An Overview of Students' Conceptual Understanding in Kinematics Using Computer Based Test (CBT) Class XI SMA Negeri 19 Palembang

Ketang Wiyono [1], Sudirman [2], Kristylia Sury [3], Saparini [4], Melly Ariska [5]
Universitas Sriwijaya, Indonesia[1,2,3,4,5]
ketang_wiyono@fkip.unsri.ac.id[1], sudirman@fkip.unsri.ac.id[2], kristiliasuri@gmail.com[3],
saparini@fkip.unsri.ac.id[4], mellyariska@fkip.unsri.ac.id[5]

ABSTRACT

This study aims to analyze the category of understanding the concept of kinematics using Certainty of Response Index (CRI) assisted Computer Based Test (CBT) and to determine misconceptions in class XI students of SMA Negeri 19 Palembang. The method used in this research is descriptive and the instrument used in this study is a multiple choice test using CRI and reason. The test was conducted on 57 students from class XI IPA 1 and XI IPA 3. Rasch modeling is used for the processing stage from raw data to logit numbers which will provide information related to infits and outfits in the ministep software besides manual analysis using CRI. The result of the analysis that have been carried out considering students who are outliers or misfits, data from the ministep software and the reasons for the answer given, 41 students are obtained according to the Rasch modeling and 16 students who are outliers or misfits. The result showed that the average score of concept understanding was 23.44%, while for the concept understanding category it was 2.15%, the concept understanding category but not sure was 0.00%, the misconception category was 70.02% and did not understand the concept of 27.83%. The result of the interview found several causes of misconceptions, namely the references form used in the languange in the book was difficult to understand and the learning model usel was not quite right.

INTRODUCTION

Education has a rapid development in line with the development of civilization, knowledge and technology. One of the evidences is the change in curriculum, learning process and assessment. Curiculum changes like this have occurred in other areas such as Korea [1]. Curriculum reform has also taken place in areas of Korea including Indonesia. Increasing the quality of human resources and the

competitiveness of the nation along with the development of knowledge, technology and arts. The Indonesian government implements a new curriculum to carry out the education process in elementary, junior high and senior high schools, this new curriculum in Indonesia is called the 2013 curriculum. The 2013 curriculum is an innovation and improvement from the previous curriculum, namely the 2006 curriculum.

The 2013 curriculum wants the ability of Human Resources (HR) to have high quality. The goal of the 2013 curriculum is not only to emphasize knowledge and skills but more emphasize the scientific approach (scientific approach) at the primary to secondary education levels competency [2]. The 2013 curriculum pays more attention to educational content, shifting the paradigm of learning from a teacher-centered approach to a learner-centered approach and using competency-based assessments. Thus students are expected to understand a concept so that the results of the learning process can enter into long-term memory and students can understand the basics of learning [2]. The 2013 curriculum is expected to be able to produce more productive, creative, innovative and affective human resources using the strengthening of attitudes, knowledge and skills competencies [3]. The world of education is required to prepare superior competent Human Resources (HR) to be able to compete in the global job market. This is closely related to technological developments.

Technology will certainly make it easier to obtain information that is effective and efficient. The use of information systems as data processing tools can increase the speed of work so that energy and time efficiency in processing data is achieved compared to manual methods, usually the teacher can spend time calculating and adding up each student's test results. Along with technological developments, teachers can use learning media as a tool for conducting assessments such as Computer Based Testing in various schools [4]. One of the electronic gadgets that can be converted into learning media is an Android-based smartphone. An example of an application that can be used as a tool for assessment is the Kuisku application. The kuisku application is an application found on an android smartphone to create a multiple choice quiz application that can make it easier because the results of working on these questions go directly to the email of the question maker. This application is very helpful for teachers along with technological developments. The development of science and technology has direct implications for curriculum development which includes the development of educational content / materials, learning media, and the use of an evaluation system.

Educational evaluation is always associated with the learning achievement of students [5]. Educational evaluation, there are three components that are interrelated and form an inseparable unit, namely measurement, assessment and evaluation. The quality of learning can be seen from the results of these three components. It should be noted that a good scoring system is very influential on increasing the motivation of students in learning. The teacher's ability to make learning evaluations occupies an initial position for improving the quality of learning.

