JIPF (JURNAL ILMU PENDIDIKAN FISIKA)
p-ISSN: 2477-5959 | e-ISSN: 2477-8451 *Vol. 7 No. 2, May 2022, Page 134-144*

Development of Four-Tier Multiple Choice Test Instrument to Identify Students' Concept Understanding of Newton's Law Material

Fatni Mufit[1*)], Syamsidar[2]
Universitas Negeri Padang, Indonesia[1,2]
[*)]Corresponding E-mail: fatni_mufit@fmipa.unp.ac.id

Received: April 12th, 2021. Revised: September 21st, 2021. Accepted: October 5th, 2021

Keywords :
Four-tier Multiple Choice Test; Student's Misconceptions; Newton's Laws

ABSTRACT
Physics learning is learning that requires students to understand the concepts. In fact, most students still do not understand the concepts they have learned, especially the concepts in Newton's Law so that it can cause misconceptions. Students' misconceptions on Newton's Law can be identified using diagnostic tests. However, this diagnostic test is not yet available in schools. The purpose of this study was to produce a valid and reliable Four-Tier Multiple Choice Test instrument on Newton's Laws material. The type of research carried out is design research with the Plomp development model. This research is limited to two steps, which are Preliminary Research and Prototype Phase. The data collection instruments in this study were interview guides, student concept tests, self-evaluation sheets and product validation sheets. The data analysis technique used is descriptive analysis for the interview guides, coding techniques for the concept test, Aiken's formula for validation sheet and for the reliability using KR-20 formula. The results of preliminary research shows that teachers use more conventional learning which has the potential to cause misconceptions. Meanwhile, more than 50% of students experience misconceptions. Furthermore, the results of the instrument validation are: first, the validity aspect of the instrument scores between 0.56 to 0.79 which are in the valid category. Second, the reliability scores of the instrument is 0,90 which is in the very high category. It means Four-Tier Multiple Choice Test instrument on Newton's Laws material can be used.

INTRODUCTION

Physics is a basic science that deals with the behavior, symptoms, and structures of objects that are scattered in nature [1]. Physics concepts can be understood through the learning process at school. Physics learning is learning that requires students to understand concepts and find the application of these concepts. In accordance with the objectives of learning physics in senior high school according

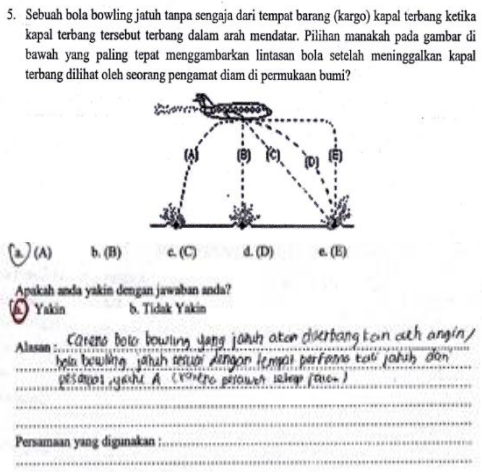
to the Ministry of National Education in 2006 [2], namely that students have the ability to understand the concepts and principles of physics and have the skills to develop knowledge. In learning, students build concepts from the experiences they have at school and in their daily lives [3]. Mufit [4] states that the concept of physics is difficult for students to understand because the concept is abstract and can usually lead to misconceptions. Problems regarding misconceptions can occur when students understand the concept of motion based on their intuition and it is often not according with scientific concepts. In addition, misconceptions can also occur when students have difficulty reading graphs, analyzing problems and applying them to equations.

