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Characteristics of Students' Cognitive Ability on the Hyperopia Concept: Rasch Analysis

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Abstract

Knowing the characteristics of students' cognitive abilities is very useful for designing appropriate learning so that students can achieve holistic cognitive abilities. This study aimed to analyze the characteristics of students' cognitive abilities on the hyperopia concept. Rasch analysis includes person and item analysis, which is used to analyze the characteristics of students' cognitive abilities. The research subjects were 64 K-10 students consisting of 38 female students and 26 male students at a public high school in West Bandung Regency. The instrument used to identify students' cognitive abilities on the hyperopia concept is an essay test consisting of 6 items from levels C1-C6 according to the revised Bloom's taxonomy. The results show that the student's cognitive abilities at the level of remembering (100%), understanding (94%), and applying (91%) are in the very good category. Meanwhile, the cognitive abilities at the analyzing, evaluating, and creating levels were below the average cognitive abilities of the students (logit value 0.79). The cognitive ability of female students at the analyzing level is significantly higher than that of male students. The results of this study can be used as an assessment to develop learning activities.

Keywords: Cognitive Ability; Hyperopia; Rasch Analysis

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INTRODUCTION

Cognitive ability is a very important ability in the thinking process. Cognitive abilities are closely related to concept mastery and students' understanding of concepts. That is because concept mastery and concept understanding is the ability of students in the cognitive domain (Dalila et al., 2022; Fajrina et al., 2016). Students are required to be able to master a concept to communicate appropriately, grouping ideas, and events

experienced or encountered in everyday life (Suranti et al., 2017). Refers to Bloom's Taxonomy revised by Anderson and Krathwohl, the cognitive domain is divided into the ability to remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6) (Jatmiko et al., 2016; Krathwohl, 2002). Students who can master the concept will be able to abstract objects encountered and can be classified into certain groups (Kaniawati, 2017). Teachers can easily



interpret the expected level of cognitive mastery and knowledge through Bloom's Taxonomy (Rukmini, 2008). Furthermore, Fatmawati stated that Bloom's Taxonomy affects students' cognitive abilities, for example, learning strategies, critical thinking, and problem-solving (Fatmawati, 2013).

All scientific conceptions possessed by students must be supported by appropriate cognitive abilities. Students have various cognitive structures due to the many concepts in physics that are systematically arranged (Hançer & Durkan, 2008). In addition, students bring various conceptions when entering class (Basori et al., 2020; Hermita et al., 2018; Setiono et al., 2021). Cognitive ability refers to the ability of a student to understand a scientific meaning that occurs, both in theory and in its application to every problem that occurs in everyday life. Learning outcomes show the level of achievement of learning outcomes in each student and this is the most important thing for teachers to be analyzed based on cognitive abilities (Hardianti, 2018). Students who study physics require students' broad cognitive abilities. Meanwhile, according to the research of Sianturi and Gultom, there are several factors that affect student learning difficulties contained in the inhibiting category, namely intelligence indicators owned, parents, home atmosphere indicators, teachers, school environment, and subject indicators (Sianturi & Gultom, 2016). Students will have difficulty understanding learning if their cognitive abilities are low. Wicaksono revealed that if the student's cognitive ability is low, then it has the potential to grow unexpected attitudes, especially in learning activities (Wicaksono, 2016).

Research related to students' cognitive abilities and concept mastery has been carried out. Dalila conducted related research on the effect of learning differentiation on PBL on cognitive

learning outcomes that occur in each student (Dalila et al., 2022). Wicaksono found the effectiveness of virtual science learning in increasing students' concept mastery (Wicaksono et al., 2017). Research has been carried out by Johan regarding the effect of interactive conceptual learning on increasing students' concept mastery (Johan et al., 2018). In addition, several studies related to the analysis of students' concept mastery based on the revised Bloom's Taxonomy have been carried out, including concept mastery at the cognitive level of remembering to apply (Furqani et al., 2018) as well as at the cognitive level of analyzing to creating (Wandari et al., 2018; Wicaksono et al., 2017). However, research on students' cognitive abilities related to the concept of hyperopia has not been carried out much.

Hyperopia is one of the important concepts learned in physics learning (Jones & Zollman, 2014; Ling, 2017; Widiyatmoko & Shimizu, 2018). The concepts in hyperopia relate to the formation of shadows on the eye. The process of shadow formation is one of the abstract concepts that occur in physics learning, it requires critical thinking skills to understand the theory (Nurhayati & Angraeni, 2017). Hyperopic eyes have lower optical power than normal eyes, so the image falls behind the retina (Millán et al., 2014). Hyperopic eyes cannot focus the light coming from an object so that it is right on the retina (Gómez-Varela et al., 2014). Thus, hyperopia is an application of the optical concept of the eye. Hyperopia is an essential concept in physics and forms the basis for further concepts. Hyperopia is a basic concept that will be studied when students take health majors in college, for example, optometry. The process of solving problems in physics requires thinking skills (Winarti, 2015). Therefore, students must have good cognitive abilities related to the hyperopia concept

since students are in high school so that students' scientific conceptions can be well embedded.

The importance of mastering the concept of hyperopia encourages teachers to know the extent to which students' cognitive abilities are related to this concept. The characteristics of students' cognitive abilities have a very important role in the learning process. The level of students' concept mastery can be seen in its development after learning from the teacher. Characteristics of students' cognitive abilities can also serve as material for analyzing the suitability of learning scenarios that have been carried out on the learning material. Furthermore, the teacher can plan the next learning step, which refers to the characteristics of the cognitive ability of the students beforehand. Thus, research that aims to analyze the characteristics of students' cognitive abilities needs to be done.

