JPPIPA 10(2) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Students' Critical Thinking Ability Profile Using HOTS-Based Questions

M. Noris[1*], Misbahul Jannah[2], Margiyono Suyitno[3], Setria Utama Rizal[4]

[1] Universitas Muhammadiyah Bima, Indonesia.
[2] Universitas Islam Negeri Ar-Raniry Banda Aceh, Indonesia.
[3] STIT Madina Sragen, Sragen, Indonesia.
[4] Institut Agama Islam Negeri Palangka Raya, Indonesia.

Received: September 9, 2023
Revised: November 10, 2023
Accepted: February 25, 2024
Published: February 29, 2024

Corresponding Author:
M. Noris
muhammadnoris905@gmail.com

DOI: 10.29303/jppipa.v10i2.5435

Abstract: Critical thinking includes higher processes, such as analysis, synthesis, evaluation, conclusion, and reflection. This research aims to determine the profile level of students' critical thinking abilities. The research sample consisted of 28 students taken by random sampling consisting of 2 classes. Data was obtained through test and non-test techniques which included a critical thinking ability test using 20 questions. Meanwhile, the non-test uses an observation sheet on students' critical thinking abilities. Analysis of data obtained from the results of students' critical thinking skills tests was then analyzed using analysis items with the Rasch model. The results of the profile analysis of students' critical thinking skills were classified as moderate. This is proven by test results and observations in basic biology courses. Based on the results of tests on students' critical thinking skills, it is known that there are 16 students who have high levels of critical thinking skills, 5 students with moderate critical thinking skills, and 6 students with weak critical thinking skills. Meanwhile, the results of observations of the critical thinking abilities of Bima Muhammadiyah University students in basic biology courses are in the moderate critical thinking ability category with a category score of around 68.06%.

Keywords: Critical thinking ability; HOTS; HOTS instrument; Profile analysis

Introduction

Critical thinking ability is a skill that students must have. Critical thinking skills are proven to prepare students to think about various fields of knowledge in the cognitive domain (Rahman, 2018). According to (Facione, 2011), critical thinking skills consist of 6 dimensions, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. Meanwhile, according to (Marzano et al., 2009; Perdana, Budiyono, et al., 2019; Suyatman et al., 2021b, 2021a) that critical thinking skills are part of higher order abilities (HOTS). High-level thinking abilities must be empowered with learning models that can empower students' high-level thinking abilities.

One of the factors causing low critical thinking skills is the use of conventional learning methods such as lectures which are still accommodated by teachers. Traditional learning models like this cannot hone and develop students' critical thinking abilities (Nugraha et al., 2017; Rahman, 2018; Sismayani et al., 2019; Sulistiani et al., 2016). One learning model that can develop critical thinking skills is the problem based learning model. PBL is considered suitable for developing students' critical thinking skills because this learning model trains and emphasizes students to be actively involved (Nugraha et al., 2017; Sismayani et al., 2019). According to Khoiri (2013) said that problem based learning can improve problem solving skills, critical and creative skills, increase learning outcomes, communication skills, team work, adaptation to new knowledge, and self-evaluation.

The problem based learning model is a series of learning activities that emphasize the process of solving

How to Cite:
Noris, M., Jannah, M., Suyitno, M., & Rizal, S. U. (2024). Analysis of Students' Critical Thinking Ability Profile Using HOTS-Based Questions. *Jurnal Penelitian Pendidikan IPA*, *10*(2), 530–538. https://doi.org/10.29303/jppipa.v10i2.5435

problems faced scientifically. The problem based learning model emphasizes curiosity (Suhirman et al., 2021). PBL is active learning with an approach centered on the problem solving process (Khoiri, 2013). This will lead to meaningful learning (Abu-Ghaneema, 2018; Jiménez-Aleixandre et al., 2018). The use of the PBL model has proven to be much better than conventional learning such as discussions and lectures (Darhim et al., 2020). PBL can also improve critical thinking skills (Kardoyo et al., 2020). Apart from improving critical thinking skills, PBL can also improve speaking and argumentation skills (Chumsukon et al., 2021; Kaçar et al., 2020; Nurtamara et al., 2019; Perdana, Jumadi, et al., 2019). Critical thinking ability is a high level ability. Therefore, to empower students' high-level thinking abilities in biology courses, appropriate evaluation instruments are needed to empower HOTS abilities.

The low critical thinking abilities of students are also caused by the evaluation instruments used being relatively unable to empower students' critical thinking abilities. Therefore, there is a need for HOTS-based instruments to empower students' critical thinking skills, especially in biology courses. HOTS-based instruments are believed to be able to empower high-level thinking abilities, such as analytical thinking abilities (Suyatman et al., 2021b), critical thinking abilities (Thorndahl et al., 2020; van den Berg, 2004), collaborative abilities and problem solving (Gunawan et al., 2020; Makitalo et al., 2009; Papadouris, 2012; Shishigu et al., 2018), as well as innovative and creative abilities (Burke et al., 2023; Marthaliakirana et al., 2022).

The development of a HOTS-based evaluation instrument is expected to be able to empower students' critical thinking abilities. Therefore, this research aims to analyze the critical thinking ability profile of Bima Muhammadiyah University students in biology courses using a HOTS-based evaluation instrument.