Evaluation is very necessary for education with an evaluation of a teacher who will find out information whether the student understands the material presented or not [6]. Evaluation can be in the form of an assessment carried out to find out the students' understanding of the concepts that the teacher has given. The physics learning process will run well if the learning is carried out in accordance with the expected functions and goals. The physics learning process is also required to slowly express and understand concepts. The fact is that many students at school still have difficulty solving problems in physics lessons regarding concepts.

Concept is a basic component that is very important in the learning process of physics, for example, the concept of mechanics which contains kinematics and dynamics material. The concepts of mechanics in kinematics and dynamics material are based on basic competencies in the physics syllabus of class X, students are required to analyze physical quantities in straight motion at constant velocity and analyze interactions on forces and the relationship between force, mass and straight motion of objects. This can be realized if students are able to answer questions on the mechanics concept where in this study using the FCI instrument which has a high level of ability to better understand the concept.

Concept understanding is the ability to grasp meanings such as being able to express a material presented in a more understandable form (translation), being able to provide interpretation, and being able to apply it (extrapolation) [7]. Understanding the concept is needed by students who have experienced the learning process. Achieving success in learning physics cannot be separated from understanding the concepts students have [8]. The level of conceptual understanding based on Modified CRI consists of 4 categories, namely: (1) students who understand concepts, (2) students who understand concepts but are not sure, (3) students do not understand concepts and (4) students who experience misconceptions [9]. Physics learning is actually an interesting subject, however several studies have shown that many students still have difficulty understanding physics concepts that make students experience misconceptions [10].

Students can be said to experience misconceptions when these students cannot explain the meaning of the concept correctly. Meanwhile, students who understand the concept can explain the meaning of the concept correctly. Misconceptions in physics learning are very resistant if they are not given careful attention by the teacher [11]. Examples of misconceptions that are often found in students are that many students are confused with kinematic concepts. The concept of kinematics is fundamental in learning physics. This material is basic material which is very closely related to other physics concepts. So that students must have competent concepts on the concept of mechanics so that in the next physics learning students can understand the concept [12]. Concept understanding can be identified in various ways. This method includes identifying conceptual understanding using a diagnostic test instrument in the form of multiple choices in which there are alternative concepts that students might think about.

Research using the concept of physics on straight motion material has been carried out. The results showed that the misconceptions experienced by students were 50% and students with a good understanding of the concept of straight motion were only 21.67% while students answered correctly by guessing and lacking knowledge of each reach of 10.42% and 17.50% [13]. Further research was conducted by Misykah & Adiansha [14]. The results of this study indicate that the percentage of students who guessed at 12.83% understood the concept of 23.90% did not understand the concept of 29.88%, and misconceptions were 33.39%. In addition, further research was conducted by Ariska [15]. The results of this study showed that the percentage of students who experienced misconceptions on mechanical concepts was 65.58% and students with good conceptual understanding were only 12.0% who understood the concept but were not sure of 4.9% and those who do not understand the concept of 17.4% [16].

Based on an interview conducted by the researcher with one of the physics teachers at SMA Negeri 19, the students at the SMA were still not used to solving high-level conceptual understanding questions, it was proven that when the teacher's semester tests made questions of understanding the concept, there were still many students who could not work on the question even though the material on the question had been given. Responding to some of the problems in previous studies that have been described and interviews with one of the teachers, the researcher attempted to conduct a study of students' misconceptions on understanding the kinematic concept that occurred in SMA Negeri 19 Palembang by using the FCI instrument which aims to determine the category of student conceptual understanding and to find out the misconceptions that occur in class XI SMA Negeri 19 Palembang.

METHOD

The method used is descriptive. The variable in this study was the understanding of the kinematic concept using CRI assisted by CBT for class XI students of SMA Negeri 19 Palembang. The data collection technique used in this study was a multiple choice objective test technique using FCI questions equipped with the Certanly of Response Index (CRI) method and interviews. In this study, the researchers analyzed the categories of students' conceptual understanding using multiple choice tests with the reason that they were equipped with CRI and interviews. The test result data will be included in the ministep software, which is one of the series in Rasch modeling. The output in the software is a

table of Item Measure, Person Measure, Variable Maps and Reliability which have been previously converted into logit numbers. This logit number must meet the requirements of the Mean Square (MNSQ) Z-Standard Outfit (ZSTD), Point Measure Correlation (Pt Mean Corr) and the Reliability value according to Rasch modeling.

