Analysis of Prospective Physics Teacher's Misconceptions on Interference Material using Certainty of Response Index (CRI)

Andhiani Eka Kusumawati*, Wulan Anggraini, & Bayu Setiaji
Physics Education Study Program, Yogyakarta State University
*Email: andhianieka.2020@student.uny.ac.id

Received: 15 June 2022; **Accepted**: 28 June 2022; **Published**: 29 June 2022
DOI: http://dx.doi.org/10.29303/jpft.v8i1.3679

Abstract *- The purpose of this research is to find out the occurrence of misconceptions in students regarding the concept of light interference and to find out the causes of these misconceptions. The research was conducted in the form of a three-tier multiple-choice test and analyzed using the Certain of Response Index (CRI) method which will be a benchmark in the level of confidence in answering a question. The research was conducted on 21 undergraduate students of UNY Physics with light interference material. From this study, it was shown that the level of conceptual understanding of undergraduate students in Physics at UNY on light interference was included in the category of not understanding concepts at 46.91%, understanding concepts at 36.12%, and misconceptions at 17.07%. The results of the level of misconceptions obtained are low. This is caused by a conceptual error that is owned by students and the application of concepts that do not match the statements given.*

Keywords*: Interference; misconception; Certainty of Response Index (CRI).*

INTRODUCTION

The pandemic situation began in 2020 and has had both positive and negative impacts. The pattern of activities regulated during the pandemic is now gradually becoming normal as usual. In this new normal period, people live by carrying out activities as usual even though they are still sided by side with the covid-19 virus. All sectors of life have also begun to reorganize their activities, one of which is the education sector.

In this *new normal period*, several high school education levels and below have been carrying out face-to-face learning by implementing strict health protocols. In addition, there are still several schools and universities whose learning is still carried out online. For about two years undergoing online learning, has had a positive and negative impact on students, both students, and college students.

Online learning can potentially lead to misconceptions in students, one of which is physics. (Azzarkasyi, 2020). The online learning process is carried out by providing brief material by the educator, then the students themselves add and complete their material notes using the internet or other modules. This learning has a positive side, namely students can learn independently. This also has a negative impact, namely the potential for misconceptions or misunderstandings in interpreting concepts based on information obtained through the various media used. According to Suparno (2005), a misconception or a wrong concept is a discrepancy between the concepts that are owned or understood with concepts based on scientific understanding or understanding accepted by experts in that field. Misconceptions in students can be caused by several factors, such as early preconceptions, abilities, stages of development, interests, ways of thinking, and other friends (Suparno, 2005). This shows that the misconception is also caused by the influence of other friends where the explanation of the concept given by the friend is also not scientifically appropriate.

The closing of educational institutions and the implementation of online learning systems also have an impact on the success rate of students, in addition to misconceptions, there are also impacts such as learning loss which is a good condition that a small part or most of the achievement of learning outcomes is lost due to disruption of the learning process in education (Haryati, 2022). Disruption of the learning process can result in decreased interest and motivation to learn.

Physics is one part of the Natural Sciences which studies how various phenomena or natural phenomena occur in everyday life and knows the interactions in them so that the universe can be formed. Physics is not only related to theories and formulas but there are also important concepts to learn. This concept forms the basis for a deeper and broader study of physics. Thus, in learning physics, more emphasis is placed on mastery or understanding of concepts. Embedded concepts must be per scientific physics concepts (Sheftyawan et al., 2018) that are, based on valid research results that have been tested by previous experts. The concepts of physics are used by experts, one of which is to study phenomena that occur in physical nature. The causes, processes, and effects of phenomena that occur can be known or even predicted through the application of appropriate physical concepts. Therefore, it is important to have an understanding of concepts in studying physics to understand the phenomena that occur in nature.

