 84% with very eligible category, and 85.25% with Very Eligible criteria. The instrument of development results has product attractiveness in small group trials and field testing is very attractive to the CBT-based question instrument developed by the researcher. The percentage obtained from small group trials through student responses was 86.5% and field trials were 81.5% with each category being very interesting. The results of the instrument try-out on the validity, reliability, difference power test, level of difficulty and distraction obtained a valid instrument as many as 15 items from the 20 existing questions, the reliability (r_{11}) obtained was 0.97 with a high level of reliability, for difference power. 15 questions in good category, for difficulty level 7 questions in Easy category and 8 questions with enough / Medium category.

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