The Rasch model is part of the Item Response Theory (IRT) which is used massively for analyzing psychometric data in the field of education (Khine, 2020). Researchers in the field of physics education also use the Rasch model to analyze psychometric data on students' abilities (e.g. Ene & Ackerson, 2018; Lamanepa, 2021; Mahtari et al., 2019; Risdianto et al., 2020; Ubaidillah et al., 2022; Wati et al., 2019; Widiyatmoko & Shimizu, 2018; Zochling et al., 2022). By using the Rasch model, students' responses after taking the test can be analyzed according to the difficulty level of the items and the student's abilities (Engelhard, 2013). In addition, biased responses can be addressed through Rasch analysis, so that psychometric characteristics can be analyzed effectively (Bradley et al., 2015). Moreover, the analysis of the Rasch model can analyze each student's score holistically (Chan et al., 2021). In the field of social science, Rasch analysis is an appropriate approach to use (Boone et

al., 2014; Liu, 2010). Several studies have been carried out using the Rasch model, including an analysis of the effect of physics teachers' pedagogical content knowledge and motivation on learning outcomes and students' interests (Keller et al., 2017), an analysis of student learning outcomes in technical education (Saidfudin et al., 2010), analysis of the effect of e-learning based virtual laboratory on metacognitive skills (Yusuf & Widyaningsih, 2020), analysis of the influence of culturally responsive inquiry on student learning outcomes (Anantanukulwong et al., 2022), an analysis of the effect of STEM-based e-learning on students' HOTS abilities (Yusuf et al., 2018), as well as an analysis of concept mastery and learning difficulties in optical instruments (Ainiyah et al., 2020). However, research related to the analysis of students' cognitive abilities using the Rasch model has not been carried out much, especially on the concept of hyperopia. Thus, the research question is how the characteristics of students' cognitive abilities in the concept of hyperopia. We systematically investigated these question by using the Rasch model which focuses on analyzing the characteristics of students' cognitive abilities related to the hyperopia concept. Additionally, the cognitive abilities analyzed in this study cover the ability to remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6).

METHOD

The descriptive method was used in this research. Meanwhile, this research was conducted using Rasch analysis. This study aims to analyze the characteristics of students' cognitive abilities on the hyperopia concepts. The cognitive abilities of the students refer to cognitive abilities according to the revised Bloom's taxonomy, which includes the ability to remember (C1), understand (C2), apply

(C3), analyze (C4), evaluate (C5), create (C6).

The research has been conducted on public high school students in West Bandung Regency. The research subjects were 64 K-10 students consisting of 26 male students and 38 female students. All research subjects have studied the concept of hyperopia.

The cognitive ability test developed in this study refers to the revised Bloom's taxonomy. A cognitive ability test on the topic of hyperopia was developed to determine students' cognitive abilities. Cognitive ability tests were developed because of the limitations of conventional formative assessments in providing holistic information (Brendefur et al., 2018). A total of six essay test items covering C1 to C6 level items have been developed. Test indicators include the ability to describe the meaning of hyperopia correctly (C1), explain the measurement of the focal point of the lens correctly (C2), determine the strength of the progressive lens correctly (C3), analyze the solution for forming an image in the hyperopic eye (C4), conclude the appropriate lens for hyperopic eyes (C5) and properly designing hyperopia-related experiments (C6). A sample of students' cognitive ability tests that have been developed is shown in Figure 1.

You are a researcher skilled in the field of optometry. You are researching a hyperopia child. After conducting experiments in the laboratory, sketch the formation of the image formed on the hyperopia eye!

Answer:

.....
.....

Figure 1 Sample question for analyzing

The validator assesses the level of construct validity of the test and states that the test is valid. Instrument trials were carried out on high school students

at one of the public high schools in West Bandung Regency to determine the eligibility level of the test. Rasch analysis using Ministep software version 4.3.2 is used to analyze the eligibility of the test, which includes the validity and reliability. Obtained the empirical validity of the test with valid categories. Meanwhile, the reliability of the test according to Cronbach Alpha has been declared reliable (0.77) and is included in the good criteria (Isa & Naim, 2016; Xie et al., 2014). The result of the test analysis is shown in Figure 2.

Person_RAN SCORE-TO-MEASURE CORRELATION = 1.00
Cronbach ALPHA (KR-20) Person_RAN SCORE "TEST" RELIABILITY = .72 SEM = .07

SUMMARY OF 6 MEASURED Item									
	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	ZSTD	OUTFIT MNSQ	ZSTD	
MEAN	39.3	64.0	.00	.28	1.00	-.35	1.00	-.16	
SEM	3.7	.0	.27	.01	.05	.65	.10	.69	
P.S.D	8.2	.0	.60	.02	.14	1.46	.21	1.55	
S.S.D	9.0	.0	.66	.02	.15	1.60	.24	1.70	
MAX.	50.0	64.0	.88	.31	1.26	1.77	1.47	2.33	
MIN.	27.0	64.0	-.83	.26	.83	-2.51	.81	-2.39	
REAL RMSE	.29	TRUE SD	.53	SEPARATION	1.85	Item RELIABILITY	.77		
MODEL RMSE	.28	TRUE SD	.53	SEPARATION	1.92	Item RELIABILITY	.79		
S.E. OF Item MEAN	.27								

Figure 2 Test reliability

Quantitative data were obtained based on the tests of students' cognitive abilities. Quantitative analysis of cognitive abilities was carried out using the Rasch model to answer the problems in this study. Rasch analysis was carried out using the Ministep software, which is based on the logit value of students' cognitive abilities. The characteristics of students' cognitive abilities were based on logit values through person-fit analysis (Chan et al., 2021), namely Outfit Mean Square (MNSQ), Outfit Z-Standard (ZSTD), and Point Measure Correlation (Pt Mean Corr). The cognitive abilities of students fit the model if: $0.5 < \text{Outfit MNSQ} < 1.5$; $-2.0 < \text{Outfit ZSTD} < +2.0$; or $0.4 < \text{Pt Mean Corr} < 0.85$ (Sumintono & Widhiarso, 2015; Wati et al., 2019). Separation analysis was based on logit values to classify students' cognitive abilities.

RESULT AND DISCUSSION

Student's cognitive abilities

Student's cognitive abilities are obtained based on essay tests related to the

hyperopia concept. Students have participated in learning activities related to the hyperopia concept. The learning activities were carried out with conventional learning methods through experimental activities.

Data analysis of students' cognitive abilities was carried out using the Rasch model. Cognitive abilities data is described on a logit scale. Student identities are stated in the gender code F for females and M for males. In addition, numeric codes are also used to distinguish identities between students.

The results of the analysis obtained from the study showed that students' abilities were above the difficulty level of the item. The average result of a student's ability (M for people) greater than the average difficulty of an item (M for an item) is shown in Figure 4. The mean value of students' cognitive abilities is 0.79 with a standard deviation of 0.57. It explains that students have cognitive abilities that are not much different, even though these abilities are at different logit values.