Preliminary research was conducted to find out basic problems regarding students' conceptual understanding in schools. In this preliminary research a concept test was given to 91 students in class X consisting of 31 people at SMAN A, 26 people at SMAN B and 34 people at SMAN C. As for SMAN A, B, and C are representatives of schools with high categories, medium category and low category based on the results of the National Examination [5]. The concept test is carried out using the Force Concept Inventory(FCI) test instrument which is accompanied by a student's confidence level (two-tier multiple choice) and open reasons to find out the student's reasons. The FCI is a multiple choice test instrument to determine students' understanding of concepts related to Newtonian mechanics, namely force. The FCI instrument consists of 30 multiple choice questions developed by Hestenes, Wells and Smackhamer which have been tested for validity and reliability [6]. However, for the initial data, only 5 FCI questions and 5 calculation questions were selected to find out whether the students understood the concept or just memorized physics formulas / equations. Based on the results of the tests that have been carried out, only a few students understand the concept and there are still students who do not understand the concept. However, most students experience misconceptions. The data obtained from the analysis of students' conceptual understanding can be seen in Table 1.

Table 1. Data from the Analysis of Students' Concept Understanding

School Code	Concept Understanding		
	No Understand	Misconception	Sure Understand
SMAN A	16.1%	79.4%	4.5%
SMAN B	13.1%	83.8%	3.1%
SMAN C	5.9%	93.5%	0.6%

Students experience more misconceptions, namely more than 50% of students. Meanwhile, only a few students understood the concept, ranging from 0% to 5%. In general, students answered the FCI questions incorrectly. In question number 5 regarding the motion of a parabola which asks the shape of the trajectory of a bowling ball that accidentally falls from an airplane flying in a horizontal direction. Figure 1 below is one of the questions tested on students.


5. Sebuah bola bowling jatuh tanpa sengaja dari tempat barang (kargo) kapal terbang ketika kapal terbang tersebut terbang dalam arah mendatar. Pilihan manakah pada gambar di bawah yang paling tepat menggambarkan lintasan bola setelah meninggalkan kapal terbang dilihat oleh seorang pengamat diam di permukaan bumi?

(A) (B) (C) (D) (E)

a. (A) b. (B) c. (C) d. (D) e. (E)

Apakah anda yakin dengan jawaban anda?

a. Yakin b. Tidak Yakin

Alasan : Karena bola bowling yang jatuh akan dipengaruh oleh angin/ bola bowling jatuh sesuai dengan tempat pertama kali jatuh dan gesekan yaitu A (karena searah dengan [illegible])

Persamaan yang digunakan :

Fig 1. *Concept questions and answers given by students*

From the results of the tests tested on these students, most of the students answered them incorrectly. The following is a recapitulation of students' answers to question number 5 which is presented in Table 2.

Table 2. Recapitulation of Student Answers to Problem Number 5

Answer options	A	B	C	D	E
Percentage of answers	40.7%	58.2%	0%	1.1%	0%

Students generally answer B with the reason that every falling object will always have a straight trajectory because it is influenced by gravity. Apart from answering B, some students also answered A on the grounds that the bowling ball that fell was influenced by the air friction force and the wind so that the ball was pushed backwards. Students are wrong in answering but believe that their answer is correct, this is what shows a misconception. Students who answered the correct choice were only 1.1% which indicated that the students had not understood the concept of motion correctly. This is in accordance with Mufit's opinion that students' conceptual understanding of style is very low (≤ 50%) and most students experience misconceptions [7]. Misconceptions generally occur in vertical motion material, horizontal motion, circular motion. In accordance with the research conducted by Artiawati [8] which states that the highest misconception is in the concept of motion, that is if the velocity of an object in constant motion has a large value, then the object's acceleration is also of great value. Students have difficulty solving problems in physics even though they understand the topic being asked. Students also separate concepts and equations, making it difficult to understand physics concepts [7].

