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Advancing Metacognitive Awareness Inventory (MAI) in Teacher Education: Rasch Model among Indonesian Early Childhood Education Students

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Abstract

Background: Metacognitive awareness is essential in learning, especially for prospective early childhood education students, as it contributes to developing reflective thinking skills needed in educating young children. However, research on metacognitive awareness among early childhood education students in Indonesia could be more extensive, particularly in using the Metacognitive Awareness Inventory (MAI) instrument's Indonesian version.

Objective: The current study aims to evaluate the reliability and validity of the Indonesian version of the MAI instrument using Rasch analysis and to investigate the level of metacognitive awareness of early childhood education students based on age, semester, and type of university.

Methodology: The study employed a quantitative survey of 357 early childhood education students at public and private universities in Surakarta, Central Java. Data were collected using the Indonesian version of the MAI and analysed using the Rasch model to assess the reliability and validity of the instrument and the distribution of respondents' metacognitive abilities.

Results: The Indonesian version of the MAI instrument was highly reliable, with an item reliability value of 0.98. Factor analysis supported the instrument's validity, with one dominant component explaining 95.41% of the total variance. The distribution of metacognitive awareness showed that most respondents were at the average level. However, there was an increase in the above-average and excellent categories among older and final-semester students.

Unique Contribution: The current study strengthens the validity and reliability of the Indonesian version of the MAI in measuring metacognitive awareness among early childhood education students and

contributes to the development of metacognitive awareness based on age and semester, which has not been widely explored in the literature.

Conclusion: Metacognitive awareness develops with age and semester progress in early childhood education students. The Indonesian version of the MAI instrument can be used effectively within the Indonesian cultural context, though earlier pedagogical interventions are needed to enhance metacognitive awareness in early-semester students.

Key Recommendation: Lecturers and curriculum developers are advised to integrate learning strategies that support the development of metacognitive awareness from the beginning of study, especially for early-semester and younger students.

Keywords: metacognitive awareness, Rasch model, college students, reliability, validity

Introduction

Metacognitive awareness contributes significantly to education, particularly in the context of early childhood education students. It supports more adaptive learning, enhances early childhood cognitive development, and encourages teachers to become lifelong learners who continually improve their professional competencies (Soeharto et al., 2024). Metacognitive awareness is useful for detecting and controlling thinking and learning processes and assessing them (Rashwan et al., 2021). Previous research suggests that metacognitive awareness helps teachers to better deal with different classroom situations and significantly enhances their ability to respond to students' needs more flexibly (Reisoğlu et al., 2020). Therefore, they could recognise teaching issues and continuously enhance their abilities as long as they reflect on themselves. Furthermore, another study found that prospective teachers who received systematic training could increase their metacognitive awareness and better organise their learning (Dabarera et al., 2014; Rapchak, 2018).

Given the learning culture, social factors and policies in the Indonesian education system, 'learning to learn' is a challenging awareness to build among students (Escorcia & Gimenes, 2020). Social factors such as peer relationships and family support can play an important role in improving students' ability to teach themselves (Abdelrahman, 2020), be it by giving students the freedom to choose their learning methods by fostering an understanding of a student's idiosyncratic traits, cognitive processes, and thinking styles, or by supporting students' metacognitive abilities (Abdelrahman, 2020). Throughout the programme, students can also pause to reflect on their learning and how they appreciate each topic (Thingbak et al., 2024). Therefore, Merdeka Belajar offers a flexible and result-orientated learning environment that encourages desired learning outcomes while helping students strengthen their awareness of cognitive processes.

Measuring metacognitive awareness informs us about how people become aware and regulate their thought processes, thus allowing us to improve education (Reisoğlu et al., 2020). Some students with high scores in metacognitive awareness tests support it (Goren & Kaya, 2023). These students exhibit great aptitude for learning, can be independent and control their understanding of the material they study (Love et al., 2019). Metacognitive awareness could also be the ability to plan, monitor and evaluate thinking processes, an essential part of learning and independent decision-making (Hamilton et al., 2022). Experts in study skills argue that metacognitive awareness helps identify the most efficient study strategies and minimise errors (Dabarera et al., 2014).

