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Study of metacognitive awareness at the individual level of students across study programs using Rasch modeling

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Abstract
Evaluating students' metacognitive awareness is necessary to identify weaknesses and strengths in managing their cognition, which can help develop effective cognitive regulation to overcome academic challenges. Therefore, this research aims to examine students' level of metacognitive awareness using Rasch modeling. Survey research was conducted on 122 students at FKIP. Metacognitive awareness was evaluated using the 18-item Jr. MAI, and each item uses a 5-point Likert rating scale. Jr. MAI in the Google form is distributed for 2–3 weeks. Metacognitive awareness data was analyzed using the Logit Value of Person (LVP) approach and the Person Wright Map in Rasch modeling. The analysis results show that the distribution of metacognitive awareness shows that the majority of physics education students tend to have a higher level of metacognitive awareness, while the distribution of metacognitive awareness among elementary school teacher education students is more even across all categories. The implication of this research is the need to develop effective cognitive regulation in overcoming academic challenges through evaluating students' metacognitive awareness.

Keywords: Metacognitive awareness, Rasch Modeling, Logit Value of Person, Wright map

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I. Introduction

Numerous academic works have documented the significant contribution of metacognition to students' learning experiences. Positive correlations have been found between the capacity to monitor and control learning and improved academic performance, as well as the well-being and health of students [1]–[3]. Selective perception, encoding and retrieving from long-term memory, storing and organizing short-term memory, and maintaining and controlling focus are all actively influenced by metacognition [4]. Learning at different educational levels is empirically enhanced by the application of metacognitive strategies and skills [2], [5]–[8]. Student test results, or GPA, positively correlate with metacognitive strategies [9], [10].

Various studies have shown the role of metacognition in improving academic achievement, such as learning outcomes [11], [12], and problem-solving abilities [13]. Coutinho [14] found a positive correlation between metacognitive abilities and academic achievement. The academic achievement of students with high metacognitiveness will be better than that of those with lower metacognitiveness [15].

Evaluating students' metacognitive awareness needs to be done to map the weaknesses and strengths of students' cognitive management. Appropriate mapping will help students have effective cognitive regulation in solving the academic problems they face. Metacognitive awareness will help students understand information, overcome difficulties, and monitor the progress of their academic achievements. So, it will have an impact on improving academic performance.

The Indonesian national education curriculum mandates metacognitive skills for high school students [16]. This is confirmed in the Minister of Education and Culture Regulation of the Republic of Indonesia Number 37 of 2018 [17]. Research on metacognitive awareness has been widely carried out, for example, in the development of metacognitive awareness self-report instruments [1], [18]–[20], the process of adapting self-reports to various cultural contexts [3], [21]–[26], and the implementation of self-report in primary and secondary education [16], [27]–[31]. The study results show limited information regarding the application of self-report instruments to assess students' metacognitive awareness, especially in the FKIP at Ahmad Dahlan University. Meanwhile, studies of metacognitive awareness at the student level also need to be carried out. Therefore, this research aims to examine the level of metacognitive awareness at the individual student level in the FKIP UAD environment using Rasch modeling.

II. Methods

This research is included in quantitative survey-type research. The student metacognitive awareness survey was conducted using a Google form, which was distributed via student and lecturer WhatsApp groups. The respondents involved in this research were 120 students from various study programs within the Faculty of Teaching and Education at Ahmad Dahlan University. Fifty-seven respondents from the Physics Education Study Program and Elementary School Teacher Education were used as the main subjects. The sampling technique used was convenience sampling [32].

Data collection was carried out using the Jr. metacognition awareness instrument. The MAI was previously adapted by Sukarelawan et al. [26]. Jr. MAI consists of 18 items spread into two dimensions: knowledge of cognition (KoC, 9 items) and regulation of cognition (RoC, 9 items). Each item in the Jr.MAI uses a 5-point Likert rating scale ranging from 1 (never) to 5 (always).

The procedure that will be carried out in this research begins with formatting a metacognitive awareness instrument in the form of a Google form. At the same time, research permits are processed. After the research permit is issued, the data collection process will take approximately 2–3 weeks. After the data collection process is carried out, the data screening process and data analysis will continue. At the end of the research, the process of compiling mandatory and additional outputs and preparing a report will be carried out. Schematically, the research procedures and stages are depicted in Figure 1.