Based on previous research, conceptual errors have been found in some physics materials. Research conducted by Saputri (2015) states that there are still students who have a wrong understanding (misconception) of geometric optical concepts caused by preconceptions, wrong intuition, associative and humanistic thinking, and incomplete *reasoning.*

The purpose of preconception is the initial conception that is had before following a lesson, then false intuition is a feeling in a person that comes from observing events continuously, associative thinking is a relationship between two or more things, such as associating concepts or terms that can lead to misconceptions. While humanistic, which is looking at objects with a human view, and incomplete reasoning, which comes from incomplete information, so when concluding, misconceptions can occur (Suparno, 2005). Misconceptions that occur can be one of the causes of low learning outcomes. Students' understanding of how the concept of a physical phenomenon occurs then explains how its physical meaning still tends to be low. According to M. Taufiq (2012), in physics lectures, it was found that the concept mastery of prospective physics teacher students in the concept of force was still low. This happens even though students can remember facts, processes, principles, and formulas.

The same thing can happen to the concept of physical optics. Physical optics is a part of classical optics which studies interference, diffraction, dispersion, and polarization events that occur in light (Sujana, 2014). Without realizing it in the environment around us, there are several phenomena or natural phenomena from physical optics, one of which is the concept of interference. Interference phenomena can be seen in soap bubbles, oil on the water surface, film coatings, anti-reflective coatings, and color patches on the road. How the interference process occurs, either in a narrow slit, a thin layer, or newton's ring, can be understood from the physical concept of interference. The interference phenomenon has been studied by scientists to produce an

interference concept that is easy to learn and understand. But in fact, sometimes the reasons given by students to explain the concept are not appropriate or even inappropriate.

This inaccurate or inappropriate concept can indicate the occurrence of misconceptions. Physics misconceptions can be expressed as students' physics concepts that do not match the simplified physicists' concepts, can only be accepted in certain cases and do not apply to other cases, cannot be generalized, and do not show the relationship between physics concepts (Pebriyanti *et al. al.* 2015). Then according to Hakim (2012) states that one indicator of the occurrence of misconceptions is that the answers given by students are correct but students are unable to explain the right reasons for answering and are accompanied by high confidence in the truth of the answers submitted. Apart from that, students' understanding of concepts is in the category of understanding concepts or not knowing concepts.

Misconceptions that occur in students can result in delays in mastering the next material. Therefore, it is very important to know whether the concepts embedded in students are scientifically appropriate or not. In addition, it is necessary to know the causes of these misconceptions so that the right way to overcome these misconceptions can be found. Based on the explanation that has been described, the researcher will conduct research that aims to find out the students' misconceptions about the physical optical concept of interference material and the causes of misconceptions in students related to the physical optical concept of interference material.

RESEARCH METHODS

The method used in this research is *the Certain of Response Index (CRI)*. This method is used to distinguish subjects/respondents who have misconceptions and those who do not understand or do not know the concept. This method was developed by Saleem Hasan, Dion Bagayoko, and Ella L. Kelley. According to Saleem Hasan, CRI is a measure of the respondent's level of confidence in answering the questions given.

The purpose of this study is to determine the percentage of misconceptions in physics teacher candidates regarding the concept of interference material and to find out what causes these misconceptions to occur. The subjects in this study were prospective physics teachers who have obtained material on interference in the physical optics course. The instrument used is in the form of a questionnaire containing eight true or false choices, accompanied by reasons and an index of respondents' confidence in answering the questions.

The indicators used to identify the conceptual understanding of prospective physics teachers are four indicators. Each indicator has three kinds of statements that are used as questions. Question numbers 1 - 3 are indicators explaining the conditions for interference, question numbers 4 - 6 are indicators explaining interference between two narrow slits, question numbers 7 - 9 are indicators explaining the occurrence of interference in thin layers, and question numbers 10 - 12 are indicators explaining interference. on Newton's rings.

The time for working on the questions on the questionnaire was divided into four groups, which means that several respondents worked on the questionnaire at a certain time. There are two kinds of Angel which contain eight questions. Every two items include one indicator. The selection of two questions from the three questions

provided was done *randomly*. Each group of questions is given one questionnaire between the two questionnaires that have been made.

The time for answering questions in each batch is limited to 45 minutes. Data collection was carried out online with 21 prospective physics teacher respondents who would fill out a questionnaire on a *Google Form* distributed via *WhatsApp*.

The data obtained were then analyzed according to the misconception analysis from CRI, to determine the level of respondents' confidence in answering each question from the questions given. A low CRI level indicates a lack of confidence in the concept that is known by the respondent in answering a question, while a high CRI level indicates a belief and certainty in a concept known by the respondent. CRI was developed using a scale of six, namely from a scale of 0 to a scale of 5, as shown in the following table.