For logit numbers obtained from the output of the Ministep software, there is an interval scale that explains the state of these numbers. as for the scale, namely:
1. Accepted Mean Square (MNSQ) outfit values: $0.5 < MNSQ < 1.5$
2. Accepted Z-Standard (ZSTD) outfit value: $-2.0 < ZSTD < +2.0$
3. Measure Correlation (Pt Mean Corr) Point Value: $0.4 < Pt\ Measure\ Corr < 0.85$.

Based on these values students will be qualified according to or not by modeling. In addition to using the software in this study, analysis will be carried out manually with regard to the reasons for student answers and the existing CRI scale. From the results of this manual analysis, 4 percentage categories of students' conceptual understanding will be obtained. Then to determine the category of misconceptions can be determined using the modified CRI method.

Table 1. Modified CRI Criteria

No	Answer	CRI	Reason	Category
1	1	> 2.5	1	PK
2	1	< 2.5	1	PKTY
	1	> 2.5	0	
3	0	> 2.5	1	M
	0	> 2.5	0	
	1	< 2.5	0	
4	0	< 2.5	1	TPK
	0	< 2.5	0	

The steps in analyzing the research data are as follows [17].
1. Student answer data are processed using Ministep software.
2. See the validity of questions from Ministep software in the Item Measure table.
3. Checking the suitability of students on Rasch modeling from Ministep software on the Person Measure table.
4. Calculating the logit value to determine the level of ability of students, with a formula

Odds:

$$P = B / Q \tag{1}$$

Odd Ratio Equation [18] is

$$Odd\ Ratio = \frac{P}{1 - P} \tag{2}$$

With Logit Equation

$$Logit = \log(\frac{P}{1 - P}) \tag{3}$$

5. Student answer data are grouped based on the sub-concepts of kinematics.
6. Determine students' CRI answer data and group them based on sub-concepts.
7. Determine the four categories of conceptual understanding (understand concepts, understand

concepts but are not sure, misconceptions, and do not know the concept) which are listed in table 1.
8. Calculating the frequency of answers of students.
9. Determine the percentage of the four categories of students' conceptual understanding for each question, using the formula [19].

$$P = \frac{f}{N} \times 100\%$$

(4)

10. Make a graph of the percentage of students based on the four categories of conceptual understanding.

RESULTS AND DISCUSSIONS

Description of Research Data
Data analysis was carried out by looking for the average percentage of students' concept understanding using FCI questions and also looking for the average conceptual understanding of each kinematic concept, but before looking for the average percentage of conceptual understanding the researcher first validated the questions to see the quality that matter. Validation was performed using Rasch modeling assisted by the Ministep application on the item measure. Furthermore, researchers analyzed how many students including respondents outliers or mifits and respondents who were in accordance with the Rasch modeling [20]. The results of the concept understanding test were then analyzed so that the percentage results were obtained in the four existing categories, namely, the concept understanding category, concept understanding but not sure, misconceptions and not understanding the concept. The average result of the percentage understanding of the concept of class XI IPA 1 and XI IPA 3 students can be seen in table 2 below.

Table 2. Result Data

Category	Percentage
Maximum Score	54.55%
Minimal Score	0.00%
Average Score	23.44%
Standard Deviation	11.65%

Based on Table 2, it was found that the average score of the conceptual understanding test results of students in class XI IPA 1 and XI IPA 3 was 23.44%. From the average score of the test results, the percentage of categories for understanding the concept is obtained as in the following table.