Use the Metacognitive Awareness Inventory (MAI) to assess metacognitive awareness in Indonesia without adaptation and pre-testing of validity. This could perhaps lead to inaccuracies when applied in particular cultural contexts (Abdelrahman, 2020; Oz, 2016). Prior research is warning us that measurement tools adapted from other cultures do not undergo a series of validity tests. Therefore, they often fail to pick up the local cultural context and bring that about or even lead to misleading measurement outcomes (Soeharto et al., 2024). When adopting the Indonesian version of the MAI Instrument, attention to the variables that are indispensable for validation is especially important in a country that differs vastly in culture and

educational background from where it was first developed (Escorcia & Gimenes, 2020). Prior research has shown that instruments with international test standards, such as the MAI, can be applied widely. However, cultural differences should be considered in how respondents understand or respond to questions (Hamilton et al., 2022). Thus, the validity test must be conducted in the MAI's native environment since then results will be more accurate if carried out after measuring the metacognitive awareness of Indonesian society itself, and any effects due to cultural distortion can be avoided.

The Objective of The Study

This study sought to tailor and validate the Metacognitive Awareness Inventory (MAI) specifically for young learners in Indonesia. The tool shifted from a general-purpose instrument to one more finely tuned to their context by adapting the MAI to fit this particular group better. Such adaptation, similar to designing a tool tailored to specific needs, was essential to ensure the results would hold meaning for Indonesian students. The reliability and validation tests confirmed that the adapted tool was consistent and supported by solid data. Notably, early childhood students in Indonesia show substantial metacognitive awareness.

Methods

Study design and procedures

The current study used a quantitative approach and survey method to obtain student metacognitive awareness data. The research design was cross-sectional, where data were collected from respondents at one specific time (Cresswell et al., 2003). The research procedure began by giving the participants the Indonesian version of the MAI survey instrument. Before data collection, participants gave consent to participate in this study through a questionnaire. To maintain anonymity and confidentiality, participants' identities were not recorded on the answer sheets, and all data collected were used solely for research purposes.

Sample size

The current study's sampling technique was conducted in the Surakarta area, Central Java, involving 357 students. The sample comprised early childhood education students at public and private universities. Sampling was carried out by purposive sampling (Cresswell et al., 2003), where participants were selected based on specific criteria, namely students who were actively attending lectures in odd semesters. The demographic distribution of participants is shown in Table 1.

Table 1. Demographics of Respondent Characteristics

Category	Subcategory	N	Frequency (%)
Gender	Male	0	0
	Female	357	100
Age	18 – 19	120	33.6
	20 – 21	170	47.6
	22 – 23	67	18.8
Course semester	1st semester	90	25.2
	3rd semester	80	22.4
	5th semester	100	28.0
	7th semester	87	24.4
University	Public university	230	64.4
	Private university	127	35.6

Translation

The MAI translation process followed the standard cross-cultural adaptation and validation approach to ensure accuracy and appropriateness within the local cultural context (Castillo-Diaz & Gomes, 2023). The

first stage of the process involved two independent translators with academic backgrounds, such as Doctorates in English Education, who translated the MAI from English to Indonesian. Both translators worked independently without communicating with each other. Any differences between the two translators were discussed to reach a consensus. After exploring and resolving these differences, the two translators synthesised the translation into a single final version. The next step involved back-translation, where two translators independently back-translated the Indonesian version into English. The original English version of the MAI was referenced in this process. Finally, the translation results were compared with the original version of the MAI to check for validity and similarity of meaning, ensuring that the Indonesian version had semantic and conceptual equivalence with the original version.