Student's cognitive abilities are grouped based on the mean value and standard deviation. This was obtained from the analysis of the Rasch model which determines the chances of students answering correctly based on various levels of cognitive ability and item difficulty (Setyorini et al., 2021). The distribution of cognitive abilities is described following the normal curve pattern. The distance between the mean value and 1 standard deviation indicates 1 SD. Meanwhile, the distance between

the mean values to 2 standard deviations shows 2 SD. The mean value is 0.79 with 1 standard deviation resulting in a group of +1 SD with a logit value of +1.01. If this value is added by 1 standard deviation, it results in a +2 SD group with a logit value of +1.93. The same is true for the standard deviations of -1 SD and -2 SD. The student's cognitive abilities which are in the range of more than +2 SD or less than -2 SD are outlier data. Figure 3 shows the results of the analysis of the characteristics of students' cognitive abilities.

The results of the Rasch analysis in Figure 3 show that the student's cognitive abilities are divided into four groups, namely very high, high, low, and very low. Meanwhile, in general, the cognitive abilities of students with positive logit scores are in the low to very high category. The results of this analysis show that all students have an Outfit MNSQ, Outfit ZSTD, or Pt Mean Corr that fits the Rasch criteria (Chan et al., 2021; Sumintono & Widhiarso, 2015). Thus, it is said that the cognitive abilities of students fit with the model. The Outfit ZSTD value shows the cognitive ability of students fits with the model because it is in the range of -1.9 to 1.9 (Boone et al., 2014). Moreover, in Figure 3, the Outfit MNSQ value obtained from the average cognitive ability of students is 0.95, so the results fit the model because they are in the interval of 0.5 to 1.5 (Boone et al., 2014). The comparison of students' cognitive abilities can be seen in Figure 4.

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MISQ	OUTFIT ZSTD	PTMEASUR- AL ZSTD	EXACT CORR.	EXP. OBSN	MATCH EXP%	Person		
Very High													
M59	48	6	1.84	2.12	1.34	.67	1.52	1.40	A-.62	.22	83.3	83.3	M59
F54	47	6	1.78	1.96	1.62	1.64	1.50	1.85	B-.81	.27	70.0	67.7	F54
F35	47	6	1.78	1.96	1.62	1.64	1.50	1.85	C-.81	.27	50.0	77.7	F35
F53	47	6	1.78	1.96	1.62	1.64	1.48	1.85	D-.81	.27	50.0	77.7	F53
M36	45	6	1.72	1.88	1.29	.61	1.48	1.04	E-.41	.22	83.3	83.6	M36
F07	44	6	1.64	1.82	1.29	.61	1.48	1.04	F-.41	.22	83.3	73.3	F07
M11	44	6	1.64	1.82	1.29	.61	1.46	1.04	G-.41	.22	83.3	83.3	M11
M56	43	6	1.58	1.76	1.50	1.38	1.46	1.49	H-.58	.27	50.0	77.7	M56
F18	42	6	1.50	1.72	1.43	1.23	1.45	1.14	I-.42	.27	50.0	76.7	F18
M13	41	6	1.42	1.68	1.43	1.23	1.45	1.14	J-.42	.27	50.0	76.7	M13
M14	41	6	1.42	1.68	1.24	.77	1.45	1.06	K-.19	.27	60.0	67.3	M14
F06	40	6	1.36	1.62	1.21	.70	1.39	.96	L-.13	.27	60.0	67.7	F06
M09	39	6	1.28	1.54	1.36	1.44	1.37	1.39	M-.28	.29	33.3	72.4	M09
F10	39	6	1.28	1.54	1.10	.40	1.30	.78	N-.54	.27	83.3	77.6	F10
F08	39	6	1.28	1.54	1.24	.76	1.28	.50	O-.43	.27	50.0	76.7	F08
F05	39	6	1.28	1.54	1.24	.76	1.28	.50	P-.43	.27	80.0	76.7	F05
F02	39	6	1.28	1.54	1.24	.76	1.28	.50	Q-.52	.27	80.0	67.7	F02
M01	39	6	1.28	1.54	1.24	.76	1.24	.50	R-.38	.27	70.0	67.7	M01
M12	38	6	1.20	1.46	1.15	.52	1.18	.55	S-.68	.27	70.0	67.7	M12
F03	38	6	1.20	1.46	1.14	.65	1.15	.66	T-.76	.29	66.7	72.4	F03
High													
F42	37	6	1.00	1.40	1.12	.40	1.14	.37	U-.76	.22	83.3	83.3	F42
F30	37	6	1.00	1.40	1.12	.40	1.14	.37	V-.48	.22	83.3	83.3	F30
M28	37	6	1.00	1.40	1.03	.21	1.09	.35	C-.82	.27	83.3	76.7	M28
M26	37	6	1.00	1.40	1.03	.21	1.09	.35	X-.63	.27	83.3	76.7	M26
F25	37	6	1.00	1.40	1.03	.21	1.09	.35	Y-.48	.27	83.3	87.3	F25
F21	37	6	1.00	1.40	1.03	.21	1.09	.35	Z-.80	.27	83.3	87.3	F21
F20	37	6	1.00	1.40	.91	-.14	.98	-.19	a-.76	.27	83.3	67.7	F20
F19	37	6	1.00	1.40	.91	-.14	.98	-.19	b-.42	.27	83.3	77.7	F19
F47	36	6	.92	1.32	.92	-.14	.97	-.19	c-.42	.27	83.3	67.6	F47
M46	35	6	.92	1.32	.91	-.14	.92	-.19	d-.42	.27	83.3	67.7	M46
F45	35	6	.92	1.32	.90	.08	.92	-.12	e-.45	.22	83.3	83.3	F45
F43	35	6	.92	1.32	.86	-.54	.84	-.58	f-.52	.29	66.7	72.4	F43
F41	34	6	.76	1.02	.86	-.54	.84	-.58	g-.52	.29	66.7	72.4	F41
F39	34	6	.76	1.02	.86	-.54	.84	-.58	h-.55	.27	83.3	77.6	F39
F32	34	6	.76	1.02	.84	-.38	.77	-.45	i-.55	.27	83.3	77.7	F32
M60	32	6	.44	.84	.76	-.14	.73	-.34	j-.65	.22	83.3	83.3	M60
M58	32	6	.44	.84	.72	-.23	.70	-.12	k-.74	.29	66.7	72.4	M58
F51	32	6	.44	.84	.72	-.23	.70	-.12	l-.74	.29	66.7	62.4	F51
M50	32	6	.44	.84	.72	-.23	.70	-.12	m-.36	.29	66.7	62.4	M50
Low													
F22	31	6	.34	.72	.72	-.1.23	.70	-.1.25	n-.42	.29	66.7	72.4	F22
F37	30	6	.18	.84	.66	-1.04	.69	-.96	o-.81	.27	83.3	77.3	F37
F34	30	6	.18	.84	.64	-1.66	.69	-1.63	p-.86	.29	100.0	82.4	F34
F33	30	6	.18	.84	.64	-1.66	.69	-1.63	q-.86	.29	100.0	82.4	F33
F16	30	6	.18	.84	.64	-1.66	.69	-1.63	r-.86	.29	100.0	72.4	F16
M15	30	6	.18	1.02	.64	-1.66	.69	-1.63	s-.62	.29	100.0	82.4	M15
M04	30	6	.18	1.02	.64	-1.66	.69	-1.63	t-.68	.29	100.0	62.4	M04
F64	29	6	.02	1.02	.64	-1.66	.65	-1.63	u-.88	.29	100.0	86.3	F64
F63	29	6	.02	1.02	.64	-1.66	.65	-1.63	v-.88	.29	100.0	86.3	F63
M55	29	6	.02	1.02	.64	-1.66	.65	-1.63	w-.34	.29	100.0	86.3	M55
F57	29	6	.02	1.02	.63	-1.14	.63	-1.08	x-.63	.27	83.3	77.7	F57
F52	29	6	.02	1.02	.63	-1.14	.63	-1.08	y-.63	.27	83.3	67.7	F52
F49	29	6	.02	1.02	.63	-1.14	.63	-1.08	z-.58	.27	83.3	67.7	F49
M48	29	6	.02	1.02	.63	-1.14	.63	-1.08	a-.58	.27	83.3	76.7	M48
M62	28	6	-.02	1.02	.64	-1.66	.61	-1.63	b-.62	.29	86.0	72.4	M62
M31	28	6	-.02	1.02	.64	-1.66	.61	-1.63	c-.74	.27	86.0	82.4	M31
F29	28	6	-.02	1.02	.64	-1.66	.61	-1.63	d-.42	.27	74.0	82.4	F29
M17	28	6	-.02	1.02	.64	-1.66	.61	-1.63	e-.40	.27	74.0	72.4	M17
Very Low													
F23	27	6	-.18	1.32	.64	-1.66	.61	-1.63	f-.56	.27	68.0	73.4	F23
M44	26	6	-.30	1.40	.64	-1.66	.60	-1.63	g-.38	.22	68.0	72.4	M44
F40	25	6	-.52	1.62	.64	-1.66	.60	-1.63	h-.63	.22	43.0	83.4	F40
M24	24	6	-.64	1.68	.64	-1.66	.60	-1.63	i-.28	.29	64.0	83.4	M24
M27	24	6	-.64	1.68	.63	-1.14	.57	-1.08	j-.85	.27	64.3	83.7	M27
M38	23	6	-.78	1.72	.63	-1.14	.57	-1.08	k-.60	.27	76.3	76.3	M38
F61	23	6	-.78	1.72	.63	-1.14	.57	-1.08	l-.76	.29	58.3	67.7	F61