Table 1. CRI and its Criteria

No.	CRI	Criteria
1.	0	*(Totally guessed answer)*
2.	1	*(Almost guessed)*
3.	2	*(Not sure)*
4.	3	*(Sure)*
5.	4	*(Almost certain)*
6.	5	*(Certain)*

Some provisions apply to distinguish individual respondents' answers between those who know the concept, misconceptions, and do not know the concept, as follows.

Table 2. CRI Analysis Based on Answer Criteria

Answer Criteria	Low CRI (CRI < 2,5)	High CRI (CRI > 2,5)
Correct answer	Correct answer but low CRI **don't know the concept (*lucky guess*)**	Correct answer and high CRI **master the concept well**
Wrong answer	Wrong answer and low CRI **don't know concept**	Wrong answer but high CRI **misconception occurs**

Based on the table above, if the answer is correct but the CRI level is low, it means that the respondent does not know the concept (*lucky guess*). If the respondent's answer is correct and the CRI level is high, it means that the respondent has mastered the concept. If the answer is wrong and shows a low CRI level, it means that the respondent does not know the concept. If the answer is wrong but the CRI level is high, it means that there is a misconception in the respondent. Furthermore, with these results, the percentage calculation of each of these criteria is carried out using the following formula,

$$\text{Percentage x} = \frac{x}{N} \times 100\%$$

$$\text{Percentage y} = \frac{y}{N} \times 100\%$$

$$\text{Percentage z} = \frac{z}{N} \times 100\%$$

Description:

x = Number of respondents who do not know the concept

y = Number of respondents who do not know the concept

z= Number of respondents who have misconceptions

N= Total number respondents

After calculating the data obtained, the results will be analyzed descriptively on each of the sub-concepts that have been determined. By adding up the percentage of respondents who know the concept and do not know the concept of each sub-concept based on the confidence of the respondents' answers to each question. Meanwhile, the respondents who experience misconceptions will be interviewed to find out whether there

are misconceptions and what are the causes of these misconceptions.

RESULTS AND DISCUSSION

Results

Based on the results of data analysis using CRI, it is known that the understanding of the concept of prospective physics teachers on interference material has a low level of misconception, namely 17.07% with 46.91% not understanding the concept and 36.12% understanding the concept. The low results of misconceptions indicate that the concepts that prospective physics teachers apply in solving problems are not following existing scientific concepts.

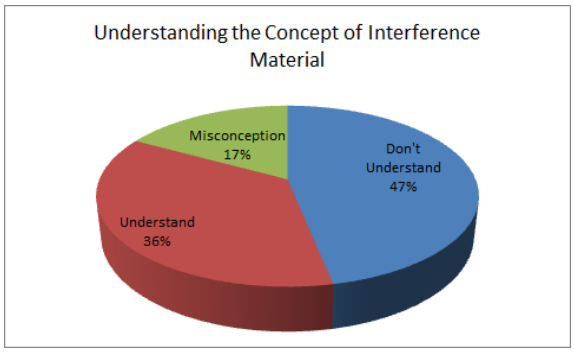

Figure 1. Understand the concept of interference

On the other hand, the category of not understanding the concept shows the highest number. The high category of not understanding is because prospective physics teachers are not prepared when they are going to work on questions so they forget some explanations about this interference material because this material was studied at the beginning of the physical optics material. This also causes prospective physics teachers to hesitate in answering even though their answers are correct.

Discussion

Understanding the concept of interference material in detail is grouped into four indicators, namely explaining the conditions for interference, explaining interference from two narrow slits, explaining the occurrence of interference in thin layers, and explaining the occurrence of interference in Newton's rings. The percentage of concept understanding in each indicator can be seen in Figure 2 below. The highest misconception is found in indicator one, which explains the conditions for interference. This happened because of a conceptual error that was understood by the prospective physics teacher regarding phase, frequency, and amplitude. Students are also wrong in applying the concept in a statement even though the concept built by the prospective physics teacher is correct. In addition, the results of misconceptions on other indicators show almost the same results and are classified as low, ranging from 9% - 11%.