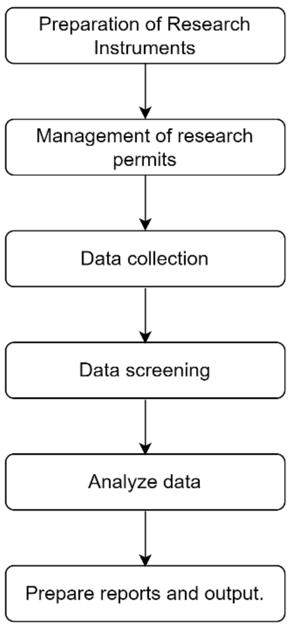

Figure 1. Research flow diagram

Students' metacognitive awareness was analyzed using Rasch modeling. This model refers to modern test theory, which has several advantages over classical test theory. For example, modern test theory can overcome missing data and reliability using Cronbach's alpha and person and item aspects [33]. In addition, Rasch modeling can facilitate analysis down to the individual level. By using Rasch modeling, quantitative and qualitative information can be obtained.

The software used to analyze metacognitive awareness was Winsteps version 4.6.1 [34]. Technique Specifically, students' metacognitive awareness was analyzed using the Logit Value of Person (LVP) combined with Person Wright Map (PWM) visualization [35]. The combination of LVP and PWM makes it possible to map students' metacognitive awareness in detail down to the individual level. The Logit Value of a Person (LVP) can explain metacognitive awareness quantitatively, and the Person Wright Map (PWM) can explain metacognitive awareness qualitatively.

III. Results and discussion

Jr. MAI Quality

1. Reliability

The reliability of the instruments used was evaluated based on those shown in Table 1 and Table 2.

Table 1. Person Reliability

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	67.0	18.0	1.32	.36	1.03	-.20	1.03	-.22
SEM	.8	.0	.09	.00	.07	.17	.07	.17
P.SD	8.3	.0	1.03	.03	.72	1.88	.71	1.88
S.SD	8.3	.0	1.04	.03	.73	1.88	.71	1.89
MAX.	82.0	18.0	3.55	.45	5.21	6.92	4.39	6.05
MIN.	27.0	18.0	-3.02	.31	.13	-4.26	.13	-4.27

REAL RMSE .41	TRUE SD .95	SEPARATION 2.29	Person RELIABILITY .84
MODEL RMSE .36	TRUE SD .97	SEPARATION 2.65	Person RELIABILITY .88
S.E. OF Person MEAN = .09			

CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .88 SEM = 2.85

Table 2. Item Reliability

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	446.7	120.0	.00	.14	1.00	-.09	1.03	.07
SEM	10.6	.0	.19	.00	.05	.38	.07	.47
P.SD	43.7	.0	.78	.01	.21	1.57	.28	1.94
S.SD	44.9	.0	.80	.01	.21	1.62	.28	1.99
MAX.	491.0	120.0	2.13	.15	1.53	3.62	1.92	5.66
MIN.	322.0	120.0	-.87	.12	.68	-2.72	.67	-2.85

REAL RMSE .15	TRUE SD .77	SEPARATION 5.29	Item RELIABILITY .97
MODEL RMSE .14	TRUE SD .77	SEPARATION 5.48	Item RELIABILITY .97
S.E. OF Item MEAN = .19			

The person separation index is a measure that indicates how well the metacognitive instrument used can separate individuals who have different levels of ability [37]–[39]. Index 2.29 shows that the metacognitive instrument used has quite good abilities for separating individuals who differ in the abilities measured [40]–[42]. However, higher values are usually desired to ensure that the metacognitive instrument used can better differentiate between individuals with different abilities. The person reliability value of 0.84 shows the extent to which the metacognitive instrument consistently measures individual abilities [43], [44]. This value is at a fairly good level because the closer it is to 1, the better the measuring instrument is at providing consistent measurements of the same individual if measured multiple times.

The item separation index shows how well the metacognitive instrument can separate the items used to measure metacognitive awareness variables [37], [45]. Index 5.29 indicates that the metacognitive instrument used has a very good ability to separate the items used. This shows that the items used have high sensitivity in measuring the desired metacognitive awareness variable. A reliability of 0.97 indicates how consistently the items in the metacognitive instrument can measure metacognitive awareness variables [46], [47]. This very high value indicates that the items used consistently measure the desired metacognitive awareness and provide similar results when tested repeatedly.

Based on the data provided, the metacognitive instrument used is highly reliable in terms of individual (person) and item measurements. However, further improvements are needed, especially in strengthening the ability of metacognitive instruments to differentiate between individuals or items with greater differences in ability levels.

2. Item Fit

The fit of the items to Rasch modeling is shown in Table 3.