In addition to the FCI questions, there are 5 multiple choice questions consisting of numbers that are also tested on students. From the results of the tests conducted, many students answered correctly, especially on questions regarding parabolic motion. This proves that students are only able to use formulas without understanding the real concept. Silviani [9] said that the learning process which is informative and only focuses on textbooks, formulas, and memorization or on theoretical concepts alone can cause students to not master the concept, causing misconceptions. Figure 2 below is the answer of one of the students to the calculation questions given

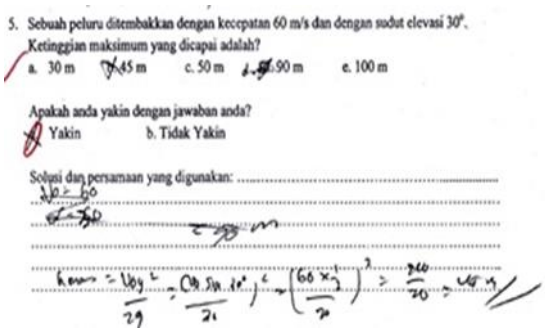


Fig 2. *Calculation questions are given along with students' answers*

In Figure 1 and Figure 2 above, it can be seen that students are still wrong in answering questions about the concept of physics. It can be said that students' understanding of concepts is still low. However, if students are given count questions whose variables are known, the students can answer them correctly. This is proof that students only apply formulas and do not yet understand the concept. In addition to the tests that were tested on students, preliminary research was also carried out on the teacher using an interview guide. This interview activity was carried out with three class X physics teachers in three different schools including SMAN A, SMAN B and SMAN C. Based on the results of these interviews, The teachers in the three schools used more conventional learning models (lecture method) and students were less active in learning, especially in discovering the concepts and principles of physics by themselves. This allows misconceptions in students. Teachers in these three

schools also stated that they had never used a test instrument to detect student misconceptions, so it was rarely known whether students had misconceptions or not.

The factors that cause misconceptions are: students themselves, teachers, teacher teaching methods errors, errors in physics textbooks, context errors, and improper evaluation. According to Mufit, the cause of misconceptions and difficulty in understanding the concept of physics is teacher-centered learning [4]. Not only that, Alhinduan [10] also stated that physics learning activities that interpret physics concepts based on the formulas contained in the book without going through the process of analysis, processing, can cause students to be less able to understand physics concepts well which can trigger misconceptions. Because misconceptions are closely related to the wrong conceptions of students, so to find out whether students have misconceptions or not and to classify the level of conception, students should use a test instrument that is specifically designed to detect misconceptions. Therefore, in this study a four-tier multiple choice test instrument was developed.

This instrument is an instrument in the form of questions consisting of four levels (tier). At the first level, it contains the questions that were tested on students. The second level contains the level of student confidence in the questions at the first level. The third level contains the reasons related to the questions and the fourth level contains the level of students' confidence regarding the reasons at the third level. This test instrument has several advantages including that it can be applied to a large number of subjects, more efficient use of time, does not require a long time to correct and is objective and can assess student misconceptions such as not understanding concepts or not understanding concepts at all. However, the Four-Tier Multiple Choice Test instrument has not been widely used in schools to determine students' understanding of concepts.

METHOD

This type of research is design research. In this study, the product produced was a Four-tier Multiple Choice Test instrument. The research model used is the Plomp development model. This model consists of three stages, namely preliminary research, development or prototyping phase,and assessment phase. However, this research is only limited to the prototyping phase. The preliminary research stage consists of two steps, namely a needs analysis and reviewing the literature. This stage is carried out so that the basic problems experienced by students in learning can be identified. The data collection instruments used at this stage were interview guides and student concept tests. The data analysis used was descriptive analysis for the interview guide and for the students' concept test using coding techniques. Furthermore, the development/prototyping phase. This phase consists of two steps, namely the prototype design and formative evaluation which is carried out to test the validity of the prototype. At this stage, data collection was carried out using a self-evaluation sheet and a product validation sheet. The data analysis technique used is descriptive analysis for the self-evaluation sheet and V Aiken's formula for the product validation sheet. The V Aiken's formula is used to calculate the content validity of a product based on the results of the expert's assessment. The formula proposed by Aiken is as follows.

$$V = \frac{\sum S}{[n(c-1)]} \quad (1)$$

$$S = r - lo \quad (2)$$

Information :
lo = the lowest score of the validity assessment
c = the highest score of validity assessment
r = score given by the validator

The interpretation of the results using the V Aiken's formula is between the values of 0 to 1. The V Aikens index is presented in Table 3.