MEAN	34.4	6.0	0.79	1.34	.94	-.35	.95	-.31			75.7	76.0	
P.SD	6.4	.0	.57	.36	.31	1.08	.33	1.1			15.5	6.7	

Figure 3 Characteristics of students' cognitive abilities

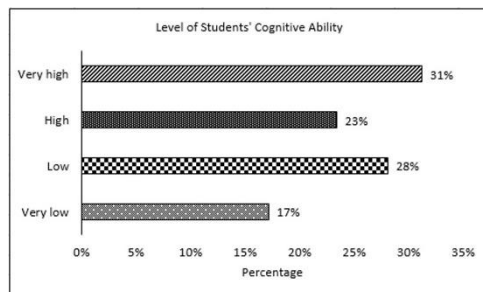


Figure 4 Level of students' cognitive abilities

Figure 4 shows that some 31% of students have very high cognitive abilities. Meanwhile, 23% of students are at a high level of cognitive ability. However, 17% of students have very low

cognitive ability, while 28% of other students are at a low level of cognitive ability. Thus, it can be said that almost 50% of students still have fewer cognitive abilities. In line with the research of Widiyatmoko & Shimizu which states that 33% of students understand the concept of hyperopia and 25% of students understand the characteristics of hyperopia (Widiyatmoko & Shimizu, 2018).

Rasch's analysis also explains the cognitive abilities possessed by both female and male students. Referring to Figure 4, the comparison of cognitive abilities possessed by female and male students is shown in Figure 5.

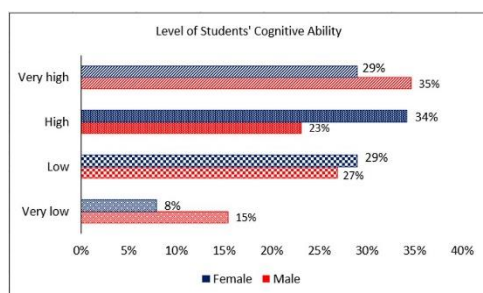


Figure 5 Level of the cognitive abilities of both female and male students

The cognitive abilities of female students are better than male students. Although the number of male students who have very high cognitive abilities is more than female students, the number of male students who have high cognitive abilities is less than female students. In addition, the number of male students who have very low cognitive abilities is almost twice that of female students.

Distribution of Students' Cognitive Abilities

The cognitive ability of each student at each level of cognitive ability is known based on Rasch analysis. The results of the analysis show the cognitive abilities of students towards cognitive level achievements based on their logit values. Parameters of item difficulty level and estimation of students' cognitive abilities were calibrated using a Wright Map with the same scale so that the relationship between the two parameters can be known (Chin et al., 2022). Figure 6 shows the results of the Wright map analysis, namely the distribution of students' cognitive abilities to cognitive levels. In general, there are two parts to a Wright map, namely person and items. The results of the analysis obtained from the study show that students' abilities are very diverse, but not far apart. Thus, the items used can provide a variety of useful information in the concept of assessment for learning.

All students and items are in the logit range -1.9 to 1.9, so there are no outlier

data (Boone et al., 2014). The higher the student's logit position indicates the higher the cognitive ability of the student. Meanwhile, the lower the student's logit position on the Wright map indicates the lower the cognitive ability of the student. The Wright map shows the difficulty level of the items. The higher the logit item position on the Wright map indicates the greater the difficulty level of the item. Meanwhile, the lower the logit items' position, the easier the items are. The cognitive level according to the revised Bloom (C1-C6) is not always proportional to the level of difficulty but is proportional to the complexity of students' thinking. Thus, items at the analyzing level are not necessarily more difficult than items at the understanding level. The complexity of the items varies at each cognitive level.