Table 3. Item Fit to Rasch modeling

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
1	409	120	.74	.13	1.01	.15	1.03	.28	.57	.59	54.2	53.1	S1
2	491	120	-.87	.15	.93	-.54	.94	-.44	.66	.55	54.2	58.3	S2
3	448	120	.02	.14	1.13	1.01	1.26	1.89	.44	.57	58.3	56.2	S3
4	469	120	-.40	.14	1.00	.07	1.03	.26	.55	.57	62.5	56.9	S4
5	449	120	.00	.14	1.09	.70	1.08	.68	.54	.57	55.0	56.2	S5
6	322	120	2.13	.12	1.22	1.73	1.23	1.74	.45	.59	44.2	49.5	S6
7	452	120	-.06	.14	.99	-.07	1.00	.08	.59	.57	65.0	56.3	S7
8	472	120	-.46	.14	.80	-1.64	.80	-1.62	.63	.56	65.8	57.4	S8
9	488	120	-.81	.15	1.18	1.36	1.13	1.02	.60	.56	53.3	58.2	S9
10	446	120	.06	.14	.98	-.11	.99	-.04	.60	.58	65.0	55.9	S10
11	481	120	-.65	.15	.94	-.39	.96	-.25	.60	.56	63.3	58.0	S11
12	466	120	-.34	.14	.70	-2.53	.69	-2.66	.69	.57	68.3	56.9	S12
13	458	120	-.18	.14	.76	-1.92	.76	-1.98	.70	.57	62.5	56.3	S13
14	479	120	-.61	.15	.82	-1.40	.80	-1.68	.73	.56	64.2	57.7	S14
15	432	120	.32	.14	.68	-2.72	.67	-2.85	.59	.58	66.7	54.9	S15
16	478	120	-.59	.15	.94	-.44	.95	-.36	.61	.56	62.5	57.7	S16
17	446	120	.06	.14	1.21	1.52	1.21	1.56	.57	.58	59.2	55.9	S17
18	354	120	1.65	.12	1.53	3.62	1.92	5.66	.28	.59	47.5	51.5	S18
MEAN	446.7	120.0	.00	.14	1.00	-.1	1.03	.1			59.5	55.9	
P.SD	43.7	.0	.78	.01	.21	1.6	.28	1.9			6.6	2.3	

In Rasch modeling, Infit and Outfit MnSq are used to evaluate the suitability of items to the Rasch model [32], [48]. The range of values given for Infit MnSq is between 0.68 and 1.53, and for Outfit MnSq, it is between 0.67 and 1.92. There is an acceptable goodness-of-fit range from 0.5 to 1.5, which is considered ideal in Rasch modeling [26], [49], [50]. In general, Infit and Outfit MnSq values within this range indicate a good fit between the items measured by the Rasch model. However, there are exceptions where a value of up to 2.0 is still acceptable because it does not significantly reduce the quality of the metacognitive instrument used [40].

Although most of the Infit and Outfit MnSq values are within the desired acceptable range, the presence of a few values slightly outside the limits (but still below 2.0) does not substantially affect the quality of the metacognitive instrument used. This indicates that most of the items in the measurement meet the standards required in the Rasch model, although some items have response patterns that are slightly different from what the model expects.

In the overall analysis, most of the items on the metacognitive instrument fit well with the Rasch model, and one item fit slightly outside ideal limits. However, the metacognitive instrument used can still be considered good in measuring the metacognitive awareness studied based on evaluating its suitability for the Rasch model. This has an impact on measurement certainty and increases measurement efficiency. Accurate and precise measurements will increase efficiency in decision-making or intervention.

3. Rating Scale

The functional distribution of the Likert rating scale used in the metacognitive awareness instrument is shown in Figure 2.