Method

The research population was 85 students in the nutrition study program, faculty of health, Bima Muhammadiyah University. The research sample involved 28 students taken by random sampling consisting of 2 classes. Data was obtained through test and non-test techniques which included a critical thinking ability test using 20 question items. Meanwhile, the non-test uses an observation sheet on students' critical thinking abilities. Analysis of data obtained from students' critical thinking skills test results was then analyzed using item analysis with the Rasch model. The validity of the test items was measured using the Rasch model. According to Sumintono et al. (2015) items are declared valid or function normally in carrying out measurements if they meet the criteria in Table 1.

Table 1. Criteria for Determining the Validity of Question Items (Sumintono et al., 2015)

Aspect	Information
Outfit mean square (MNSQ)	0.5 < MNSQ < 1.5
Outfit Z-standard (ZSTD)	-2.0 < ZSTD < + 2.0
Point Measur Correlation	0.4 < Pt Measure Correlation < 0.85

Question items are declared invalid or do not function normally in carrying out measurements if they do not meet one of the three criteria above. If this happens then the question item is declared not good and needs to be repaired or replaced.

Table 2. Cronbach's Alpha Value Criteria

Scale	Interpretation
<0.5	Very Bad
0.5-0.6	Bad
0.6-0.7	Medium
0.7-0.8	Good
>0.8	Very good

Table 3. Criteria for Person Reliability and Item Reliability Values

Scale	Interpretation
<0.67	Weak
0.67-0.80	Enough
0.81-0.90	Good
0.91-0.94	Very Good
>0.94	Special

The observation stage is carried out after learning is completed to determine the level of students' critical thinking abilities. The results of observations of students' critical thinking abilities were analyzed after learning for 3 cycles. The formula for calculating the value of a student's critical thinking ability level is as follows:

$$P\ \frac{F}{N} x\ 100\ \% \quad (2)$$

Description:
P = Percentage (%)
F = Score obtained
N = Maximum score

Criteria for determining students' critical thinking abilities, calculated based on the score obtained according to (Suyatman et al., 2021a). Can be seen in table 4.

Table 4. Categories of Students' Critical Thinking Abilities

Interpretation Score (%)	Category
81.25 < X ≤ 100	Very High
71.50 < X ≤ 81.25	High
62.50 < X ≤ 71.50	Medium
43.75 < X ≤ 62.50	Low
0 < X ≤ 43.75	Very Low

Result and Discussion

Student Critical Thinking Ability Test Results

Based on the results of the analysis, the item reliability value is 0.83, Person Reliability is 0.00. which shows that the question items have high reliability. Meanwhile, Cronbach's Alpha value is 0.17 with weak criteria. This means that the level of consistency in students' answers is relatively low, and the quality of the questions on the test instrument used has quite good reliability, namely 0.83. It can be seen in Figure 1 below:

SUMMARY OF 28 MEASURED Person

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	6.0	20.0	-.95	.87	.84	-.5	1.48	-.3
S.D.	1.3	.0	.94	.07	1.10	1.8	2.70	1.6
MAX.	7.0	20.0	-.22	.92	4.42	5.0	9.90	3.7
MIN.	3.0	20.0	-2.89	.76	.11	-1.8	.10	-1.7

REAL RMSE	1.00	TRUE SD	.00	SEPARATION	.00	Person RELIABILITY .00
MODEL RMSE	.87	TRUE SD	.34	SEPARATION	.39	Person RELIABILITY .13
S.E. OF Person MEAN = .18						

Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .17

SUMMARY OF 15 MEASURED Item

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	11.1	28.0	.00	.71	.97	-.1	1.71	.3
S.D.	10.4	.0	2.44	.21	.15	.7	1.45	1.2
MAX.	24.0	28.0	2.63	1.01	1.16	.5	4.99	2.5
MIN.	1.0	28.0	-3.07	.44	.65	-1.8	.43	-1.8

REAL RMSE	.75	TRUE SD	2.32	SEPARATION	3.08	Item RELIABILITY .90
MODEL RMSE	.74	TRUE SD	2.33	SEPARATION	3.16	Item RELIABILITY .91
S.E. OF Item MEAN = .65						

MINIMUM EXTREME SCORE: 5 Item
UMEAN=.0000 USCALE=1.0000

SUMMARY OF 20 MEASURED (EXTREME AND NON-EXTREME) Item

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	8.4	28.0	.97	.98				
S.D.	10.2	.0	2.70	.51				
MAX.	24.0	28.0	3.86	1.81				
MIN.	.0	28.0	-3.07	.44	.65	-1.8	.43	-1.8

REAL RMSE	1.12	TRUE SD	2.46	SEPARATION	2.20	Item RELIABILITY .83
MODEL RMSE	1.11	TRUE SD	2.46	SEPARATION	2.22	Item RELIABILITY .83
S.E. OF Item MEAN = .62						

Item RAW SCORE-TO-MEASURE CORRELATION = -.98
420 DATA POINTS. LOG-LIKELIHOOD CHI-SQUARE: 253.91 with 378 d.f. p=1.0000
Global Root-Mean-Square Residual (excluding extreme scores): .2869
Capped Binomial Deviance = .0994 for 560.0 dichotomous observations

Figure 1. Item reliability values and Cronbach's alpha

Meanwhile, to review the fit and misfit questions, an analysis was carried out by looking at the MNSQ value in the Measure Order. The results of the measure order show that the quality of the question items that students can answer correctly can be identified by the number of students who can answer each question item correctly. The results of the analysis show that the most difficult or difficult question is question no. 2, 3, 5, 6, and 14. Question items in the easy category are shown in question numbers 12 and 17. The following are the results of the ministep test on fit and misfit question items, you can see Figure 2.