Figure 6 shows that all students can remember (C1). Meanwhile, almost all students also can understand (C2). Even though almost all students can achieve C1 and C2 abilities, this does not indicate that these items are invalid or unreliable. Students with a very low level of cognitive abilities can solve problems at the remembering level (C1). Meanwhile, there were three students (F40, M44, and F23) who were able to reach the level of understanding (C2). There is only one student (F23) with a very low level of cognitive ability who can solve problems at the applying cognitive level (C3). All students who have low cognitive abilities can solve problems at C1-C3 levels. M60, M58, M50, and F51 students were unable to achieve applying ability (C4) when compared to other students who had high cognitive abilities. Not all students who have very high cognitive abilities can achieve the ability to create (C6). Some of these students can only achieve evaluating ability (C5). This is in line with the research of Nurhayati & Angraeni which stated that students have better analytical abilities (C4) than evaluating abilities (C5) (Nurhayati &

Angraeni, 2017). In addition, the ability to create (C6) on optical concepts is the lowest. Lamanepa states that the average logit of students' abilities is greater than the item difficulty level (Lamanepa, 2021). It appears that students can master

item C4, even though these items are slightly above the average ability of students. Figure 7 presents a comparison of the cognitive abilities of female students and male students.

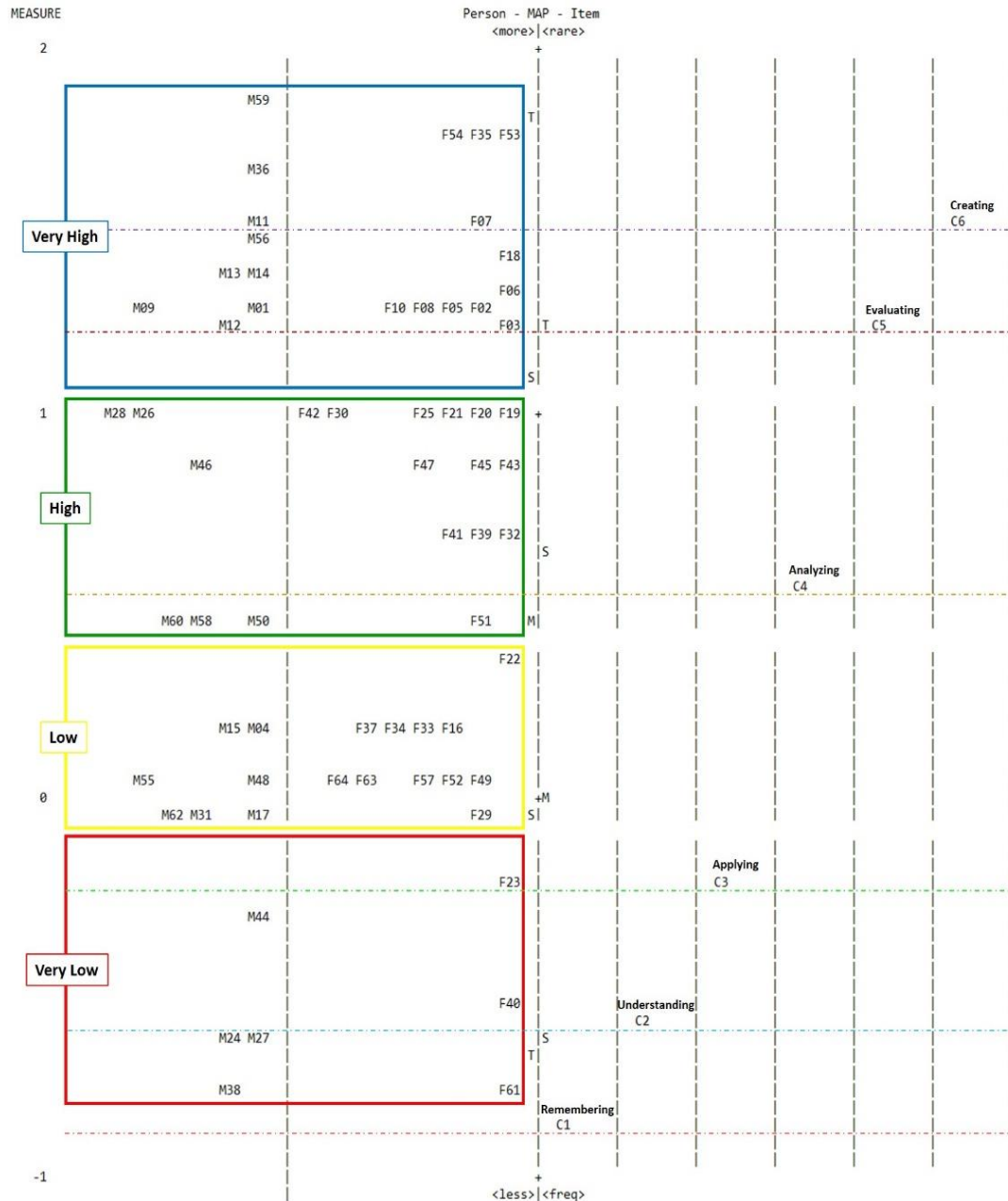


Figure 6 Students' cognitive abilities

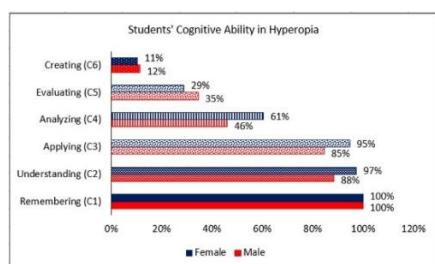


Figure 7 The cognitive abilities of both female and male students

Figure 7 shows the cognitive abilities of female students at the C1 level are the same as the cognitive abilities of male students. At ability levels C2, C3, C5, and C6, there is no significant difference between female students and male students. A significant difference (15%) was seen in the ability to level C4. At that level, the cognitive abilities of female students are significantly higher than male students.

Item C4 asks students to analyze the solution for forming images on hyperopic eyes through pictures, based on the experimental data that has been done. Some students experience difficulties in analyzing the solution for forming shadows on hyperopic eyes because they still have the wrong concept of hyperopia. Sample student answers on the ability to analyze show an analysis of two different student abilities. Figure 8 shows a sample of student F39's answers at the analyzing level (C4).