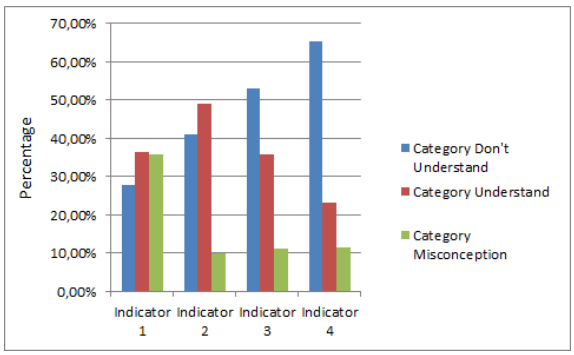

Figure 2. Percentage of concept understanding category in each interference indicator

On the other hand, the highest percentage was obtained in the category of not understanding the concept, precisely on indicator four of 65.24% which explained the concept of the occurrence of newton's rings. This is indicated by the reasons put forward by the prospective physics teacher which are not correct regarding the things that affect the process of forming newton's rings even though the answer chosen by the prospective physics teacher is correct. In

addition, prospective physics teachers have a good level of conceptual understanding in the second indicator with a percentage of 49.05%, namely the ability to explain the occurrence of interference in two narrow gaps.

Understanding Concepts on Each Item

Based on the results of the data that has been obtained after analyzing the answers from respondents of as many as 21 prospective physics teachers, it can be seen that the level or category of understanding between prospective physics teachers will vary, both in indicators or beliefs of each prospective physics teacher answering the questions. which are given. In addition, it is also accompanied by percentage data in each category of not understanding concepts, understanding concepts, and misconceptions contained in the 12 questions.

The results of the data obtained from research conducted on the category of misconceptions that get the highest percentage value are contained in item number one, namely 70.00%. Question number one is part of the indicator that explains the occurrence of interference with the concept discussed regarding the phase size contained in two light waves as a condition for interference to occur in these waves.

Meanwhile, questions number four, seven, nine, and twelve show the smallest percentage value with no misconceptions about the concept questions given. In question number four, the prospective physics teacher who understands the concept of the difference in wave mileage is quite high with a percentage of 60.00%. Then questions number seven, nine, and twelve with prospective physics teachers whose level of not understanding the concept is quite high with the percentages being 60.00%, 80.00%, and 70.00%, respectively. Details of the percentage of concept understanding in each item can be seen in Figure 3 below.

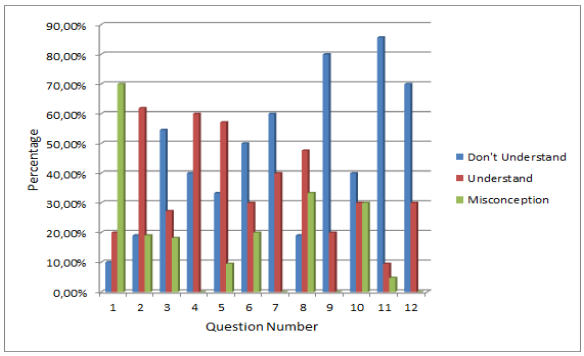

Figure 3. Percentage of concept understanding, in each item

Concept Understanding on Each Indicator

Indicators explain the conditions for interference of the total percentage of prospective physics teachers who work on the questions on this indicator, each item has a different category level. The indicator explains the conditions for this interference to have three questions. The first question has the highest misconception category among other questions, which is 70.00%. The second question has a misconception category which is almost the same as the third question, namely 19.05% and 18.18%. The second question also has the highest concept understanding category with a percentage of 61.90%. While the third question has the highest category of not understanding the concept at 54.55%. This shows that each question has a different category.

Students who experience misconceptions about this indicator are due to errors in applying the concept of prospective physics teachers to the large concept of phase and frequency. In addition, prospective physics teachers tend to only memorize the concept of the conditions for the occurrence of the interference. This causes when the questions are made differently, it will make the prospective physics teacher confused in answering. This

is shown in the reasons stated by the prospective physics teacher that are less specific in the discussion in question, but the statement put forward is the correct concept.