Item STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
2	0	28	3.86	1.81	MAXIMUM MEASURE				.00	.00	100.0	100.0	S2
3	0	28	3.86	1.81	MAXIMUM MEASURE				.00	.00	100.0	100.0	S3
5	0	28	3.86	1.81	MAXIMUM MEASURE				.00	.00	100.0	100.0	S5
6	0	28	3.86	1.81	MAXIMUM MEASURE				.00	.00	100.0	100.0	S6
14	0	28	3.86	1.81	MAXIMUM MEASURE				.00	.00	100.0	100.0	S14
4	1	28	2.63	1.01	1.06	.4	4.99	2.0	-.28	.11	96.4	96.3	S4
7	1	28	2.63	1.01	1.05	.4	2.76	1.3	-.16	.11	96.4	96.3	S7
8	1	28	2.63	1.01	1.05	.4	2.76	1.3	-.16	.11	96.4	96.3	S8
15	1	28	2.63	1.01	.96	.3	.65	.2	.15	.11	96.4	96.3	S15
1	2	28	1.88	.73	1.16	.5	4.79	2.5	-.40	.16	92.9	92.7	S1
9	2	28	1.88	.73	1.04	.3	1.66	.9	.00	.16	92.9	92.7	S9
11	2	28	1.88	.73	.95	.1	.66	-.1	.22	.16	92.9	92.7	S11
13	2	28	1.88	.73	1.10	.4	2.03	1.2	-.12	.16	92.9	92.7	S13
20	18	28	-1.64	.44	.66	-1.8	.62	-1.8	.76	.43	89.3	73.6	S20
10	22	28	-2.50	.50	1.04	.2	.94	.0	.39	.39	75.0	79.3	S10
16	22	28	-2.50	.50	.65	-1.4	.43	-1.6	.75	.39	82.1	79.3	S16
19	22	28	-2.50	.50	.79	-.8	.57	-1.1	.63	.39	82.1	79.3	S19
18	23	28	-2.76	.53	.86	-.4	.61	-.8	.54	.37	85.7	82.4	S18
12	24	28	-3.07	.58	1.06	.3	1.06	.3	.30	.34	85.7	85.7	S12
17	24	28	-3.07	.58	1.06	.3	1.06	.3	.30	.34	85.7	85.7	S17
MEAN	8.4	28.0	.97	.98	.97	-.1	1.71	.3			89.5	88.1	
S.D.	10.2	.0	2.70	.51	.15	.7	1.45	1.2			6.3	7.5	

Figure 2. Misfit order

The analysis results show that Question No. 2, 3, 5, 6, and 14 cannot be answered correctly by all students. Questions No. 12 and 17 could only be answered correctly by 24 students. Question 18 could only be answered correctly by 23 students. Question no. 16 and 19 can only be answered correctly by 22 students. Question no. 20 can only be answered correctly by 18 students. Question no. 1, 9, 11, and 13, can only be answered correctly by 2 students and questions no. 4, 7, 8, 15 could only be answered correctly by 1 student.

Item STATISTICS: MISFIT ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
4	1	28	2.63	1.01	1.06	.4	4.99	2.0	A-.28	.11	96.4	96.3	S4
1	2	28	1.88	.73	1.16	.5	4.79	2.5	B-.40	.16	92.9	92.7	S1
7	1	28	2.63	1.01	1.05	.4	2.76	1.3	C-.16	.11	96.4	96.3	S7
8	1	28	2.63	1.01	1.05	.4	2.76	1.3	D-.16	.11	96.4	96.3	S8
13	2	28	1.88	.73	1.10	.4	2.03	1.2	E-.12	.16	92.9	92.7	S13
9	2	28	1.88	.73	1.04	.3	1.66	.9	F .00	.16	92.9	92.7	S9
12	24	28	-3.07	.58	1.06	.3	1.06	.3	G .30	.34	85.7	85.7	S12
17	24	28	-3.07	.58	1.06	.3	1.06	.3	H .30	.34	85.7	85.7	S17
10	22	28	-2.50	.50	1.04	.2	.94	.0	g .39	.39	75.0	79.3	S10
15	1	28	2.63	1.01	.96	.3	.65	.2	f .15	.11	96.4	96.3	S15
11	2	28	1.88	.73	.95	.1	.66	-.1	e .22	.16	92.9	92.7	S11
18	23	28	-2.76	.53	.86	-.4	.61	-.8	d .54	.37	85.7	82.4	S18
19	22	28	-2.50	.50	.79	-.8	.57	-1.1	c .63	.39	82.1	79.3	S19
20	18	28	-1.64	.44	.66	-1.8	.62	-1.8	b .76	.43	89.3	73.6	S20
16	22	28	-2.50	.50	.65	-1.4	.43	-1.6	a .75	.39	82.1	79.3	S16
MEAN	8.4	28.0	.97	.98	.97	-.1	1.71	.3			89.5	88.1	
S.D.	10.2	.0	2.70	.51	.15	.7	1.45	1.2			6.3	7.5	