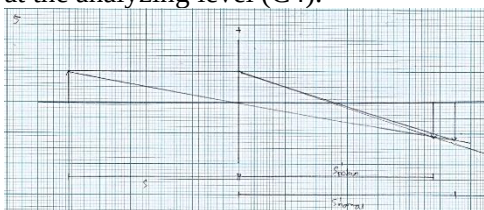


Figure 8 A sample of the student's correct answer

Figure 8 shows a sample of the correct answer from the formation of shadows on hyperopic eyes through pictures, based on experimental data that has been done. In hyperopic eyes, an image is formed in front of the retina of the eye. Students use

appropriate symbols to describe the formation of shadows on hyperopic eyes. However, some students are not right in providing solutions to problems. Figure 9 shows a sample of incorrect answers on C4 ability.

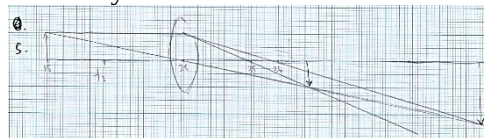


Figure 9 A Sample of the Student's Wrong Answer

Student M15 is not correct in analyzing the solution for forming shadows on farsighted eyes. The student uses the wrong symbol to describe a positive thin lens. Thin lenses should be denoted by a vertical line, while positive types of lenses are denoted by putting a positive notation (+) above the lens. In addition, the scale given is also wrong. This shows that F39 students can describe information as an effort to solve problems based on the right concept. F39 student has good analytical ability because she can write solutions that are in line with the problem, based on complete completion steps. Meanwhile, M15 student has not shown proper analytical ability. This is in line with indicators in analyzing problems are seen from the ability of students to describe information under the correct concepts and solutions (Prasetyani et al., 2016). Results showing the student's low ability indicate that the student has difficulty representing the solution in the form of a diagram, one of which is the formation of a shadow diagram on the eyes. Research conducted by Ainiyah, et al., agreed that students experience difficulties in studying and experimenting with optical instruments, understanding the application of optical devices, and solving problems in the form of ray diagrams and mathematical calculations (Ainiyah et al., 2020). Moreover, female students at the age of K-10 have better abstract thinking skills than male

students (Rijke et al., 2018). Cognitive abilities are very important in the student's academic engagement (Lavrijsen et al., 2021). However, the results of this study are in contrast to Paraboni & Costa who states that there is no difference between students who have high and low cognitive abilities (Paraboni & da Costa, 2021). Meanwhile, Hardianti stated that the cognitive abilities of female students were greater than male students (Hardianti, 2018). Thus, this research reveals the fact that students' ability activities in analyzing, evaluating, and creating related optical concepts need to be improved through a more supportive learning activity.

CONCLUSION

Data analysis and discussion using the Rasch model related to the characteristics of students' cognitive abilities on the hyperopia concept have been carried out. The cognitive abilities of students at the level of remembering (C1), understanding (C2), and applying (C3) are included in the very high category. Meanwhile, cognitive abilities at the levels of analyzing (C4), evaluating (C5), and creating (C6) are below the average cognitive ability of students. Unlike the ability to analyze, the ability to evaluate (C5) and to create (C6) is included in the low category. These results implied that learning activities that can improve students' cognitive abilities at the level of analyzing, evaluating, and creating related to the concept of hyperopia are needed.

REFERENCES

- Ainiyah, Q., Yuliati, L., & Parno, P. (2020). Analisis penguasaan konsep dan kesulitan belajar materi alat-alat optik pada siswa kelas xi man tuban. *Jurnal Riset Pendidikan Fisika*, 5(1), 24–29.
- Anantanukulwong, R., Chiangga, S., Pongsophon, P., & Tan, A.-L. (2022). Enhancing students' learning of the concept of equilibrium through a culturally responsive inquiry of the bulan kite. *Science & Education*. <https://doi.org/10.1007/s11191-022-00398-0>
- Basori, H., Suhandi, A., Kaniawati, I., & Rusdiana, D. (2020). Concept progression of high school students related to the concept of parallel electric circuits as the effect of applying CCROI integrated with T-ZPD strategy. *Journal of Physics: Conference Series*, 1521(2), 022009. <https://doi.org/10.1088/1742-6596/1521/2/022009>
- Boone, W. J., Staver, J. R., & Yale, M. S. (2014). *Rasch Analysis in the Human Sciences*. Springer Netherlands. <https://doi.org/10.1007/978-94-007-6857-4>
- Bradley, K. D., Peabody, M. R., Akers, K. S., & Knutson, N. M. (2015). Rating scales in survey research: Using the rasch model to illustrate the middle category measurement flaw. *Survey Practice*, 8(1), 1–12. <https://doi.org/10.29115/SP-2015-0001>
- Brendefur, J. L., Johnson, E. S., Thiede, K. W., Strother, S., & Severson, H. H. (2018). Developing a multi-dimensional early elementary mathematics screener and diagnostic tool: the primary mathematics assessment. *Early Childhood Education Journal*, 46(2), 153–157. <https://doi.org/10.1007/s10643-017-0854-x>
- Chan, S.-W., Looi, C.-K., & Sumintono, B. (2021). Assessing computational thinking abilities among Singapore secondary students: A Rasch model measurement analysis. *Journal of Computers in Education*, 8(2), 213–236. <https://doi.org/10.1007/s40692-020-00177-2>
- Chin, H., Chew, C. M., Yew, W., & Musa, M. (2022). Validating the cognitive diagnostic assessment and assessing students' mastery of