Table 3. Average understanding of the Concept of Student

| Concept Understanding Category	Percentage
Understand the Concept	2.15%
Understand the Concept but not sure	0.00%
Misconception	70.02%
Don't Understand the Concept	27.83%

Based on table 3 above, it can be concluded that the understanding of the concepts of students in class XI IPA 1 and IPA 3 at SMA Negeri 19 Palembang on the kinematics concept that has been tested which has the highest percentage is students with a misconception category of 70.02% otherwise the lowest percentage is found in the category of understanding the concept but not sure of 0.00%, then the category of understanding the concept of 2.15% and the category of not understanding the concept of 27.83%.

Concept Understanding Analysis
The results of the test data that have been obtained from students of SMA Negeri 19 Palembang are analyzed first because to find out information about the level of quality of the questions using Rasch modeling using Ministep software. The following is a table of measure items. The number of questions

used is 11 physics questions on the kinematics concept. The item measure table can be used for validation in Rasch modeling. This table can provide information in the form of logit number data that shows the quality of the questions used. The figures in the table are analyzed through the number intervals in the Infit and Outfit criteria. From the results obtained, it can be concluded that the questions are valid in the Rasch modeling rules because they have met the Infit and Outfit criteria. The observed aspect lies in the Mean-Square, Z-Standard and Point Measure Correlation.

In the Table 4 can also be seen that the difficulty level of the question, namely question number 2 is a question with a high level of difficulty because of the 57 students who can answer only 2 students while the questions with a low difficulty level or can be said to be easy are in question number 4 because that can answered as many as 28 students from 57 students. The value of the ZSTD and Pt Mean Corr outfit can be seen that 16 students are classified as outliers or mifits while 41 students are classified as students who are already in accordance with Rasch modeling. Furthermore, the results of the test data that have been obtained are analyzed and the answers and reasons are then grouped into four categories of understanding the concept of kinematics and sub-concepts of kinematics in class XI IPA 1 and XI IPA 3.
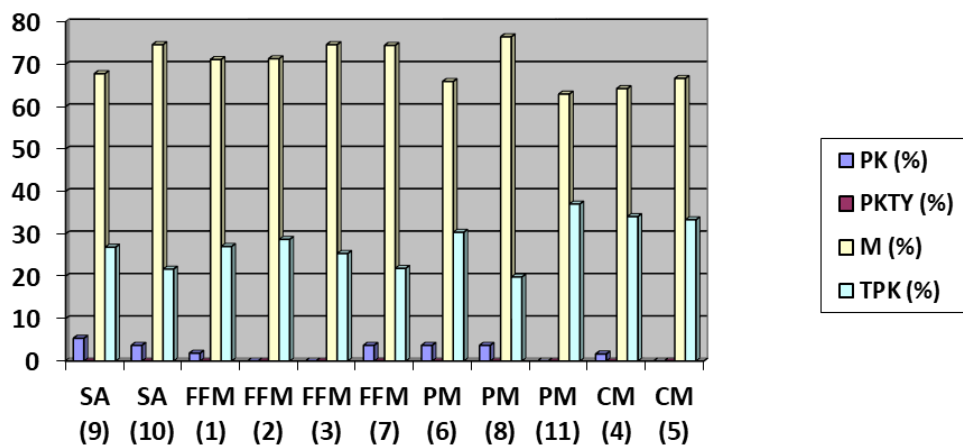
Fig 1. Average Categories for Understanding the Students Concept Based on Subconcept

Based on Fig 1 the test data results are grouped according to the sub-concept of the questions being tested, namely Speed and Acceleration, Free Fall Motion, Parabolic Motion and Circular Motion. The sub-concepts were analyzed according to the four existing categories of conceptual understanding. The percentage of misconceptions is the highest category that occurs in SMA Negeri 19 Palembang class XI IPA 3 and XI IPA 4. The sub-concept that has the highest misconception is in the free fall motion sub-concept.

Discussion
The results of the test results for students' concept understanding of SMA Negeri 19 Palembang were obtained from the analysis of the conceptual understanding of students in class XI IPA at SMA Negeri 19 Palembang by using FCI questions which were limited to kinematics material in the form of multiple choice with open reasons totaling 11 questions and in the process using app Kuisku. The students' choice of answers and reasons were analyzed using Rasch modeling in ministep software and using manually modified CRI which had 4 categories of understanding on each item. Rasch modeling was first made by Dr. Georg Rasch which in this study was used to determine the level of difficulty of the questions used and the level of students' ability.