Statistical analysis

The validity and reliability testing of the MAI was conducted using the Rasch model. To ensure the fit of the Rasch model, we first conducted a conditional unidimensionality analysis using principal component analysis. This included examining infit, which is information-weighted and detects how closely responses fit the expected pattern, and outfit values more sensitive to significantly deviant responses. Infit values provide greater precision for items that match the ability level of the respondent, while the outfit is more effective in distinguishing items that fall outside of that ability level. Boone et al. (2014) recommend a threshold starting at 0.5 in the 0-1 range as a marker of acceptable fit. Values from 0.5 to 1.5 indicate consistent response patterns across different ability levels, signalling an item's good fit. Values at or below 0.5 indicate potential overfitting, where items become highly predictable and lack fresh insights. On the other hand, values above 1.5 point to underfitting, reflecting an excess of variability that doesn't align smoothly with the model's framework (Affandy et al., 2024; Boone et al., 2014). In educational research, infit and outfit are valuable metrics, with an optimal range of 0.7 to 1.3 (Affandy et al., 2024). This span signals that an item can effectively maintain balanced averages and critical density, adding a meaningful layer of variety to the data (Affandy et al., 2021). In addition to mean square, z-standardised fit statistics were also used, with an ideal value close to 0. Z-standardised fit statistics values above two were considered indicators of underfit, while values below -2 indicated overfit. The results of student metacognitive awareness evaluation were then grouped using the average Person score from the Rasch analysis output and its standard deviation (Affandy et al., 2021). Students' metacognitive awareness was then categorised into five categories: excellent, above average, average, below average, and very poor.

Results

Validity and reliability of the MAI questionnaire

Before testing the validity and reliability of the MAI questionnaire using the Rasch model, the assumption of unidimensionality was first established. Principal component analysis tests the hypothesis of unidimensionality (Field, 2024). The results of the principal component analysis indicated that the MAI instrument had good unidimensionality (Figure 1). The Kaiser-Meyer-Olkin (KMO) test result was 0.936, indicating that the sample was adequate for factor analysis. In addition, Bartlett's Test of Sphericity, with a chi-square of 45.693 and a significance value of 0.001 (df = 326), indicated a significant correlation between items, allowing principal component analysis to proceed. The total variance explained test results showed that the first component explained 95.415% of the total variance, which was very dominant compared to other components.

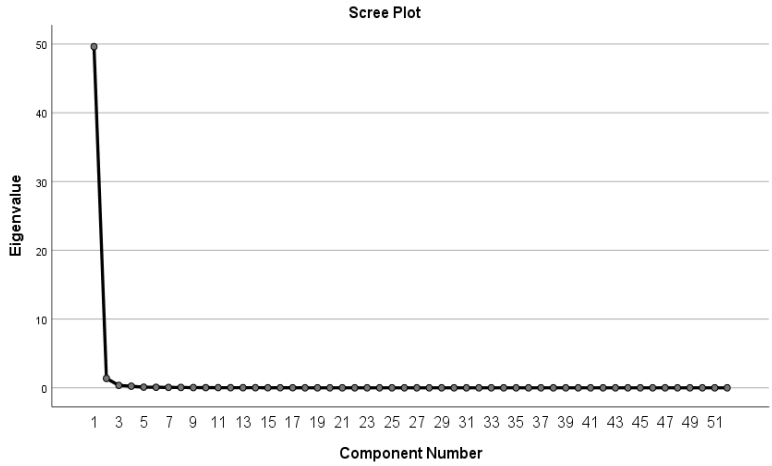

Figure 1. Principal Component Analysis Results on MAI

The results of the statistical fit analysis using the Rasch model are presented in Figure 2, indicating that the mean infit and outfit mean square values of all 52 items were 0.99 and 1.00, respectively, which were within the range considered as the Rasch model fit limit (0.5 to 1.5). However, the standard deviation values for infit mean square and outfit mean square were 0.33 and 0.34, indicating variation between the items. The maximum infit mean square value was 0.33, the maximum outfit mean square value was 0.36, the minimum infit mean square value was 0.67, and the minimum outfit mean square value was 0.68. The results of the item reliability analysis, based on a Cronbach's Alpha of 0.94 and item reliability of 0.98, indicated that the MAI instrument was consistent and reliable in measuring students' metacognitive awareness. The item reliability value showed that the items consistently measure students' metacognitive awareness. As for the person-item separation index, there were two relevant values: the Item Separation value was 6.70 for actual data (real separation) and 7.13 for model data.

CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .94

SUMMARY OF 52 MEASURED Item

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	1196.1	357.0	.00	.07	.99	.74	1.00	.54
S.D.	109.4	.0	.48	.00	.33	.43	.34	.32
MAX.	1360.0	357.0	.80	.07	.33	.91	.36	.82
MIN.	1012.0	357.0	-.75	.06	.67	.33	.68	.73

REAL RMSE	.07	TRUE SD	.48	SEPARATION	6.70	Item	RELIABILITY	.98
MODEL RMSE	.07	TRUE SD	.48	SEPARATION	7.13	Item	RELIABILITY	.98
S.E. OF Item MEAN = .07								

Figure 2. Summary of fit statistics

Evaluation of pre-service primary teachers' metacognitive awareness

Figure 3 presents the results of the distribution of person ability scores on a logit scale for all respondents. Overall, the distribution of scores indicates a trend towards the middle category, with few respondents having lower or higher levels of metacognitive ability.

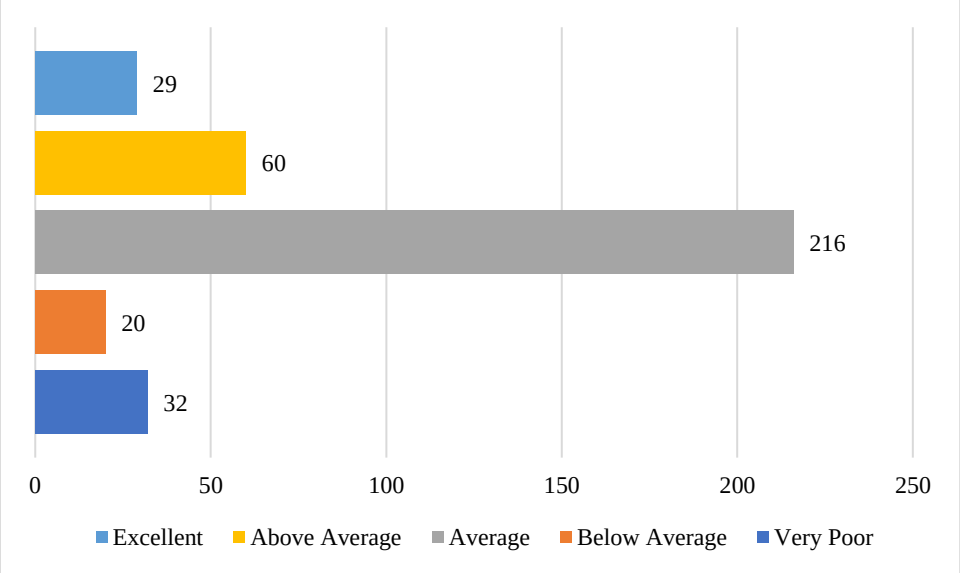

Figure 3. Distribution of Person Ability Score of Metacognitive Ability of Students

Based on Figure 3, it is evident that the students' metacognitive ability scores were not evenly distributed. Most respondents (60.5%) were in the average category, indicating that most students had metacognitive abilities at the middle level. A few respondents fell into the very poor (9.0%) and below average (5.6%) categories, suggesting that the group of students with low metacognitive abilities was relatively small. However, 16.8% of respondents scored above average, and 8.1% fell into the excellent category, indicating that several students had excellent metacognitive skills, although the proportion was smaller than that of the group at the intermediate level.