Table 3. Interpretation of the Results of Formula V Aikens

Indeks V Aikens	Category
V < 0,4	Less Valid
0,4 < V < 0,8	Valid
V > 0,8	Very Valid

The prototype of the instrument that has been declared valid by the experts is then carried out with a field test on the instrument. The four-tier multiple choice instrument, Newton's Law material was tested on 21 SMAN A students. Furthermore, the field test results were analyzed to determine the reliability, item validity and instrument difficulty index. The reliability of the test was analyzed using the KR-20 formula.

$$r_{11} = \left(\frac{n}{n-1}\right)\left(\frac{S^2-\sum pq}{S^2}\right) \quad (3)$$

information:
r_{11}: overall test reliability
p: the proportion of subjects who answered correctly
q: the proportion of subjects who answered incorrectly
∑pq: the sum of the product between p and q
N: many items
S^2: standard deviation from the test

If the reliability value has been obtained, it can be interpreted in the Table 4.

Table 4. Interpretation of Reliability Values [11]

Coefficient IntervalRelationship Level	
0.0 - 0.20	Very low
0.20 - 0.40	Low
0.40 - 0.60	Moderate
0.60 - 0.80	High
0.80 - 1.0	Very high

The validity of the four-tier multiple choice instrument items of Newton's law material was analyzed using the Point Biserial Correlation Coefficient formula, namely

$$r = \frac{(M_1-M_2)}{S_n}\sqrt{\frac{n_1 n_2}{n^2}}(3) \quad (4)$$

information:
M_1: Mean of continuous variable for group1
M_2: Mean of continuous variable for group2
n_1: data points in group1
n_2: data points in group2
S_n: Standard deviation of continuous variable

Interpretation of item validity data can be seen in Table 5.

Table 5. Interpretation of Item Validity Data [12]

Criteria	Category
$r_{count} > r_{table}$	Valid
$r_{count} > r_{table}$	Invalid

Furthermore, the instrument difficulty index is analyzed using the equation:

$$P = \frac{B}{Js} \quad (4)$$

information:
P: difficulty index
B: participants who got the item correct
Js: the total number of participants who gav the answer

Interpretation of the instrument difficulty index can be seen in Table 6.

Tabel 6. Interpretation of the Instrument Difficulty Index [12]

Difficulty Index (P)	Classification
0,00 – 0,30	Hard
0,31 – 0,70	Moderate
0,71 – 1,00	Easy

RESULTS AND DISCUSSIONS

Based on the research that has been carried out, two research results were obtained as follows.
Results of Preliminary Research
1. Needs Analysis Results
First, the initial study conducted on teachers in the form of interview activities. From the results of the interviews with the three teachers, the results obtained are: (1) learning in schools is still conventional, namely using the lecture method so that learning is centered on the teacher, (2) The teacher has never used an instrument to determine students' conceptual understanding. The teacher only tests students for the attainment of cognitive aspects, (3) Generally students experience misconceptions on the material of force and motion, rotational dynamics, and simple harmonic vibrations. Misconceptions occur because of low understanding of concepts. In addition, in teaching learning the teacher still uses a conventional model (lecture method). Students only receive information and concepts from the teacher's explanation so that students are not active in the learning process and do not build physics concepts based on their own experiences. The results of teacher-centered learning make students do not understand the concept and are only interested in memorizing formulas [13].Syuhendri stated that everyone can experience misconceptions in all physics concepts [14]. If more and more misconceptions are experienced, it will be very difficult to lead to the correct concept. Research conducted by Pratiwi shows that misconceptions are experienced by students in Newton's Law material [15]. The highest misconception occurs in the concept of reaction action on objects. Students experience misconceptions in these concepts because students tend to think that objects of the same type and direction work an action-reaction force.