Apart from that, the understanding of the concept of prospective physics teachers is quite good on the second question relating to the terms of frequency and amplitude conditions in the process of interference. Although in this question there are still misconceptions that are classified as low at 19.05%. The lowest misconception is in the third question of 18.18%. This misconception is caused because the prospective physics teacher is not precise in understanding the relationship between the concept of phase difference with the conditions of frequency and amplitude in the process of destructive interference. Details of the percentage level of concept understanding of prospective physics teachers on this indicator are shown in Figure 4 below.

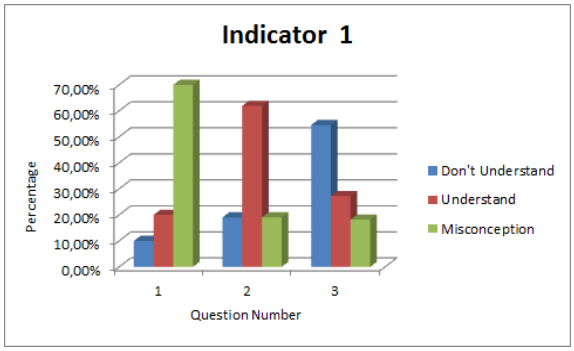

Figure 4. The percentage of understanding of the concept on the indicator explains the conditions for the occurrence of Interference

The indicator describes the interference of two narrow slits from the total percentage of prospective physics teachers who work on the questions on this indicator, each item shows a fairly good understanding of the concept. The indicator explains the interference requirements of two narrow slits and has three questions. The first question has the highest concept understanding category among other questions, which is 60.00%. The second question has a concept understanding category with a percentage of 57.14%. The third question has the highest category of not understanding the concept at 50.00%. This shows that almost all prospective physics teachers have understood the concept of this indicator, although there are still prospective physics teachers who do not understand the concept and experience the highest misconception with a percentage of only 20.00%. Students who experience misconceptions on this indicator can be due to lack of understanding of the concept of the distance between dark and light patterns so that they are wrong in giving answers and when writing down the reasons for the answers which shows the confusion of prospective physics teachers in the concept. Details of understanding the concept of this indicator are presented in Figure 5 below.

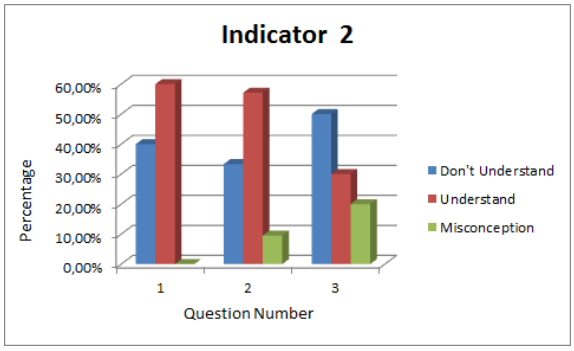

Figure 5. The percentage of understanding of the concept on the indicator explains the interference of two narrow gaps

The indicator describes the occurrence of interference in the thin layer from the total percentage of prospective physics teachers who work on the questions on this indicator, each item has a minimal level of misconception. The indicator explains the occurrence of interference in the thin layer and has three questions. The highest misconception is found in question number two, namely the application of the concept of interference to the physical phenomenon of soap bubbles and oil with a percentage of

33.33%. The high percentage is due to a mismatch in the application of the concepts of reflection and refraction involved in thin layer interference. The concept that the prospective physics teacher has regarding reflection and refraction itself is correct, but the prospective physics teacher is not quite right in connecting the explanation of reflection and refraction with the occurrence of interference in existing physical phenomena. In addition, in other questions there are no misconceptions or the percentage is 0%.

In addition to misconceptions, the highest category in the third indicator is question number three with a percentage of 80.00%. These results are caused because the prospective physics teacher does not understand the concept of different wavelengths and there is no preparation for learning before taking the test. In addition, prospective physics teachers tend to only memorize the concept of phase change and the magnitude of the wavelength shift in the occurrence of the interference. Details of understanding the concept of prospective physics teachers on this indicator are shown in Figure 6 below.