Information: *Mean = 0.97; SD = 0.15.*

Figure 3. Misfit order

Based on the Mean and SD values, the number of Logit Items can be determined. Sum of logit items from MEAN and S.D. is 0.97 + 0.15 = 1.12, so from this

criterion it can be seen which items are fit and which are misfit. Based on the value of the number of logit items from MEAN and S.D. namely 1.12 logit, the following information is obtained:

Table 5. Misfit and Fit questions

Question Number	INFIT MNSQ Value	Description
S4	1.06	Fit
S1	1.16	Misfit
S7	1.05	Fit
8	1.05	Fit
13	1.10	Fit
9	1.04	Fit
12	1.06	Fit
17	1.06	Fit
10	1.04	Fit
15	0.96	Fit
11	0.95	Fit
18	0.86	Fit
19	0.79	Fit
20	0.66	Fit
16	0.65	Fit

Based on the table above, it can be seen that there are three misfit items, namely S1, S2, S3, S5, S6, and S14. This means that the items do not function normally to be used in measurement (Sumintono et al., 2015) If it is found that a question is not suitable, this indicates that there is a misconception among students who are working on that question.

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)

		-- Empirical --		Modeled
Total raw variance in observations	=	43.6 100.0%		100.0%
Raw variance explained by measures	=	28.6 65.6%		62.3%
Raw variance explained by persons	=	4.4 10.0%		9.5%
Raw Variance explained by items	=	24.3 55.6%		52.8%
Raw unexplained variance (total)	=	15.0 34.4%	100.0%	37.7%
Unexplned variance in 1st contrast	=	4.9 11.3%	32.8%	
Unexplned variance in 2nd contrast	=	3.0 6.9%	20.2%	
Unexplned variance in 3rd contrast	=	2.0 4.5%	13.2%	
Unexplned variance in 4th contrast	=	1.5 3.4%	9.9%	
Unexplned variance in 5th contrast	=	1.1 2.5%	7.2%	

Figure 4. Raw variance value explained by measure

Based on the results of the Unidimensionality analysis, the Raw Variance Explained by Measure value is around 65.6%. Based on the test results, it can be seen that the raw data variance measurement results are around 65.6% in the Good category. This means that the test instruments or questions used are considered capable of measuring students' critical thinking abilities. This shows that the questions developed are HOTS based. Meanwhile, Pearson's ability to answer question items can be analyzed using the LVP table which can be seen in table 6.

Table 6. Pearson's Ability to Answer Questions Based on Higher Other Thinking Skills (HOTS)

Raw variance category	Description
< 50 %	Very Bad
50- 60 %	Bad
60-70 %	Good
70 -80 %	Very Good
.>80 %	Perfect

Based on the LVP table, information is obtained as to where students 05P, 06P, 07P, 08P, 10P, 15P, 16P, 19P, 20P, 21L, 22P, 23P, 26P, 27P, and 28P are able to answer difficult questions, then it can be ascertained that these students can answer moderate and easy questions. 03P, 12P, 25L, 11P, and 14 L students were able to answer questions in the medium category. So it is certain that the student can answer easy questions. Students 01P, 02L 13P, 17P, 18P, and 24P can answer easy questions. However, the student was unable to answer questions in the medium and difficult categories. 04P students, questions in the easy category cannot be answered, especially with questions in the medium and difficult categories, so it is certain that the student cannot answer. Can be seen in the figure 5.