Based on the data that has been obtained in table 3, the average score is 23.44% while the concept understanding category is 2.15% because many students answered correctly but seen the reason the

answer was wrong which caused when categorized as understanding the concept had a higher percentage. smaller than the average score. Table 5 shows that there are 16 students classified as students who are not in accordance with the Rasch modeling seen from the predetermined criteria. In addition, the reason that the 16 students were not included in the Rasch modeling can be seen in the 053 respondent having high ability but not including rasch modeling or misfits because the respondent was considered a guesswork. If seen from the reasons for the answers to questions, the respondent did not answer and was not sure. The same situation occurs in 221 respondents where the respondent is classified as misfits with the indication that the answer given is guesswork because easy questions cannot be done while the more difficult questions can be done and the questions that are answered correctly look random. Table 6 can see the understanding of the concept by looking at the reasons and the level of confidence of the respondent or student.

The students' understanding of the concepts of class XI SMA Negeri 19 Palembang varied, namely for the category of understanding the concept of 2.15%, understanding the concept but not sure 0.00%, 70.02% misconception and not understanding the concept 27.83%. From the percentage of the 4 categories of conceptual understanding, it can be concluded that the category XI class of SMA Negeri 19 Palembang has the highest percentage. This is in line with previous research [13] [17] explaining that the kinematics material for class X SMA Negeri 6 Palu experienced misconceptions by 50.00%. In addition, Boone, Yale, & Staver [21] stated that the kinematics material that experienced the most misconceptions in students was 74.9%.

Problems 1 and 2 state the time and distance traveled by 2 balls of different weight. In both questions, students answered the same thing, namely heavy balls falling to the ground faster than light balls. The students' answers should be that objects that fall on the same place on the earth's surface experience the same acceleration and do not depend on the size, weight or arrangement of the object because there is no air friction. From this description, it can be concluded that students have wrong pre-concepts. So that students still experience many misconceptions in questions number 1 and 2. Misconceptions that occur to students are 71.12% and 71.30%. This is in line with research conducted by Kurniasih [16] and Syuhendri [22], respectively, which have misconceptions of 79.45% and 91.4% on the concept of free fall motion.

Problem number 3 states that the reason a rock falling from the top of a multi-storey building to earth falls is because of the acceleration caused by gravity which is almost constant during the fall. Most of the students answered B on the grounds that an object falling faster was due to the greater gravity the closer the rock got to the earth. It can be concluded that for question number 3 there are still many students who have misconceptions of 74.63%. This is in line with previous research conducted by Rusli, Haris, & Yani [23], the misconceptions experienced by students were 73.2%.

Questions 4 and 5 ask about the concept of circular motion. Where in this circular motion concept, students experience many misconceptions, namely 64.26% and 66.67%. There are students who experience misconceptions who answer correctly but the reason is wrong, namely when the rope breaks the line it will move perpendicularly because there is no friction that causes objects to come out of the circular trajectory parallel or always follow the shape of the last trajectory. In a circular motion, an object has a velocity vector which is always perpendicular to the acceleration vector, therefore the ball's trajectory when the rope breaks will correspond to the direction of its velocity vector, which is perpendicular. This is in line with previous research [24] which experienced misconceptions of 54.11%.

Questions 6 and 8 ask about the concept of parabolic motion in which students are asked to determine the trajectory. Question number 6 many students answered option B but did not give the right reasons and some did not give reasons. The student who gave reasons answered that the trajectory when the bullet is fired will fall slowly to form a parabolic trajectory in option B. Even though this question is a parabolic concept of motion, namely when the cannonball is fired at an elevation angle of 0 °, the bullet will fall to form a parabolic curve . This is due to the influence of the initial velocity of the cannonball in the horizontal direction and the gravitational force in the vertical direction. From this description, it can be concluded that students who experienced misconceptions in question number 6 were 65.93% and

in question number 8 students who experienced misconceptions were 76.48%. This is in line with research conducted by Fauziah & Darvina [25] who experienced a misconception of 47.00%.