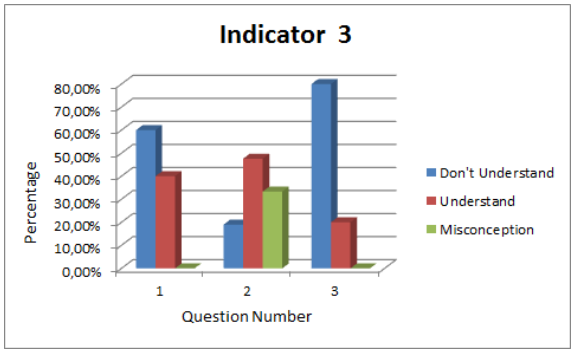

Figure 6. Percentage of concept understanding on indicators explaining the occurrence of interference in thin layers

The material in the fourth indicator is part of the material in the indicator explaining the occurrence of interference in the thin layer. The illustration of the interference phenomenon in this indicator is that it occurs in Newton's rings. The discussion will focus more on the concept of how interference occurs in Newton's rings.

From the total percentage of prospective physics teachers who work on the questions on this indicator in each item, the results of the category understanding of the concept are the same. In the indicator explaining the occurrence of interference in Newton's rings, there are three questions. The first question has the highest category, which is not understanding the concept with a percentage of 40.00%. The second question has the highest category of not understanding the concept with a percentage of 85.71%. The third question has a category of not understanding the concept of 70.00%. This shows that almost all prospective physics teachers do not understand the concept of interference in Newton's rings. While the percentage of prospective physics teachers who experience the highest misconception is 30.00%.

Students who experience misconceptions about this indicator can be due to lack of understanding of the concept of phase difference experienced by reflected waves so almost the majority of physics teacher candidates' answers are wrong and the reasons given do not show an answer to the concept. The percentage of concept understanding on this indicator is shown in Figure 7 below.

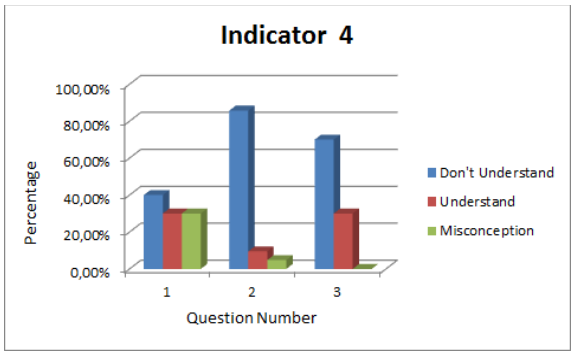

Figure 7. Percentage of concept understanding on indicators explaining the occurrence of interference in Newton's rings

Based on the explanation of the results in this study, it shows that the concept understanding of the prospective physics teacher has a fairly good conceptual understanding. This is shown in the low category of misconceptions produced with the highest percentage of 70.00% and the lowest percentage of 0%. Based on the results of the analysis of the reasons for each answer, it can be seen that the prospective physics teacher who has misconceptions has the wrong concept in only a few of the questions provided. This conceptual error occurs in the statement of the problem regarding the magnitude of the phase on the conditions for interference, the formula for the difference in paths for minimum interference, determining the distance between bright patterns, and the phase size of the reflected wave against the incident wave in Newton's ring.

Apart from that, the misconceptions of prospective physics teachers also occur because the initial concepts possessed by the prospective physics teacher are correct but are not appropriate or less specific in the statement of the question in question. This occurs in the statement of problems relating to the magnitude of the frequency as a condition for interference, the formula for the difference in paths for minimum and maximum interference, the role of reflection in the formation of rainbows in soap bubbles and rainbows, and the type of lens used in Newton's ring formation experiment.

The cause of the misconception can be concluded in the form of incomplete or inappropriate associative thinking and reasoning. These results are in line with the research results obtained by Saputri (2015), namely the causes of misconceptions of prospective physics teachers on geometric optics concepts in the form of preconceptions, associative thinking, humanistic thinking, wrong intuition, and reasoning or incomplete reasons.

Based on the results of this study, the causes of misconceptions in the form of incomplete or inappropriate reasons are very prominent in the large-phase concept as a condition for interference. The results of this study also prove research from Azzarkasyi (2020) which states that online learning has the potential to cause students to experience misconceptions in science learning, one of which is basic physics.