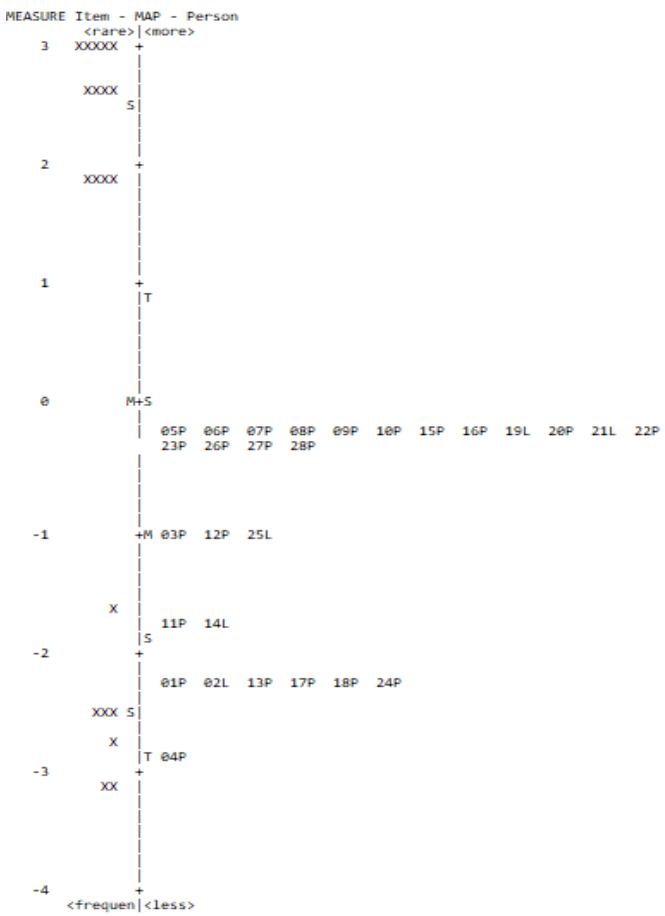

Figure 5. Measure item-MAP-Pearson

The division of person abilities in the LVP WinSteps table can be done by determining the minimum and maximum logit values for each ability category. Each individual will be given a logit value based on the results of the analysis of item responses on the questionnaire carried out using WinSteps. Then, the individual logit value will be placed in one of the ability categories that have been determined in the WinSteps LVP table.

Table 7. Individual Logit Values

Label	Man	Woman	Total
High	2	14	16
Medium	2	3	5
Low	1	5	6
Very Low	0	0	1

Based on the results of LVP WinSteps, it was found that there were 16 students with high level critical thinking skills, consisting of 2 men and 14 women. In the category of students with moderate critical thinking abilities, there were 5 students consisting of 2 men and 3 women. Meanwhile, in the category of students with low critical thinking skills, there are 6 students consisting of 1 male and 5 females and there is 1 female student with very low abilities. So it can be concluded that gender differences in students do not affect students' ability to solve questions in the difficult category.

The results of research using the PBL model which was carried out for 3 cycles and then given HOTS-based questions to improve students' critical thinking skills showed a better level of students' critical thinking abilities. This can be seen from the Cronbach alpha value of around 0.1 with weak criteria, but the Pearson reliability level is very good with a value of 0.91. According to Fakhriyah (2014) PBL learning emphasizes constructing knowledge based on understanding and experience gained both individually and as a group. The PBL model is based on factual problems faced in everyday life so that it encourages students to pay more attention to solving problems. PBL is proven to improve students' critical thinking skills (Kardoyo et al., 2020; Noris, Suyitno, et al., 2023).

Learning with PBL is learning based on discovery. In line with Brunner's theory (Ellerton, 2022; Takaya, 2008) which suggests that discovery-based learning helps in the process of knowledge reconstruction. Apart from that, PBL provides good attention to students to carry out a series of scientific processes in the problem solving process. This is in line with Dewey's theory (Mamun et al., 2020; Sutarto, 2017; Thorburn, 2018) which emphasizes problem solving abilities. more strongly supported by information processing theory (Feigenbaum, 2003; Kandarakis et al., 2008; Lutz et al., 2003) which states that the absolute requirements for moving towards memory or long-term memory are good attention and perception to receive information. PBL-based learning will lead to meaningful learning (Abu-Ghaneema, 2018; Adams et al., 2022; Kostiainen et al., 2018). This means that PBL-based learning can improve students' critical thinking skills (Miftakhurrohmah et al., 2023; Noris, Saputro, & Muzzazinah, 2023; Noris, Saputro, Muzzazinah, et al., 2023).

Observation Stages

Based on the results of observations, the critical thinking abilities of Bima Muhammadiyah University students in basic biology courses are in the moderate critical thinking ability category with a category score of around 68.06%. This can be seen in table 8.

Table 8. Observation Results of Students' Critical Thinking Abilities Using the PBL Model

Indicator of Critical Thinking Abilities	Cycle I	Cycle II	Cycle III	Total	Mean Score (%)	Category	Score Category (%)	Category
Interpretation	3	4	3	10	83.33	Very High	68.06	Medium
Analysis	2	4	3	9	75.00	High		
Inference	3	3	3	9	75.00	High		
Evaluation	3	3	2	8	66.67	Medium		
Explain	3	3	3	5	75.00	High		
Self Regulation	1	2	1	4	33.33	Very Low		

The observation results show that students' critical thinking abilities are moderate. However, if viewed based on aspects and indicators of critical thinking skills, it can be seen that students have very high interpreting abilities (83.33%). Meanwhile, the ability to analyze and infer is relatively high with each category mean around 75.00%. The ability to evaluate (66.67%) is moderate, and the ability to self-regulate (33.33%) is very low.

The observation results show that the level of students' critical thinking skills is relatively moderate. This is natural because students have experienced difficulties in carrying out evaluations and conclusions so that this has an impact on their self-regulation skills. In line with research conducted by (Suyatman et al., 2021a), where they experience difficulty in analyzing and formulating complex problems. These obstacles

cause low critical thinking abilities in every aspect (Lapuz et al., 2020; Masruro et al., 2021; Miftakhurrohmah et al., 2023; Ramadani et al., 2021; Utami et al., 2017).

In this case, critical thinking includes higher processes, such as analysis, synthesis, evaluation, conclusion, and reflection, that enable individuals to make reasonable judgments both in the classroom, in the classroom, and in everyday life (Utami et al., 2017). So it is not surprising that students' critical thinking skills are a top priority in education today.

The importance of critical thinking skills was stated by Ellerton (2022) views critical thinking skills as a complex combination of knowledge and skills needed in the long term. More than that, Anderson et al. (2010) considers that critical thinking skills are high level skills (HOTS). Within critical thinking skills there is the ability to analyze. Afandi et al. (2018) suggests that analytical thinking abilities are part of critical thinking abilities which are classified as high-level skills.