Problem number 7 asks about the force acting on the ball which is thrown upwards and the air friction is ignored. In question number 7 students answered a lot on the grounds that when throwing the ball there is an upward force which always decreases until the ball reaches the highest point and when the ball falls there is a gravitational force. So that in this question it was found that students who experienced misconceptions were 74.45%. This is in line with the previous research conducted by Wiyono [26] and Akhsan, et al. [27] which amounted to 54.8%.

Questions 9 and 10 ask the concepts of speed and acceleration. Where for question number 9 there are two blocks that have an interval of 0.20 seconds for each block to the numbered squares. In question number 9, many students experience misconceptions because seen from the answers given they choose answer D on the grounds that the blocks have the same position. From this description, students cannot distinguish between position and speed. Even though beam a and beam b have differences in motion, namely beam a GLBB while beam b GLB. At the same time beam a and block b travel different distances.

Problem number 10 students cannot differentiate between acceleration and speed. The way to find out whether there is the same velocity for the numbered blocks is by looking at the equal distance for each numbered block. Blocks a and b have the same distance at the same time, it can be concluded that block a and block b have the same velocity and do not have acceleration or it can be said that the acceleration is zero. Misconceptions that occur in students are 67.78% and 74.63%. This is in line with previous research conducted by Limbach & Waugh [28] and Amto, Ertikanto, & Nyeneng [29] which amounted to 67.70% on the concept of speed and acceleration.

Problem number 11 asks about the exact path to describe the rocket path from point b to c. when the rocket is in position b, the rocket receives the thrust of the kostan rocket which causes the rocket to rise as shown in the path of choice E. This shows that the rocket speed will always increase and form a parabolic trajectory. Some students answered the correct choice, namely E, but the reasons were not quite right. So that many students experience misconceptions, namely 62.97%. this is in line with research [30] [31] of 67.70%.

After it is known that the misconceptions experienced by high school students, the researcher will conduct an interview to find out the cause of the misconception. Researchers give several questions to students. Based on the interview process, it turns out that the kinematics material according to the students is a difficult material, even though it has been studied when class X students still find it difficult to understand the kinematics material, because in the learning process in class X the teacher only provides formulas to be recorded without being given further explanation. right to understand the concept.

Based on the results of the interviews that caused these students to experience misconceptions, these students were not given variations in learning such as doing practicum during the learning process. Another thing that causes students to have difficulty understanding kinematics material is the lack of reference to the books used. The concept that is considered difficult to understand by students is parabolic motion. This is because the concept of parabolic motion is difficult and when the learning process is not explained in detail.

Students hope that when learning kinematics the teacher explains more conceptually, not just recording formulas and often working on questions related to kinematics material. In addition, the learning process in the classroom is further varied by using the right learning model so that students can understand more and the teacher provides more book reflections on the material to better understand. After conducting interviews with students, the researcher will conduct an interview with the teacher as well. From the results of the teacher interview, according to him, the problems faced when learning the kinematics

material were very much while the learning time was very limited which caused many concepts in kinematics that had not been discussed. One way for teachers to solve problems experienced by students is required to study independently at home first in accordance with the directions given so that when at school studendts understand more about the kinematics material, to see if students study independenly at home the teacher can provide pre-test before learning begins.

According to the teacher, many things are difficult to understand in the kinematics material but for parabolic motion material the level of difficulty is greater because there are two concepts in it that make students difficult to understand. Therefore the teacher tries to find the most appropriate method to use so that students understand and understand. The teacher applies more to the experimental method or practicum carried out in schools so that these students are more confident about the results they do and their learning outcomes will last longer than the students are given an explanation of the material on the lecture method in class which will make these students experience misconceptions.

Misconceptions in students are usually also because students only memorize the formulas contained in kinematics material without understanding the concepts and also the references used by students, the language used is difficult to understand. As a teacher, a way to overcome misconceptions is that when learning will explain the concept more, the learning model used is selected according to material needs, provides practice questions related to concepts and discusses these questions so that students do not experience misconceptions. Based on data analysis and interview results, there are still many students who experience misconceptions and the causes of the misconceptions themselves. Researchers hope that the teaching and learning model used by the teacher is more adapted to the material to be taught in accordance with the Learning Implementation Plant so that students understanding of concept related to kinematics material is better, for example in the free fall motion sub material suitable learning model is problem based learning because through this learning model can foster student creativity in solving problems faced in the real world and to encourange student motivation and creativity thinking.