The implication of the results of this study is that information on understanding the concept of light interference material in physical optics courses, whether in the categories of not understanding, understanding, and misconceptions can be used as information for lecturers or educators so that the understanding of the concept of prospective physics teachers is checked after they finish studying a material. In addition, it is hoped that future researchers who will continue this research will be able to find the causes of all categories of concept understanding, namely not understanding, understanding, and misconceptions that occur in prospective physics teachers and can be used as a reference for researchers who will develop a solution to overcome the problem of understanding the concept of physics.

CONCLUSION

Based on the results of research that has been carried out on prospective physics teachers, the results obtained in the category of not understanding the concept of 46.91%, understanding the concept of 36.12%. and low misconception of 17.07%. The cause of these misconceptions is broadly due to the concept error built by the prospective physics teacher and the discrepancy in the application of the concept to the given concept statement.

ACKNOWLEDGMENT

Acknowledgments to prospective physics teachers majoring in Physics education at UNY for their assistance as respondents in this study.

REFERENCES

Azzarkasyi, M., Armanda, A. R., Rizal, S., & Fatmaliana, A. (2020). Potensi Miskonsepsi Pada Pembelajaran Fisika Dasar Selama Masa Pandemic Covid-19. *Jurnal Biology Education*, *8*(2), 139–149. https://doi.org/https://doi.org/10.32672/jbe.v8i2.3266

Deni hafizah, Venny Haris, Eliswatis. 2014. Analisis Miskonsepsi Siswa Melalui Tes Multiple Choice menggunakan *Certain of Respons Index* Pada mata pelajaran Fisika MAN 1 Bukittinggi. *Jurnal Pendidikan MIPA*, 1 (1), 100-103.

Firmansyah, A., Kosim, K., & Ayub, S. (2017). Pengaruh Model Pembelajaran Berbasis Masalah dengan Metode Eksperimen pada Materi Cahaya Terhadap Hasil Belajar Fisika Siswa Kelas VIII SMPN 2 Gunungsari Tahun Ajaran 2014/2015. *Jurnal Pendidikan Fisika Dan Teknologi*, *1*(3), 155–160. https://doi.org/10.29303/jpft.v1i3.252

Fitria, A. (2014). Miskonsepsi Mahasiswa Dalam Menentukan Grup Pada Struktur Aljabar Menggunakan Certainty of Response Index (CRI) Di Jurusan Pendidikan Matematika Iain Antasari. *JPM IAIN Antasari*, 1(2), 45–60. doi: https://core.ac.uk/download/pdf/327227535.pdf

Haeroni, Susilawati, & Rahayu, S. (2019). Remediasi Miskonsepsi Peserta Didik Pada Materi Optik Dengan Teknik CRI Modifikasi Melalui Model Learning Cycle 5e. *Jurnal Pendidikan Fisika Dan Teknologi*, 5(1), 91–99. doi: https://doi.org/http://dx.doi.org/10.29303/jpft.v5i1.835

Hakim, A., Liliasari, & 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 Sciences4*, (3), 544–553. doi: http://www.acarindex.com/dosyalar/makale/acarindex-1423904279.pdf

Haryati, Sri. (2022). Mitigasi *Learning Loss* Sebagai Dampak Pandemi *Covid-19*. *e-book*. Dari Mitigasi Learning Loss Sebagai Dampak Pandemi Covid-19 - Google Play Buku

Jannati, E. D. (2016). Model Pembelajaran Experiential Kolb Untuk Meningkatkan Kemampuan Menjelaskan Fenomena Fisis Pada Konsep Optik. *Gravity: Jurnal Ilmiah Penelitian Dan Pembelajaran Fisika*, *2*(2), 143–155. doi:https://doi.org/http://dx.doi.org/10.30870/gravity.v2i2.1129

Jehadu, V., Warsito, A., Johannes, A. Z., & Louk, A. C. (2020). Visualisasi fenomena kombinasi difraksi dan interferensi pada celah ganda memanfaatkan metode secant berbasis pemrograman delphi. *Jurnal Fisika*, *5*(2), 156–162. doi: http://ejurnal.undana.ac.id/index.php/FISA/article/view/3540

Liliawati, W., & Ramalis, T. R. (2008). Identifikasi Miskonsepsi Materi IPBA di SMA dengan Menggunakan CRI (Certainly of Respons Index) dalam Upaya Perbaikan dan Pengembangan Materi IPBA pada KTSP. *Laporan Penelitian Tidak Diterbitkan*, 159–168.