To measure critical thinking skills, appropriate instruments are needed that can measure critical thinking skills. According to Rahayu et al. (2023) the right instrument to measure critical thinking skills is a HOTS-based instrument too. More clearly stated by Ichsan et al. (2019) that students who have HOTS will be able to analyze, evaluate and create innovations in solving problems well and precisely.

Conclusion

The results of the profile analysis of students' critical thinking skills were classified as moderate. This is proven by test results and observations in basic biology courses. Based on the results of tests on students' critical thinking skills, it is known that there are 16 students who have high levels of critical thinking skills, 5 students with moderate critical thinking skills, and 6 students with weak critical thinking skills. Meanwhile, the results of observations of the critical thinking abilities of Bima Muhammadiyah University students in basic biology courses are in the moderate critical thinking ability category with a category score of around 68.06%.

Acknowledgments
Acknowledgments are given to fellow lecturers who have helped review the documents.

Author Contributions
Conceptualizing research, M.N, M.J, M.S, S.U.R.; designing, M.N, M.J.; Collecting Data, M.N,M.J,M.S,S.U.R.; Analyzing data, M.N.; compiling manuscripts, M.N, M.J.; Revise the Data, M.J, M.N.; Submiting, M.N.; Revise the Manuscript, M.N, S.U.R, M.S.

Funding
This research was independently funded by researchers.

Conflict of Interest
No conflicts of interest.

References

Abu-Ghaneema, E. (2018). Meaningful Learning: The Main Constitutive and Consecutive Components and their Presence in Science Teaching. *Yearbook of Pedagogy*, *41*(1), 183–192. https://doi.org/10.2478/rp-2018-0013

Adams, T., Koster, B., & Brok, P. den. (2022). Patterns in student teachers' learning processes and outcomes of classroom management during their internship. *Teaching and Teacher Education*, *120*, 103891. https://doi.org/10.1016/j.tate.2022.103891

Afandi, A., Sajidan, S., Akhyar, M., & Suryani, N. (2018). Pre-Service Science Teachers' Perception About High Order Thinking Skills (HOTS) in the 21st Century. *International Journal of Pedagogy and Teacher Education*, *2*(1), 107. https://doi.org/10.20961/ijpte.v2i1.18254

Anderson, L. W., & Krathwohl, D. R. (2010). *A Taxonomy for Learning, Teaching and Assessing, a Bridged Edition*. Longman.

Burke, C. M., & Morley, M. J. (2023). Toward a non-organizational theory of human resource management? A complex adaptive systems perspective on the human resource management ecosystem in (con)temporary organizing. *Human Resource Management*, *62*(1), 31–53. https://doi.org/10.1002/hrm.22132

Chumsukon, M., & Ruangsan, N. (2021). Integration of RBL and CLR to Enhance Analytical Thinking Skills of Pre-Service Teachers. *Review of International Geographical Education Online*, *11*(5), 2591–2598. https://doi.org/10.33403/rigeo.11.05.156

Darhim, Prabawanto, S., & Susilo, B. E. (2020). The effect of problem-based learning and mathematical problem posing in improving student's critical thinking skills. *International Journal of Instruction*, *13*(4), 103–116. https://doi.org/10.29333/iji.2020.1347a

Ellerton, D. P. (2022). On critical thinking and content knowledge: A critique of the assumptions of cognitive load theory. *Thinking Skills and Creativity*, *43*(November 2021), 100975. https://doi.org/10.1016/j.tsc.2021.100975

Facione, P. a. (2011). Critical Thinking : What It Is and Why It Counts. In *Insight assessment* (Issue ISBN 13: 978-1-891557-07-1.).

Fakhriyah, F. (2014). Penerapan problem based learning

dalam upaya mengembangkan kemampuan berpikir kritis mahasiswa. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 95–101. https://doi.org/10.15294/jpii.v3i1.2906

Feigenbaum, E. A. (2003). Well-Being. In M. H. Bornstein, L. Davidson, C. L. M. Keyes, & K. A. Moore (Eds.), *Well-Being: Positive Development Across the Life Course*. Psychology Press. https://doi.org/10.4324/9781410607171

Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving students' problem-solving skills using inquiry learning model combined with advance organizer. *International Journal of Instruction*, *13*(4), 427–442. https://doi.org/10.29333/iji.2020.13427a

Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Ali, A., Arif, W. P., & Prayitno, T. A. (2019). HOTS-AEP: Higher order thinking skills from elementary to master students in environmental learning. *European Journal of Educational Research*, *8*(4), 935–942. https://doi.org/10.12973/eu-jer.8.4.935

Jiménez-Aleixandre, M. P., & Evagorou, M. (2018). Argumentation in Biology Education. In *Teaching Biology in Schools: Global Research, Issues, and Trends* (pp. 249–262). Taylor and Francis. https://doi.org/10.4324/9781315110158-20

Kaçar, S., Ormancı, Ü., Özcan, E., & Balım, A. G. (2020). Concept Cartoon Samples Integrated into Problem Based Learning in a Science Course. *Journal of Inquiry Based Activities*, *10*(2), 127–145. https://files.eric.ed.gov/fulltext/EJ1273622.pdf