- 'parallel and perpendicular lines' using the rasch model. *Participatory Educational Research*, 9(6), 436–452. <https://doi.org/10.17275/per.22.147.9.6>
- Dalila, A. A., Rahmah, S., Liliawati, W., & Kaniawati, I. (2022). Effect of differentiated learning in problem based learning on cognitive learning outcomes of high school students. *Jurnal Penelitian Pendidikan IPA*, 8(4), 2116–2122. <https://doi.org/10.29303/jppipa.v8i4.1839>
- Ene, E., & Ackerson, B. J. (2018). Assessing learning in small sized physics courses. *Physical Review Physics Education Research*, 14(1), 010102. <https://doi.org/10.1103/PhysRevPhysEducRes.14.010102>
- Engelhard, G. (2013). *Invariant measurement, using rasch models in the social, behavioral, and health sciences* (1st ed.). Routledge.
- Fajrina, R. N. A. A., Handayanto, S. K., & Hidayat, A. (2016). Deskripsi penguasaan konsep siswa terhadap materi fluida statis di tana pasir kalimantan timur. *Pros. Semnas Pend IPA Pascasarjana UM*, 1, 416–422. <https://pasca.um.ac.id/wp-content/uploads/2017/02/Rani-Nur-416-422.pdf>
- Fatmawati, S. (2013). Perumusan Tujuan pembelajaran dan soal kognitif berorientasi pada revisi taksonomi bloom dalam pembelajaran fisika. *EduSains*, 1(2). <https://e-journal.iain-palangkaraya.ac.id/index.php/edusain/article/view/13>
- Furqani, D., Feranie, S., & Winarno, N. (2018). The effect of predict-observe-explain (poe) strategy on students' conceptual mastery and critical thinking in learning vibration and wave. *Journal of Science Learning*, 2(1), 1. <https://doi.org/10.17509/jsl.v2i1.12879>
- Gómez-Varela, A. I., Salvado-Vara, F., & Bao-Varela, C. (2014). *A teaching resource using the GUIDE environment: Simplified model of the eye for secondary school students* (M. F. P. C. Martins Costa & M. Zghal, Eds.; p. 928920). <https://doi.org/10.1117/12.2070766>
- Hançer, A. H., & Durkan, N. (2008). Turkish pupils understanding of physical concept: Force and movement. *World Applied Sciences Journal*, 3(1), 45–50.
- Hardianti, T. (2018). Analisis kemampuan peserta didik pada ranah kognitif dalam pembelajaran fisika sma. *Seminar Nasional Quantum*. Seminar Nasional Quantum #25, Universitas Ahmad Dahlan. seminar.uad.ac.id/index.php/quantum
- Hermita, N., Suhandi, A., Syaodih, E., Samsudin, A., Marhadi, H., Sapriadil, S., Zaenudin, Z., Rochman, C., Mansur, M., & Wibowo, F. C. (2018). Level conceptual change pre-service elementary teachers on electric current conceptions through visual multimedia supported conceptual change. *Journal of Physics: Conference Series*, 1013, 012060. <https://doi.org/10.1088/1742-6596/1013/1/012060>
- Isa, N. M., & Naim, H. A. (2016). Science process skill assessment: teachers practice and competency. In Q. Zhang (Ed.), *Pacific Rim Objective Measurement Symposium (PROMS) 2015 Conference Proceedings* (pp. 251–266). Springer Singapore. https://doi.org/10.1007/978-981-10-1687-5_16
- Jatmiko, B., Widodo, W., Martini, M., Budiyo, M., Wicaksono, I., & Pandiangan, P. (2016). Effectiveness of the inqf-based learning on a general physics for improving student's learning outcomes. *Journal of Baltic Science Education*, 15(4), 441–451. <https://doi.org/10.33225/jbse.16.15.441>

- Johan, H., Suhandi, A., Wulan, A. R., Sapriyadi, & Herawati, A. (2018). Enhancing mastery of earth science concept of prospective physics teachers through interactive conceptual instruction supported by visualization and grads. *Jurnal Pendidikan IPA Indonesia*, 7(4). <https://doi.org/10.15294/jpii.v7i4.9799>
- Jones, D. L., & Zollman, D. (2014). Understanding vision: Students' use of light and optics resources. *European Journal of Physics*, 35(5), 055023. <https://doi.org/10.1088/0143-0807/35/5/055023>
- Kaniawati, I. (2017). Pengaruh simulasi komputer terhadap peningkatan penguasaan konsep impuls-momentum siswa sma. *Jurnal Pembelajaran Sains*, 1(1), 24–26. <https://doi.org/10.17977/um033v1i1p24-26>
- Keller, M. M., Neumann, K., & Fischer, H. E. (2017). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest: Physics Teachers' Knowledge and Motivation. *Journal of Research in Science Teaching*, 54(5), 586–614. <https://doi.org/10.1002/tea.21378>
- Khine, M. S. (Ed.). (2020). *Rasch measurement: Applications in quantitative educational research*. Springer Singapore. <https://doi.org/10.1007/978-981-15-1800-3>
- Krathwohl, D. R. (2002). A Revision of bloom's taxonomy: An overview. *Theory Into Practice*, 41(4), 212–218. https://doi.org/10.1207/s15430421tip4104_2
- Lamanepa, G. H. (2021). Metode pengukuran rasch dalam pembelajaran fisika. *Jurnal Eduscience*, 8(1), 47–52. <https://doi.org/10.36987/jes.v8i1.1975>
- Lavrijsen, J., Preckel, F., Verachtert, P., Vansteenkiste, M., & Verschueren, K. (2021). Are motivational benefits of adequately challenging schoolwork related to students' need for cognition, cognitive ability, or both? *Personality and Individual Differences*, 171, 110558. <https://doi.org/10.1016/j.paid.2020.110558>
- Ling, T. W. (2017). Fostering understanding and reducing misconceptions about image formation by a plane mirror using constructivist-based hands-on activities. In M. Karpudewan, A. N. Md Zain, & A. L. Chandrasegaran (Eds.), *Overcoming Students' Misconceptions in Science* (pp. 203–222). Springer Singapore. https://doi.org/10.1007/978-981-10-3437-4_11
- Liu, X. (2010). *Using and developing measurement instruments in science education: A rasch modeling approach*. Science & Engineering Education Sources. IAP - Information Age Publishing, Inc.
- Mahtari, S., Misbah, M., & Suryati, S. (2019). Analysis of the ability of High school students in solving science literacy questions based on the rasch model. *Kasuari: Physics Education Journal (KPEJ)*, 2(1), 11-16. <https://doi.org/10.37891/kpej.v2i1.61>
- Millán, M. S., Pérez-Cabré, E., Romero, L. A., & Ramírez, N. (2014). Programmable diffractive lens for ophthalmic application. *Optical Engineering*, 53(6), 061709. <https://doi.org/10.1117/1.OE.53.6.061709>
- Nurhayati, N., & Angraeni, L. (2017). Analisis kemampuan berpikir tingkat tinggi mahasiswa (higher order thinking) dalam menyelesaikan soal konsep optika melalui model problem based learning. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*,