Second, the initial study was conducted on students. The results obtained from the student concept test analysis included: (1) More than 50% of students who experienced misconceptions at SMAN A, SMAN B, and SMAN C. Even though the material related to the questions given had been studied by students before, (2) Students experience misconceptions in almost every question tested, (3) There are still students who do not understand the material related to the questions tested, (4) Students generally only apply the existing formula without understanding the concept behind the formula. This is proven by the results of the students' correct in answers the calculate questions but incorrectly in answering concept questions. In physics learning, students are required to be able to understand the concepts and meanings of these concepts [16]. Concepts in physics are related to one another, so that each student must understand and relate the relationship between concepts. If students misunderstand the relationship between concepts, it can lead to misconceptions [17].

2. Results of Literature Review
Based on the problems obtained from the results of the needs analysis that learning in schools is still

conventional so that teacher-centered learning, there are still students who experience misconceptions and do not understand the concept, there are no teachers who use instruments to identified students' conceptual understanding. which is presented is designing a four-tier multiple choice test instrument that is able to find out students' understanding of concepts. Therefore, a study was conducted on students' understanding of concepts, causes of misconceptions, and a four-tier multiple choice test instrument. The results of preliminary studies that have been conducted show that learning in schools still uses a conventional model, so that learning is not centered on students but on teachers. Students only accept the concepts described by the teacher without experiencing the concept themselves. According to Mufit, teacher-centered learning means that learning is dominated by teachers, while students do not actively participate in constructing physics concepts, one of which is the concept of motion [4]. This teacher-dominated learning causes students not to be independent in learning. This causes the emergence of misconception problems and low understanding of students' concepts in learning. Suparno [18] also states that the learning model using the teacher-centered lecture method and does not involve students in concept discovery tends to lead to misconceptions.Various test instruments have been developed by researchers, including instruments for understanding students' conceptual understanding and detecting misconceptions experienced by students. However, it is still rare to find the use of this instrument in schools. The instrument that can be used to detect students' understanding of concepts is the four-tier multiple choice test. In this study, a four-level test instrument was developed consisting of questions, student confidence levels and reasons. The four-tier multiple choice test was developed from a three-tier multiple choice test instrument with semi-closed answer options. This means that the development of this four-level test instrument is found in increasing the level of students' confidence in reasons at the third level [19]. Zulfikar [20] stated that this four-tier multiple choice instrument can be used to determine the level of understanding of students' concepts. This instrument is better able to detect misconceptions experienced by students and to know the level of understanding of students' concepts when compared to other instruments.

Results of the Prototyping Phase

1. Prototype Design

The prototype is designed based on the results of the analysis at the preliminary research stage, namely through needs analysis and literature review. In this study, the resulting product was a four-tier multiple choice test instrument to determine students' understanding of physics concepts. The activities carried out include: (a) creating a questiongrids that are adjusted to KD 3.7, (b) compiling instructions for solving questions, (c) compiling four-tier multiple choice test developed from FCI questions and then adjusting them to KD 3.7 so that 14 items were obtained. The questions were developed from a two-tier FCI with open-ended reasons, (d) prepare answer sheets, (e) create answer keys, (f) make scoring guidelines, and (g) create guidelines for interpreting the results.