Evaluation of metacognitive awareness based on age

Overall, the distribution of metacognitive awareness scores was uneven across all age groups. However, metacognitive ability tends to increase with age, especially after age 20. Students in the younger age group tended to be at the intermediate level, while the older ones showed more metacognitive abilities above average.

Table 2. Evaluation results of metacognitive awareness based on age

Age (N)	Very Poor (%)	Below Average (%)	Average (%)	Above Average (%)	Excellent (%)
18 (68)	5 (7,4%)	8 (11,8%)	53 (77,9%)	2 (2,9%)	0 (0,0%)
19 (52)	4 (7,7%)	5 (9,6%)	43 (82,7%)	0 (0,0%)	0 (0,0%)
20 (100)	13 (13,0%)	4 (4,0%)	52 (52,0%)	20 (20,0%)	11 (11,0%)
21 (70)	10 (14,3%)	3 (4,3%)	37 (52,9%)	12 (17,1%)	8 (11,4%)
22 (34)	0 (0,0%)	0 (0,0%)	16 (47,1%)	14 (41,2%)	4 (11,8%)
23 (33)	0 (0,0%)	0 (0,0%)	15 (45,5%)	12 (36,4%)	6 (18,2%)

Based on the metacognitive awareness evaluation data by age (Table 2), there was variation in the distribution of metacognitive scores among different age groups. Among the 18 and 19-year-olds, most respondents were in the average category, with a reasonably small percentage in the very poor and below-average categories. The trends were even more pronounced in the 21, 22, and 23-year-old age groups, where there was a decrease in the percentage in the average category and a significant increase in the above-average and excellent categories, especially among the 22 and 23-year-olds.

Evaluation of metacognitive awareness based on course semester

The results of the evaluation of metacognitive awareness based on course semesters, presented in Table 3, indicated that the higher the semester, the more students exhibited metacognitive awareness at a higher level. In the early semesters (1 and 3), most students were still at an intermediate level, while in the final semesters (5 and 7), there was a significant increase to a higher level.

Table 3. Evaluation of metacognitive awareness based on course semester

Course semester (N)	Very Poor (%)	Below Average (%)	Average (%)	Above Average (%)	Excellent (%)
1 (90)	9 (10,0%)	5 (5,6%)	74 (82,2%)	2 (2,2%)	0 (0,0%)
3 (80)	10 (12,5%)	11 (13,8%)	51 (63,8%)	2 (2,5%)	6 (7,5%)
5 (100)	12 (12,0%)	4 (4,0%)	51 (51,0%)	21 (21,0%)	12 (12,0%)
7 (87)	1 (1,1%)	0 (0,0%)	40 (46,0%)	35 (40,2%)	11 (12,6%)

Based on the data from the evaluation of metacognitive awareness by semester of study (Table 3), students' metacognitive abilities were not evenly distributed but exhibited varying trends each semester. Students in semesters 1 and 3 were primarily at the "average" level (82.2% and 63.8%), with a small proportion at the "above average" and "excellent" levels. However, in semester 5, there was an increase in the proportion in the "above average" and "excellent" categories (21.0% and 12.0%), although the majority were still at the "average" level. In semester 7, there was a significant change, with most students at the "above average" (40.2%) and "excellent" (12.6%) levels and only a few in the "average" category or lower.

Evaluation of metacognitive awareness based on university

The results of the review of metacognitive awareness based on public and private universities, presented in Table 4, generally showed that the distribution of metacognitive ability scores tended to converge at the middle level, with few respondents having very low or very high scores.

Table 4. Evaluation of metacognitive awareness based on university

University (N)	Very Poor (%)	Below Average (%)	Average (%)	Above Average (%)	Excellent (%)
Public university (230)	23 (10,0%)	7 (3,0%)	137 (59,6%)	44 (19,1%)	19 (8,3%)
Private university (127)	9 (7,1%)	13 (10,2%)	79 (62,2%)	16 (12,6%)	10 (7,9%)

Based on the metacognitive awareness evaluation table grouping respondents from public and private universities (Table 4), the results showed that most students, both in public and private universities, were at the “average” or medium level of metacognitive ability. In public universities, 59.6% of respondents were in this category, while in private universities, 62.2% were in the same category.