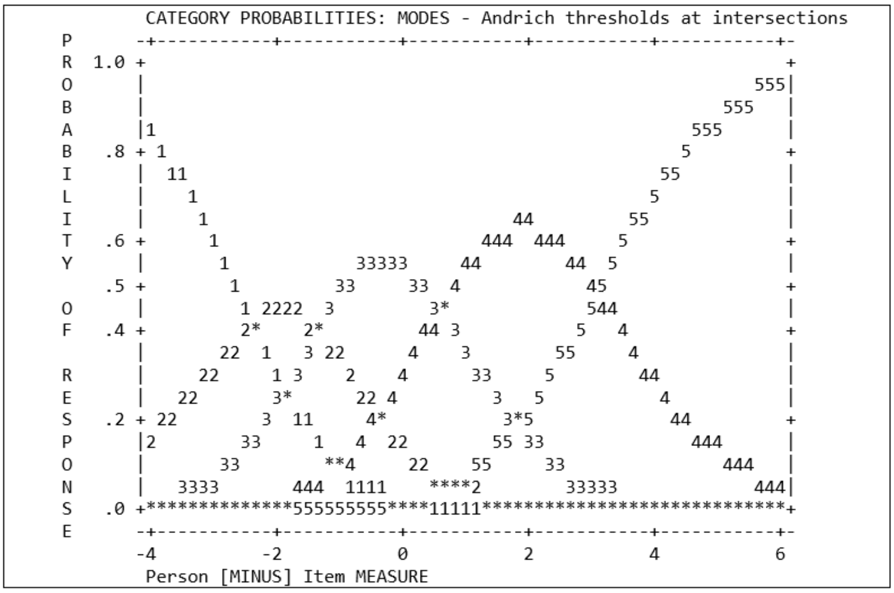

Figure 2. Distribution of Likert rating scale functionality

The probability of response graph in Figure 2 was used in evaluating the functionality of the 5-point Likert rating scale [51]. Probability of Response graphs is used to check whether each scale rating has a clear peak [26], [52]. In this context, the functionality of a Likert rating scale is considered good if each scale point shows a separate and clear peak on the Probability of Response graph [53]. The probability of response graph results shows that each Likert rating scale has its peak. That is, each scale point, from lowest to highest, indicates the highest response rate or highest probability of the respondent choosing the option that corresponds to each scale rating.

The presence of separate peaks for each scale rating on a Probability of Response graph is a very positive indicator of the functionality of a Likert rating scale [54]. This shows that respondents can differentiate between each scale rating and respond by their level of belief or preference. In this evaluation, the Probability of Response graph has validated that the 5-point Likert rating scale functions well because each rating has separated peaks, allowing respondents to respond according to their level of belief or opinion towards the statements in the metacognitive instrument.

College Student Metacognitive Awareness

The metacognitive awareness of physics education (PFIS) and elementary school teacher education study program (PGSD) students is summarized in Figure 3. The Wright map in Figure 3 provides an interesting insight into the relationship between students' level of metacognitive awareness and the level of difficulty of the items used [55]. With the location of the person mean (student metacognitive awareness), which is above the item mean (item difficulty), this indicates that, in general, students tend to have a higher level of metacognitive awareness than the difficulty they face in answering the items proposed [35].

However, a deeper analysis highlights the differences between study programs. Physics Education students showed a slightly higher average of metacognitive awareness than elementary school Teacher Education students. Although the mean differences appear small, statistical significance indicates that these differences did not occur by chance. This indicates substantial differences in metacognitive awareness between the two study programs. Interpretation of these differences can provide valuable insights. It is possible that the curriculum structure or learning experiences between Physics Education and Elementary School Teacher Education students play a role in the development of metacognitive awareness. Further analysis of these factors could be important to understand why these differences arise.

By knowing that differences in metacognitive awareness between study programs exist statistically, educational institutions can make specific adjustments and improvements in the curriculum or learning approach to enrich students' metacognitive awareness in the context of their study program. This could also be the basis for further research to explore what factors influence metacognitive awareness among students of different study programs.