- 3(2), 119–126.
<https://doi.org/10.21009/1.03201>
- Paraboni, A. L., & da Costa, N. (2021). Improving the level of financial literacy and the influence of the cognitive ability in this process. *Journal of Behavioral and Experimental Economics*, 90, 101656. <https://doi.org/10.1016/j.socec.2020.101656>
- Prasetyani, E., Hartono, Y., & Susanti, E. (2016). Kemampuan berpikir tingkat tinggi siswa kelas xi dalam pembelajaran trigonometri berbasis masalah di sma negeri 18 palembang. *Jurnal Gantang*, 1(1), 34–44. <https://doi.org/10.31629/jg.v1i1.4>
- Rijke, W. J., Bollen, L., Eysink, T. H. S., & Tolboom, J. L. J. (2018). Computational thinking in primary school: An examination of abstraction and decomposition in different age groups. *Informatics in Education*, 17(1), 77–92. <https://doi.org/10.15388/infedu.2018.05>
- Risdianto, E., Darmawan, A., Kristiawan, M., Wachidi, & Riyanto. (2020). Rasch model analysis on the feasibility test of basic physics ii practical guide using augmented reality. *ARNP Journal of Engineering and Applied Sciences*, 15(4), 482–490.
- Rukmini, E. (2008). Deskripsi singkat revisi taksonomi bloom. *Majalah Ilmiah Pembelajaran*, 2. <https://journal.uny.ac.id/index.php/mip/article/view/7132>
- Saidfudin, M., Azrilah, A. A., Rodzo'an, N. A., Omar, M. Z., Zaharim, A., & Basri, H. (2010). Easier learning outcomes analysis using rasch model in engineering education research. *Latest Trends on Engineering Education*, 442–447. <https://www.semanticscholar.org/paper/Easier-learning-outcomes-analysis-using-Rasch-model-Saidfudin-Azrilah/b36f39a8b1bba3a6f59d9a1115b70b1a91623c57>
- Setiono, I. A., Suhandi, A., & Liliawati, W. (2021). Conceptual progression of K-10 student on the free-falling objects acceleration concept as an effect of E-CDCCText. *Journal of Physics: Conference Series*, 1806(1), 012026. <https://doi.org/10.1088/1742-6596/1806/1/012026>
- Setyorini, A., Yamtinah, S., Mahardiani, L., & Saputro, S. (2021). A rasch analysis of item quality of the chemical literacy assessment for investigating student's chemical literacy on chemical rate concepts. *European Journal of Educational Research*, 10(4), 1769–1779. <https://doi.org/10.12973/eu-er.10.4.1769>
- Sianturi, S., & Gultom, T. (2016). Analisis kesulitan belajar dan hubungannya dengan hasil belajar siswa pada mata pelajaran biologi siswa kelas x di sma negeri 1 sidikalang tahun pembelajaran 2015/2016. *Jurnal Pelita Pendidikan*, 4(1), 170–178. <https://doi.org/10.24114/jpp.v4i1.3694>
- Sumintono, B., & Widhiarso, W. (2015). *Aplikasi Pemodelan Rasch pada Assessment Pendidikan [Application of rasch modelling in educational measurement]*. Trimkom Publishing House.
- Suranti, N. M. Y., Gunawan, G., & Sahidu, H. (2017). Pengaruh model project based learning berbantuan media virtual terhadap penguasaan konsep peserta didik pada materi alat-alat optik. *Jurnal Pendidikan Fisika Dan Teknologi*, 2(2), 73–79. <https://doi.org/10.29303/jpft.v2i2.292>
- Ubaidillah, M., Marwoto, P., Wiyanto, W., Rusilowati, A., Subali, B., Mindyarto, B., & Isnarni, W. (2022). Development of habits of mind instruments in the context of basic

- physics practicum: EFA and Rasch Model. *Journal of Educational, Cultural and Psychological Studies (ECPS Journal)*, 26, 1. <https://doi.org/10.7358/ecps-2022-026-ubai>
- Wandari, G. A., Wijaya, A. F. C., & Agustin, R. R. (2018). The Effect of STEAM-based learning on students' concept mastery and creativity in learning light and optics. *Journal of Science Learning*, 2(1), 26. <https://doi.org/10.17509/jsl.v2i1.12878>
- Wati, M., Mahtari, S., Hartini, S., & Amelia, H. (2019). A rasch model analysis on junior high school students' scientific reasoning ability. *International Journal of Interactive Mobile Technologies (IJIM)*, 13(07), 141. <https://doi.org/10.3991/ijim.v13i07.10760>
- Wicaksono, A. G. C. (2016). Perbandingan kemampuan kognitif dan metakognitif mahasiswa dengan gaya belajar yang berbeda. *Media Penelitian Pendidikan*, 10(2), 142–153.
- Wicaksono, I., Wasis, W., & Madlazim, M. (2017). The effectiveness of virtual science teaching model (vs-tm) to improve student's scientific creativity and concept mastery on senior high school physics subject. *Journal of Baltic Science Education*, 16(4), 549–561. <https://doi.org/10.33225/jbse/17.16.549>
- Widiyatmoko, A., & Shimizu, K. (2018). The development of two-tier multiple choice test to assess students' conceptual understanding about light and optical instruments. *Jurnal Pendidikan IPA Indonesia*, 7(4). <https://doi.org/10.15294/jpii.v7i4.16591>
- Winarti, W. (2015). Profil kemampuan berpikir analisis dan evaluasi mahasiswa dalam mengerjakan soal Konsep Kalor. *Jurnal Inovasi Dan Pembelajaran Fisika*, 2(1), 19–24.
- Xie, Q., Zhong, X., Wang, W.-C., & Lim, C. P. (2014). Development of an item bank for assessing generic competences in a higher-education institute: A Rasch modelling approach. *Higher Education Research & Development*, 33(4), 821–835. <https://doi.org/10.1080/07294360.2013.863847>
- Yusuf, I., & Widyaningsih, S. W. (2020). Implementing e-learning-based virtual laboratory media to students' metacognitive skills. *International Journal of Emerging Technologies in Learning (IJET)*, 15(05), 63. <https://doi.org/10.3991/ijet.v15i05.12029>
- Yusuf, I., Widyaningsih, S. W., & Sebayang, S. R. B. (2018). Implementation of e-learning based-system on quantum physics subject to student hots ability. *Journal of Turkish Science Education*, 15, 67–75. <https://doi.org/10.12973/tused.10258a>
- Zoechling, S., Hopf, M., Woihe, J., & Schmeling, S. (2022). Students' interest in particle physics: Conceptualisation, instrument development, and evaluation using Rasch theory and analysis. *International Journal of Science Education*, 44(15), 2353–2380. <https://doi.org/10.1080/09500693.2022.2122897>