2. Formative Evaluation and Prototype Revision

a. Self Evaluation Results

Self evaluationis an evaluation conducted to check the completeness of the product made by the researcher. This self-evaluation stage is carried out before the product is validated by experts. The format for this self-evaluation is a checklist (√). The instrument already contains a question grid, instructions for solving questions, four-tier multiple choice questions, answer sheets, answer keys, scoring guidelines and results interpretation guidelines. The display of the test instruments has also been made attractive. However, there are some errors in the use of language, typing letters and punctuation that have been corrected. Indicators are already using operational verbs. The use of writing fonts on the instrument is too monotonous, which has been fixed. The display color composition on the instrument looks contrasting.

b. Results of the Validity Test by Experts (Expert Review)

The validation of the test instruments was carried out by 3 experts who were physics lecturers of FMIPA UNP.Revision of the product and determination of product feasibility based on the results of the validation. The suggestions and improvements given by the validator are shown in Table 7.

Table 7. Suggestions and improvements from the validator

Validator	Suggestion
Validator 1	a. In question number 2, explain after the collision whether the two vehicles were stationary or moving b. In question number 8, also explain whether the ball reached the hand or hit the ground c. In problem number 14, it is not explained whether the motion is in the same direction or the opposite
Validator 2	-
Validator 3	a. There is still a need for improvement in the suitability of the indicators for competency achievement b. Editorial sentences such as translation results, need improvement on several questions

The following are the results of the improvements according to suggestions and corrections from the validator.

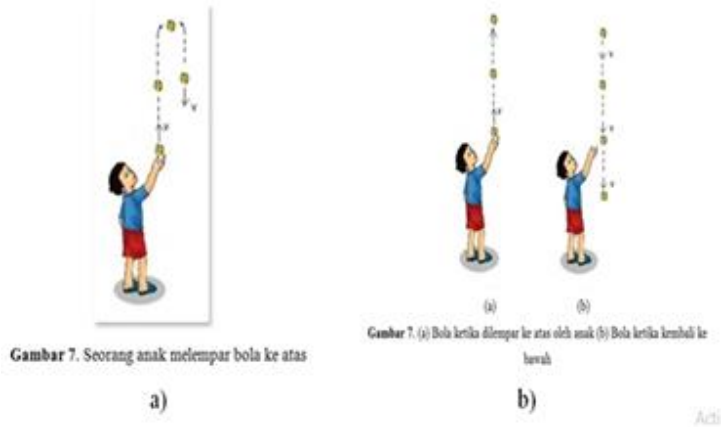


Fig 3. *(a) before revision, (b) after revision*

From the results of the validity test carried out, the data were presented in two forms, namely the results of validity based on indicators of competency achievement and item questions so that later they could be used to determine students' conceptual understanding. The results of the validity analysis based on the competency attainment indicators show that the resulting test instruments are in the valid category. The product validation instrument consists of four aspects, namely the validity aspect of the Four-tier Multiple Choice Test instrument, the content / material aspect, the construction aspect, and the language aspect. Each aspect of the validation instrument consists of several indicators. The results of the instrument validity test can be seen in Table 8.

In the aspect of validity level, the four-tier multiple choice test instrument contains indicators related to the characteristics of the four-tier test instrument. One of its characteristics is that it can validly measure misconceptions that are free from error and lack of knowledge [3]. In addition, the questions on the test can identify students' conceptions and the reason options presented can reveal the causes of student misconceptions. In the aspect of content feasibility, the product is said to be valid because the product is arranged according to the learning indicators and in accordance with the material being studied by students at school. This is in accordance with Guswina and Mufit [21] which states that the feasibility aspect of the content is in the valid category because it contains questions that are in accordance with the indicators of competency achievement, according to the material taught in SMA, contains composition of use in life and the questions and answers contain only one correct answer. Furthermore, in the construction aspect, the product is categorized as valid because the formulation of the main questions on the product is in accordance with the criteria for good multiple choice questions such as the subject matter does not provide clues to the correct answer. In the language aspect, the

four-tier multiple choice test instrument is classified as valid because it is arranged according to Indonesian principles.