CONCLUSION AND SUGGESTION

Based on the data analysis of research results regarding the concept understanding of students on kinematics, it can be concluded that: 1) the category of students' concept understanding is the highest in the category of misconception, which is 70.02%. The lowest percentage of categories is in the category of conceptual understanding but not sure at 0.00%, followed by the category of understanding the concept of 2.15% and not understanding the concept of 27.83%. 2) Misconception on the concept of free fall motion is the highest percentage, which is 72.82%. Many things cause students to experience misconceptions, including the languange in the reference book used is difficult to understand and the learning implementation plan, the learning model is more adapted to the material to be taught so that there is enough time for learning and understanding of the concept of related students better kinematics material. Further researchers are expected to develop teaching materials with use languange that is easier to understand.

REFERENCES

[1] PADU. (2013). Malaysia Education Blueprint 2013-2025. *Kementerian Pelajaran Malaysia*.

[2] Setiadi, H. (2016). Pelaksanaan penilaian pada Kurikulum 2013. *Jurnal Penelitian dan Evaluasi Pendidikan*, *20*(2): 166-178.

[3] Kementrian Pendidikan dan Kebudayaan. (2012). Pergeseran Paradigma Belajar Abad 21. [Online]. Available: http://www.kemdikbud.go.id/kemdikbud/uji-publik-kurikulum-2013-2.

[4] Novrianti, N. (2014). Pengembangan Computer Based Testing (Cbt) Sebagai Alternatif Teknik Penilaian Hasil Belajar. *Lentera Pendidikan: Jurnal Ilmu Tarbiyah Dan Keguruan*, *17*(1): 34-42.

[5] Husamah, H., Fatmawati, D., & Setyawan, D. (2018). OIDDE learning model: Improving higher order thinking skills of biology teacher candidates. *International Journal of Instruction*, *11*(2): 249-

264.

[6] Herayanti, L., Fuaddunnazmi, M., & Habibi, H. (2017). Pengembangan Media Pembelajaran Berbasis Moodle pada Mata Kuliah Fisika Dasar. *Jurnal Pendidikan Fisika dan Teknologi*, *1*(3): 205-209.

[7] Anderson, L. W., & Bloom, B. S. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman,.

[8] Febrianti, J., Akhsan, H., & Muslim, M. (2019). Analisis Miskonsepsi Suhu dan Kalor Pada Siswa SMA Negeri 3 Tanjung Raja. Jurnal Inovasi dan Pembelajaran Fisika, 6{1}: 90-102.

[9] Hakim, A., & Kadarohman, A. (2012). Student Concept Understanding of Natural Products Chemistry in Primary and Secondary Metabolites Using the Data Collecting Technique of Modified CRI. *International Online Journal of Educational Sciences*, *4*(3).

[10] Diani, R., Latifah, S., Anggraeni, Y. M., & Fujiani, D. (2018). Physics Learning Based on Virtual Laboratory to Remediate Misconception in Fluid Material. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *3*(2): 167-181.

[11] Yaniawati, R. P. (2013). E-learning to improve higher order thinking skills (HOTS) of students. *Journal of Education and Learning*, *7*(2): 109-120.

[12] Ningsih, D. R., Ramalis, T. R., & Purwana, U. (2018). Pengembangan Tes Keterampilan Berpikir Kritis Berdasarkan Analisis Teori Respon Butir. *WaPFi (Wahana Pendidikan Fisika)*, *3*(2): 45-50.

[13] Pujianto, A. (2013). Analisis konsepsi siswa pada konsep kinematika gerak lurus. *JPFT (Jurnal Pendidikan Fisika Tadulako Online)*, *1*(1): 16-21.

[14] Misykah, Z., & Adiansha, A. A. (2018, December). Effective teaching for increase higher-order thinking skills (hots) in education of elementary school. In *International Conference on Mathematics and Science Education of Universitas Pendidikan Indonesia* (Vol. 3, pp. 658-664).