Kandarakis, A. G., & Poulos, M. s. (2008). Teaching Implications of Information Processing Theory and Evaluation Approach of learning Strategies using LVQ Neural Network. *Engineering Education*, *5*(3), 111–119. Retrieved from http://www.wseas.us/e-library/transactions/education/2008/education-ex.pdf

Kardoyo, Nurkhin, A., Muhsin, & Pramusinto, H. (2020). Problem-based learning strategy: Its impact on students' critical and creative thinking skills. *European Journal of Educational Research*, *9*(3), 1141–1150. https://doi.org/10.12973/EU-JER.9.3.1141

Khoiri, W. (2013). *Implementasi Model Problem Based Learning Berbantuan Multimedia Untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa Kelas Vii Smp Negeri 4 Kudus*.

Kostiainen, E., Ukskoski, T., Ruohotie-Lyhty, M., Kauppinen, M., Kainulainen, J., & Mäkinen, T. (2018). Meaningful learning in teacher education. *Teaching and Teacher Education*, *71*, 66–77. https://doi.org/10.1016/j.tate.2017.12.009

Lapuz, A. M., & Fulgencio, M. (2020). Improving the Critical Thinking Skills of Secondary School Students Using Problem-Based Learning. *Online Submission*, *4*(1), 1–7. https://doi.org/10.5281/zenodo.3969232

Lutz, S. T., & Huitt, W. G. (2003). Information Processing and Memory: Theory and Applications. *Educational Psychology Interactive*, 1–17. Retrieved from http://www.edpsycinteractive.org/topics/cognition/infoproc.html

Makitalo, A., Jakobsson, A., & Saljo, R. (2009). Learning to Reason in the Context of Socioscientific Problems: Exploring the demands on students in 'new' classroom activities: Exploring the demands on students in 'new' classroom activities. In *Investigating Classroom Interaction: Methodologies in Action* (pp. 7–26). Brill. https://doi.org/10.1163/9789087907624_003

Mamun, M. A. Al, Lawrie, G., & Wright, T. (2020). Instructional design of scaffolded online learning modules for self-directed and inquiry-based learning environments. *Computers and Education*, *144*(September 2019), 103695. https://doi.org/10.1016/j.compedu.2019.103695

Marthaliakirana, A. D., Suwono, H., Saefi, M., & Gofur, A. (2022). Problem-based learning with metacognitive prompts for enhancing argumentation and critical thinking of secondary school students. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(9). https://doi.org/10.29333/ejmste/12304

Marzano, R. J., Pickering, D. J., Arredondo, D. E., Blackburn, G. J., Brandt, R. S., Moffett, C. A., Paynter, D. E., Pollock, J. E., & Whisler, J. S. (2009). *Dimensions of learning teacher's manual, 2nd edition*.

Masruro, S., Sudibyo, E., & Purnomo, T. (2021). Profile of Problem Based Learning to Improve Students' Critical Thinking Skills. *IJORER: International Journal of Recent Educational Research*, *2*(6), 682–699. https://doi.org/10.46245/ijorer.v2i6.171

Miftakhurrohmah, N. L., Masykuri, M., Ariyani, S. R. D. A., & Noris, M. N. (2023). Effect of Guided Inquiry-Based Excretion System E-Module to Improve Critical Thinking and ICT Literacy Skills for Students. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 681–689. https://doi.org/10.29303/jppipa.v9i2.2036

Noris, M., Saputro, S., & Muzzazinah. (2023). The Development of Problem Based Learning-Based Virtual Laboratory Media to Improve Critical Thinking Ability of Junior High School Students. *AIP Conference Proceedings*, *2805*(1). https://doi.org/10.1063/5.0147995

Noris, M., Saputro, S., Muzzazinah, M., & Rahayu, A. (2023). Development of Biology Learning Media Assisted by Construct2 to Improve Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 498–504.

https://doi.org/10.29303/jppipa.v9i2.1921

Noris, M., Suyitno, M., Utama Rizal, S., Lazuardy Firdiansyah, A., & Sukamdi, S. (2023). Implementation of Guided Inquiry Learning-Based Electronic Modules to Improve Student's Analytical Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1242–1250. https://doi.org/10.29303/jppipa.v9i3.3401

Nugraha, A. J., Suyitno, H., & Susilaningsih, E. (2017). Analisis kemampuan berpikir kritis ditinjau dari keterampilan proses sains dan motivasi belajar melalui model PBL. *Journal of Primary Education*, *6*(1), 35–43. https://doi.org/10.15294/jpe.v6i1.14511

Nurtamara, L., Sajidan, S., Suranto, S., & Prasetyanti, N. M. (2019). The Effect of Biotechology Module with Problem Based Learning in the Socioscientific Context to Enhance Students' Socioscientific Decision Making Skills. *International Education Studies*, *13*(1), 11. https://doi.org/10.5539/ies.v13n1p11

Papadouris, N. (2012). Optimization as a reasoning strategy for dealing with socioscientific decision-making situations. *Science Education*, *96*(4), 600–630. https://doi.org/10.1002/sce.21016

Perdana, R., Budiyono, Sajidan, & Sukarmin. (2019). Analysis of Student Critical and Creative Thinking (CCT) Skills on Chemistry: A Study of Gender Differences. *Journal of Educational and Social Research*, *9*(4), 43–52. https://doi.org/10.2478/jesr-2019-0053

Perdana, R., Jumadi, J., & Rosana, D. (2019). Relationship between Analytical Thinking Skill and Scientific Argumentation Using PBL with Interactive CK 12 Simulation. *International Journal on Social and Education Sciences*, *1*(1), 16–23. Retrieved from https://interactives.ck12.org/simulations/physics.html.