Table 8. Instrument Validity Test Results

No. Question	Assessment Aspects			
	Instrument Validity	Contents	Construct	Language
1	0.65	0.62	0.66	0.79
2	0.56	0.46	0.65	0.58
3	0.65	0.54	0.71	0.77
4	0.68	0.51	0.71	0.67
5	0.63	0.57	0.63	0.75
6	0.71	0.57	0.60	0.67
7	0.69	0.64	0.65	0.75
8	0.77	0.71	0.68	0.71
9	0.79	0.64	0.70	0.75
10	0.75	0.62	0.67	0.67
11	0.77	0.70	0.72	0.73
12	0.77	0.73	0.70	0.77
13	0.77	0.74	0.71	0.69
14	0.65	0.62	0.62	0.65

c. Field Test Results

Field test includes reliability test, item validity and difficulty index. Reliability test is done by testing the questions to students. Reliability test is used to find out how precisely the measuring instrument will be used to measure students' understanding of concepts. A reliable instrument is an instrument that when used several times to measure the same object will produce the same data [22]. Based on the results of the reliability test using the KR-20 formula, the results obtained were 0.90 in the very high category. Thus it can be said that each item is reliable. Analysis of the level of difficulty and item validity can be seen in Table 9.

Table 9. Analyze the Level of Difficulty and Validity of the Items

No. Question	Difficulty level	Category	Validity	Category	Information
1	0.62	Moderate	0.80	Very high	Can be used
2	0.67	Moderate	0.84	Very high	Can be used
3	0.86	Easy	0.57	Enough	Can be used
4	0.86	Easy	0.50	Enough	Can be used
5	0.62	Moderate	0.76	High	Can be used
6	0.71	Easy	0.76	High	Can be used
7	0.52	Moderate	0.64	High	Can be used
8	0.48	Moderate	0.88	Very high	Can be used
9	0.29	Hard	0.00	Very low	Needs Improvement
10	0.29	Hard	-0.05	Very low	Needs Improvement
11	0.57	Moderate	0.79	High	Can be used
12	0.52	Moderate	0.89	Very high	Can be used
13	0.57	Moderate	0.81	Very high	Can be used
14	0.62	Moderate	0.85	Very high	Can be used

From Table 9 above, it can be seen that for the difficulty level of the questions, there are 3 questions in the easy category, 9 questions in the medium category and 2 questions in the difficult category. Furthermore, for the validity of the questions, there were 2 questions in the very low category, 2 questions in the sufficient category, 4 questions in the high category, and 6 questions in the very high category. From these results, it can be concluded that there are 12 items that can be used and 2 questions that need to be corrected because the validity value is in the very low category.

CONCLUSION AND SUGGESTION

Based on the preliminary research, it was found that there was a misconception in Newton's Law material about motion, meanwhile, at school there were no test instruments available to detect students' conceptual understanding of the material. At the development stage, a four-tier multiple choice instrument was designed on the Newton law material, totaling 14 items, according to the test grid. The results of the self-evaluation test showed that the instrument prototype was complete. The results of the expert review showed that the instrument prototype was valid in the aspects of content validity, construct validity and language validity. The instrument reliability test results obtained a value of 0.90 with the very high reliability category. The results of the item validity test and the difficulty index obtained 12 items of four tier multiple choice instruments that can be used. Therefore, a four-level multiple choice instrument on Newton's Law material can be used by teachers in schools to identify the conceptual understanding of high school students.