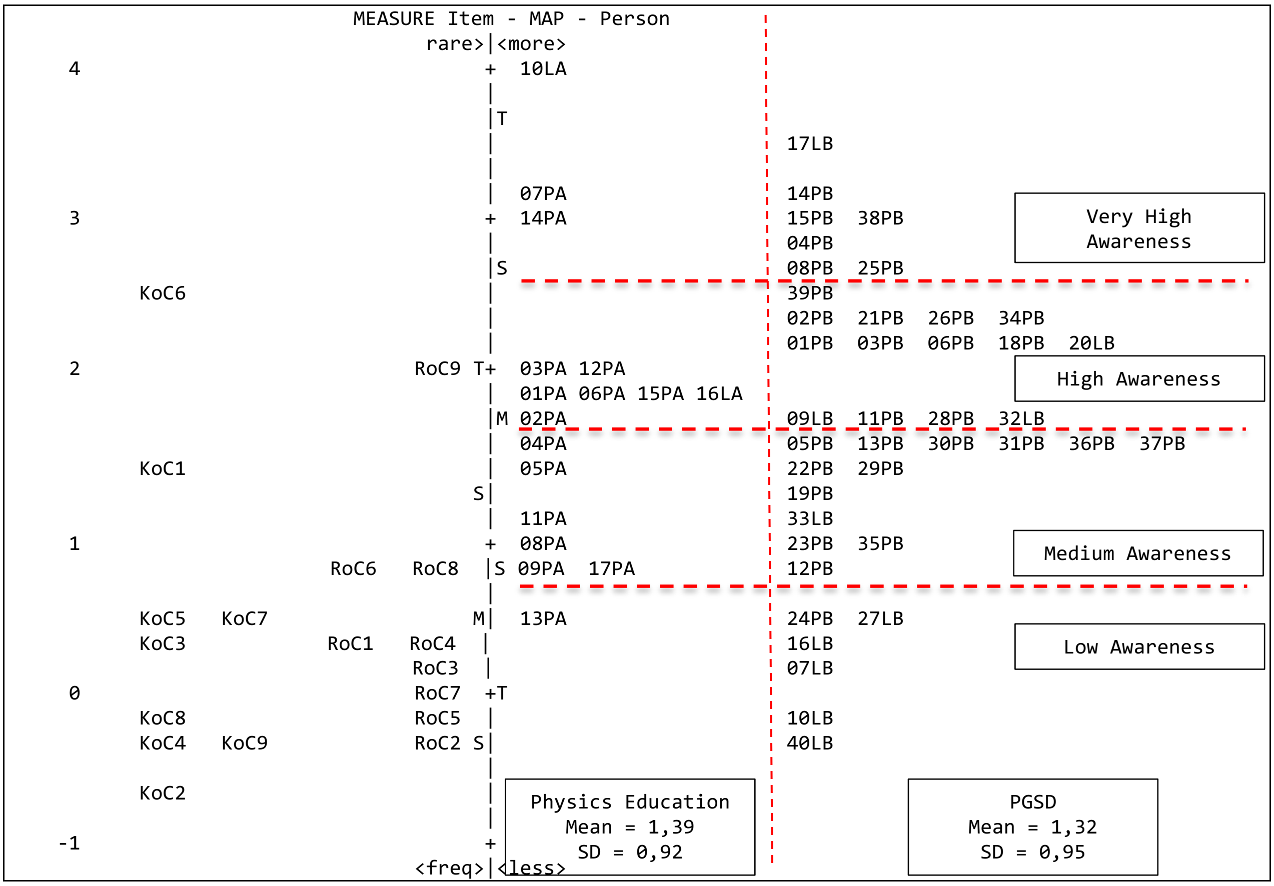

Figure 3. Wright map of students' metacognitive awareness

In the analysis of grouping students' metacognitive awareness based on mean and standard deviation values, there are differences in distribution between Physics Education and Elementary School Teacher Education students. For Physics Education, the percentage of students in the very high and high categories (17.6% + 41.2% = 58.8%) is higher than those in the medium and low categories (35.3% + 5.9% = 41.2%). This indicates that the majority of Physics Education students have a higher level of metacognitive awareness.

On the other hand, in Elementary Teacher Education, the percentage of students in the very high and high categories (17.5% + 35% = 52.5%) is almost comparable to those in the medium and low categories (32.5% + 15 % = 47.5%). This shows that metacognitive awareness is more evenly distributed among elementary school teacher education students between high, medium, and low categories. This data shows that the proportion of Physics Education students with a high level of metacognitive awareness is relatively greater than that of Elementary School Teacher Education. However, the distribution of metacognitive awareness among elementary school teacher education students is even wider across categories.

This illustrates that the Physics Education study program has certain approaches or aspects in its curriculum that support the development of relatively higher metacognitive awareness among its students. Meanwhile, the more even distribution among elementary school teacher education students may indicate greater variability in the level of metacognitive awareness within their population. Further analysis can be carried out to understand what factors influence these distribution differences and how this can be translated into improvements in Educational programs [56]–[58].

IV. Conclusions

Based on previous research and discussions, there are differences in the level of metacognitive awareness between students in the Physics Education and Elementary Teacher Education study programs. Physics Education students have a slightly higher level of metacognitive awareness than elementary school Teacher Education students. The distribution of metacognitive awareness also shows that the majority of Physics Education students tend to have a higher level of metacognitive awareness, while the distribution of metacognitive awareness among elementary school teacher education students is more even across categories. This information provides valuable insights for institutions to make specific adjustments and improvements in curriculum or learning approaches. Further analysis can be conducted to understand what factors influence these differences and how this can be translated into improved educational programs.

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