Rahayu, S., & Rosawati, E. E. (2023). The development of higher-order thinking skills (HOTS) assessment instrument in chemistry using socioscientific issues context: A preliminary trial. *2021 Education of Science, Technology, Engineering, and Mathematics International Conference (ESTEMIC) 2021*, *2572*. https://doi.org/10.1063/5.0118624

Rahman, A. (2018). Profil Kemampuan Berpikir Kritis Dan Kemampuan Metakognitif Siswa Berdasarkan Jenis Kelamin. *Jurnal Pendidikan Biologi*, *10*(1), 28. https://doi.org/10.17977/um052v10i1p28-43

Ramadani, A. S., Supardi, Z. A. I., Tukiran, & Hariyono, E. (2021). Profile of Analytical Thinking Skills Through Inquiry-Based Learning in Science Subjects. *Studies in Learning and Teaching*, *2*(3), 45–60. https://doi.org/10.46627/silet.v2i3.83

Shishigu, A., Hailu, A., & Anibo, Z. (2018). Problem-based learning and conceptual understanding of college female students in physics. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(1), 145–154. https://doi.org/10.12973/ejmste/78035

Sismayani, Khairil, & Kasmirudin. (2019). Kemampuan Berpikir Kritis menggunakanPenerapan Model Problem Based Learning (PBL) danStudent Team Achievementdivision (STAD) Pada Pembelajaran Biologi di SMP Negeri 20 Seluma. *Seminar Nasional Sains*, 1–7. Retrieved from http://conference.upgris.ac.id/index.php/snse/article/view/188%0Ahttps://conference.upgris.ac.id/index.php/snse/article/download/188/120

Suhirman, S., Prayogi, S., & Asy'ari, M. (2021). Problem-Based Learning with Character-Emphasis and Naturalist Intelligence: Examining Students Critical Thinking and Curiosity. *International Journal of Instruction*, *14*(2), 217–232. https://doi.org/10.29333/iji.2021.14213a

Sulistiani, E., & Masrukan. (2016). Pentingnya Berpikir Kritis dalam Pembelajaran Matematika untuk Menghadapi Tantangan MEA. *Seminar Nasional Matematika X Universitas Semarang 2016*, 605–612. http://dx.doi.org/10.31604/ptk.v3i2.107-114

Sumintono, B., & Widhiarso, W. (2015). *Aplikasi pemodelan RascH Pada Assessment Pendidikan*. Trim Komunikata Publishing House.

Sutarto, S. (2017). Teori Kognitif dan Implikasinya Dalam Pembelajaran. *Islamic Counseling: Jurnal Bimbingan Konseling Islam*, *1*(2), 1. https://doi.org/10.29240/jbk.v1i2.331

Suyatman, Saputro, S., Sunarno, W., & Sukarmin. (2021a). Profile of student analytical thinking skills in the natural sciences by implementing problem-based learning model. *Journal of Educational, Cultural and Psychological Studies*, *2021*(23), 89–111. https://doi.org/10.7358/ecps-2021-023-suya

Suyatman, Saputro, S., Sunarno, W., & Sukarmin. (2021b). The Conceptual Framework for Problem and Research-Based Learning (PRBL) Model in Learning the Natural Sciences to Empower Students' Analytical Thinking Skills. *Journal of Physics: Conference Series*, *1842*(1). https://doi.org/10.1088/1742-6596/1842/1/012051

Takaya, K. (2008). Jerome Bruner's theory of education: From early Bruner to later Bruner. *Interchange*, *39*(1), 1–19. https://doi.org/10.1007/s10780-008-9039-2

Thorburn, M. (2018). John Dewey, subject purposes and schools of tomorrow: A centennial reappraisal of the educational contribution of physical education.

Learning, Culture and Social Interaction, *19*(December 2017), 22–28. https://doi.org/10.1016/j.lcsi.2018.04.001

Thorndahl, K. L., & Stentoft, D. (2020). Thinking critically about critical thinking and prob-lem-based learning in higher education: A scoping review. *Interdisciplinary Journal of Problem-Based Learning*, *14*(1), 1–21. https://doi.org/10.14434/ijpbl.v14i1.28773

Utami, B., Saputro, S., Ashadi, A., Masykuri, M., & Widoretno, S. (2017). Critical thinking skills profile of high school students in learning chemistry. *International Journal of Science and Applied Science: Conference Series*, *1*(2), 124. https://doi.org/10.20961/ijsascs.v1i2.5134

van den Berg, G. (2004). The use of assessment in the development of higher-order thinking skills. *Africa Education Review*, *1*(2), 279–294. https://doi.org/10.1080/18146620408566285