Lutfia, W., & Putra, N. M. (2020). Analisis Profil Pemahaman Konsep Dan Model Mental Siswa Di Sma Kesatrian 2 Semarang Pada Materi

Interferensi Dan Difraksi Cahaya. *UPEJ Unnes Physics Education Journal*, *9*(1), 27–35. doi: https://doi.org/https://doi.org/10.15294/upej.v9i1.38278

Masturi, M. N. T. (2014). Penentuan Panjang Gelombang Sinar Menggunakan Interferensi Celah Ganda Sederhana. In *Jurnal Fisika* (Vol. 4, Issue 2, pp. 69–73). doi:https://doi.org/https://doi.org/10.15294/jf.v4i2.3828

Parwati, I., Makhrus, M., & Gunada, I. W. (2019). Pengaruh Pendekatan Konflik Kognitif Terhadap Penurunan Miskonsepsi Peserta Didik Pada Materi Usaha dan Energi. *Jurnal Pendidikan Fisika dan Teknologi*, *5*(2), 278-286. doi : http://dx.doi.org/10.29303/jpft.v5i2.1316

Pebriyanti, D., Sahidu, H., & Sutrio. (2015). Efektifitas Model Pembelajaran Perubahan Konseptual Untuk Mengatasi Miskonsepsi Fisika Pada Siswa Kelas X Sman 1 Praya Barat Tahun Pelajaran 2012/2013. *Jurnal Pendidikan Fisika Dan Teknologi*, *I*(1), 92–96. doi: https://doi.org/10.29303/jpft.v1i2.241

Saputri, D. F., & Nurussaniah. (2015). Penyebab Miskonsepsi Pada Optika Geometris. *Prosiding Seminar Nasional Fisika SNF 2015*, *IV*, 33–36. doi: http://journal.unj.ac.id/unj/index.php/prosidingsnf/article/view/5022

Sheftyawan, W. B., Prihandono, T., & Lesmono, A. D. (2018). Identifikasi Miskonsepsi Siswa Menggunakan Four-tier Diagnostic Test pada Materi Optik Geometri. *Jurnal Pembelajaran Fisika*, *7*(2), 147–153. doi: https://jurnal.unej.ac.id/index.php/JPF/article/download/7921/5577

Suparno, Paul. 2005. *Miskonsepsi dan Perubahan Konsep Dalam Pendidikan Fisika*. Jakarta: PT Grasindo.

Sujana, A. 2014. *Dasar-dasar IPA: konsep dan aplikasinya*. Bandung: UPI Press.

Tamami, F., Rokhmat, J., & Gunada, I. W. (2017). Pengaruh Pendekatan Berpikir Kausalitik Scaffolding Tipe 2a Modifikasi Berbantuan LKS Terhadap Kemampuan Pemecahan Masalah Optik Geometri Dan Kreativitas Siswa Kelas XI SMAN 1 Mataram. *Jurnal Pendidikan Fisika Dan Teknologi*, *3*(1), 76–83. https://doi.org/10.29303/jpft.v3i1.333

Taufiq, M. (2012). Remediasi miskonsepsi mahasiswa calon guru fisika pada konsep gaya melalui penerapan model siklus belajar (Learning cycle) 5E. *Jurnal Pendidikan IPA Indonesia*, *1*(2), 198–203. doi: https://doi.org/10.15294/jpii.v1i2.2139

Wahidah S., S. N., Kusairi, S., & Zulaikah, S. (2017). Diagnosis Miskonsepsi Siswa SMA di Kota Malang pada Konsep Suhu dan Kalor Menggunakan Three Tier Test. *Jurnal Pendidikan Fisika Dan Teknologi*. *2*(3). 95–105. doi: https://doi.org/10.29303/jpft.v2i3.295

Winny Liliawati dan Taufik Ramlan. 2008. Identifikasi Miskonsepsi Materi IPBA di SMA dengan Menggunakan CRI (Certainly of Respos Index) dalam Upaya Perbaikan dan Pengembangan Materi IPBA pada KTSP. Laporan Penelitian Pembinaan UPI. Bandung: Lembaga Penelitian UPI.