REFERENCES

[1] Giancoli, D. C. (2001). *Fisika Dasar Jilid 1*. Jakarta: Erlangga.
[2] Depdiknas. (2006). *Kurikulum Tingkat Satuan Pendidikan (KTSP)*. Jakarta: Depdiknas.
[3] Gurel, D. E. R. Y. A., Eryilmaz, A., & McDermott, L. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics Science and Technology Education*, *11*(5).
[4] Mufit, F., & Fauzan, A. (2019, October). The application of real experiments video analysis in the CCBL model to remediate the misconceptions about motion's concept. In *Journal of Physics: Conference Series* (Vol. 1317, No. 1, p. 012156). IOP Publishing.
[5] Puspendik. (2019). *Laporan Hasil Ujian Nasional. Kementerian Pendidikan dan Kebudayaan*,
[6] Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The physics teacher*, *30*(3): 141-158.
[7] Mufit, F. (2019). A study about understanding the concept of force and attitude towards learning physics on first-year students in the course of general physics; As preliminary investigation in development research.
[8] Artiawati, P. R., Mulyani, R., & Kurniawan, Y. (2016). Identifikasi Kuantitas Siswa Yang Miskonsepsi Menggunakan Three Tier-Test Pada Materi Gerak Lurus Beraturan (GLB). *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *1*(1): 13-15.
[9] Silviani, R., Muliyani, R., & Kurniawan, Y. (2017). Penerapan Three Tier-Test untuk Identifikasi Kuantitas Siswa yang Miskonsepsi pada Materi Magnet. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *2*(1): 10-11.
[10] Alhinduan, S. R., Kurniawan, Y., & Mulyani, R. (2016). Identifikasi kuantitas siswa yang miskonsepsi menggunakan three tier-test pada materi listrik dinamis. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *1*(1): 29-31.
[11] Arikunto, S. (2013). *Prosedur Penelitian Suatu Pendekatan Praktik Edisi Revisi*. Jakarta: Rineka Cipta.
[12] Arikunto, S. (2009). *Dasar-dasar Evaluasi Pendidikan*. Jakarta: Bumi Aksara.
[13] Mufit, F., Hanum, S. A., & Fadhilah, A. (2020, March). Preliminary research in the development of physics teaching materials that integrate new literacy and disaster literacy. In *Journal of Physics: Conference Series* (Vol. 1481, No. 1, p. 012041). IOP Publishing.
[14] Aprilia, S., Syuhendri, S., & Andriani, N. (2015). Analisis pemahaman konsep mahasiswa Program Studi Pendidikan Fisika pada pokok bahasan gerak harmonik sederhana.
[15] Pratiwi, A. D. Analisis Miskonsepsi Pada Konsep Hukum-Hukum Newton Tentang Gerak. *JURNAL Analisis Miskonsepsi Pada Konsep Hukum-Hukum Newton Tentang Gerak*.
[16] Mahmudah. (2014). *Analisis Tingkat Pemahaman Peserta Didik pada Materi Alat-alat Optik Menggunakan Teori APOS*. Semarang.
[17] Iriyanti, N. P., Mulyani, S., Ariani, D., & Retno, S. Identifikasi Miskonsepsi Pada Materi Pokok

Wujud Zat Siswa Kelas VII SMP Negeri 1 Bawang Tahun Ajaran 2009/2010. *Jurnal Pendidikan Kimia Universitas Sebelas Maret, 1*(1): 127709.

[18] Suparno, P. (2013). *Miskonsepsi dan Perubahan Konsep dalam Pendidikan Fisika*. Jakarta: Gramedia Widiasarana Indonesia.

[19] Ismail, I. I., Samsudin, A., Suhendi, E., & Kaniawati, I. (2015). Diagnostik miskonsepsi melalui listrik dinamis four tier test. *Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains*, *3*(1): 381-384.

[20] Zulfikar, A., Samsudin, A., & Saepuzaman, D. (2017). Pengembangan terbatas tes diagnostik force concept inventory berformat four-tier test. *Jurnal Wahana Pendidikan Fisika*, *2*(1): 43-49.

[21] Guswina, S., & Mufit, F. (2020). Desain Four-Tier Multiple Choice Test pada Materi Getaran Harmonis untuk Mengidentifikasi Pemahaman Konsep Siswa Kelas X SMA/MA. *Jurnal Penelitian Pembelajaran Fisika*, *6*(2).

[22] Sugiyono. (2012). *Metode Penelitian Kuantitatif Kualitatif dan R&D (17th ed.)*. Bandung: Alfabeta.