[15] Ariska, M. (2015). Studi pemahaman konsep siswa pada sub konsep rangkaian listrik arus searah di kelas XI SMA Negeri 1 Palembang. *Jurnal Inovasi dan Pembelajaran Fisika*, *2*(2): 147-154.

[16] Kurniasih, A. W. (2012). Scaffolding sebagai alternatif upaya meningkatkan kemampuan berpikir kritis matematika. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *3*(2): 113-124.

[17] Tadeko, N., & Saehana, S. (2013). Analisis Pemahaman Soal Grafik Mahasiswa Pendidikan MIPA Menggunakan Pemodelan Rasch. *Jurnal Pendidikan Fisika Tadulako*, *1*(4).

[18] Sumintono, B., & Widhiarso, W. (2014). *Aplikasi model Rasch untuk penelitian ilmu-ilmu sosial (edisi revisi)*. Trim Komunikata Publishing House.

[19] Sumintono, B., & Widhiarso, W. (2015). *RascH*.

[20] Han, C. (2019). William J. Boone, John R. Staver and Melissa S. Yale. *Rasch Analysis in the Human Sciences*. *Journal of Research Design and Statistics in Linguistics and Communication Science*, *5*(1-2): 208–211.

[21] Boone, W. J., Staver, J. R., & Yale, M. S. (2013). *Rasch analysis in the human sciences*. Springer Science & Business Media.

[22] Syuhendri, S. (2014). Konsepsi alternatif mahasiswa pada ranah mekanika: analisis untuk konsep impetus dan kecepatan benda jatuh. *Jurnal Inovasi dan Pembelajaran Fisika*, *1*(1): 56-68.

[23] Rusli, W., & Haris, A. (2016). Studi Miskonsepsi Peserta Didik Kelas IX SMP Negeri 1 Makassar Pada Pokok Bahasan Gerak dan Gaya. *Jurnal Sains dan Pendidikan Fisika*, *12*(2): 192-199.

[24] Ariska, M., Akhsan, H., & Zulherman, Z. (2018). Utilization of Maple-based Physics Computation in Determining the Dynamics of Tippe Top. *Jurnal Penelitian Fisika dan Aplikasinya (JPFA)*, *8*(2): 123-131.

[25] Fauziah, A., & Darvina, Y. (2019). Analisis Miskonsepsi Peserta Didik Dalam Memahami Materi Gerak Lurus Dan Gerak Parabola Pada Kelas X SMAN 1 Padang. *Pillar of Physics Education*, *12*(1): 73-80.

[26] Wiyono, K. (2015). Pengembangan model pembelajaran fisika berbasis ICT pada implementasi kurikulum 2013. *Jurnal Inovasi Dan Pembelajaran Fisika*, *2*(2): 123-131.

[27] Akhsan, H., Wiyono, K., Ariska, M., & Melvany, N. E. (2020, March). Development of HOTS (higher order thinking skills) test instruments for the concept of fluid and harmonic vibrations for high schools. In *Journal of Physics: Conference Series* (Vol. 1480, No. 1, p. 012071). IOP Publishing.

[28] Limbach, B., & Waugh, W. (2010). Developing Higher Level Thinking. *Journal of Instructional*

Pedagogies, *3*.

[29] Amto, A., Ertikanto, C., & Nyeneng, I. D. P. (2019). Pengaruh Keterampilan berpikir kritis melalui pembelajaran berbasis aneka sumber belajar terhadap hasil belajar fisika siswa. *Jurnal Pendidikan Fisika*, *7*(1): 28-38.

[30] Saregar, A., Jamaludin, W., & Septiani, R. (2019, February). Feasibility test of mobile learning with schoology: Efforts to foster the students' learning interest on magnetism. In *Journal of Physics: Conference Series* (Vol. 1155, No. 1, p. 012060). IOP Publishing.

[31] Syafei, I., Saregar, A., Thahir, A., Sari, P. M., & Anugrah, A. (2020, February). E-learning with STEM-Based Schoology on Static Fluid Material. In *Journal of Physics: Conference Series* (Vol. 1467, No. 1, p. 012052). IOP Publishing.