Discussion

The infit and outfit mean square values in the instrument analysis show a relatively good range, with an average infit value of 0.99 and outfit of 1.00. These values are close to the ideal of 1.00, indicating that the items in this instrument generally fit the Rasch model. The standard deviation values for infit and outfit are 0.33 and 0.34, respectively, indicating a slight variation in item fit but within acceptable limits. The reliability findings in this study, which reach 0.98 for item reliability, indicate high consistency compared to previous studies using the MAI in English or other languages (Abdelrahman, 2020; Love et al., 2019; Oz, 2016). Earlier studies on the original version of the MAI generally showed Cronbach's Alpha values ranging from 0.80 to 0.90, depending on the context and population of the study. However, the Indonesian adaptation presents specific challenges related to cultural differences and the interpretation of metacognitive concepts. The concept of metacognition is often strongly associated with reflective thinking and conscious decision-making, which may be understood differently in different cultures.

As shown by the data above, the distribution of person ability scores on a logit scale provides an overview of the variation in metacognitive awareness among students. Of the 357 respondents, most students are in the average category (60.5%), which indicates that most students have sufficient metacognitive ability but have not yet reached a very high level. Only 8.1% of students fell into the excellent category, while 9% fell into the very poor category, indicating a significant gap between respondents with high and low metacognitive skills. This distribution shows an apparent variation in metacognitive ability among students. Based on the data, the distribution, which is mainly in the average category with few students in the extreme category, indicates that the distribution of metacognitive ability is close to a regular pattern but with a slight skewness towards the bottom, given that the proportion of below average and very poor students is more significant than that of excellent students. Previous studies involving early childhood education students have shown similar distribution patterns (Hamilton et al., 2022), where most students have moderate metacognitive awareness (Goren & Kaya, 2023), but differences in distribution may occur depending on demographic factors or academic experience (Rapchak, 2018).

Older students tend to show higher metacognitive awareness levels than younger students. In the 18 and 19-year-old students' group, most were in the average category (77.9% and 82.7%), with a tiny proportion in the above-average category and no students in the excellent category. In contrast, there was an apparent increase in the above-average and excellent categories in the older students, such as 22 and 23-year-olds. The 22-year-old students had 41.2% in the above-average category and 11.8% in the excellent category, while the 23-year-old students had 36.4% in the above-average category and 18.2% in the excellent category. According to cognitive development theory, the development of metacognitive awareness is closely related to the growth of more complex cognitive abilities with age. The finding that older students tend to have higher metacognitive awareness than younger students is consistent with the metacognitive development literature (Mishra, 2014). Research suggests that metacognition develops with age as individuals gain more learning experiences and encounter more complex problem-solving tasks (Tuononen et al., 2023). Over time, this ability is honed, and older students tend to use more effective and efficient metacognitive strategies in their academic activities. However, not all differences in metacognitive awareness can be explained solely by age. Other factors, such as previous life experiences and educational background, also play an essential role. Older students have more opportunities to encounter situations that require self-reflection and management of cognitive strategies, both inside and outside the academic environment.

Early semester students (semesters 1 and 3) tend to have lower metacognitive awareness than students in the final semesters (semesters 5 and 7). In semester 1, most students were in the average category (82.2%), with a meagre percentage in the above-average category (2.2%) and none in the excellent category. The 3rd-semester students were also mainly in the average category (63.8%), with a slight increase in the excellent category (7.5%). As the semesters increase, the trend of increasing metacognitive awareness becomes increasingly visible. In semester 5, the proportion of students in the above-average category increased to 21%, and the excellent category increased to 12%. In semester 7, students showed significant improvement, with 40.2% of students in the above-average category and 12.6% in the excellent category. Only 1.1% of students in semester 7 were in the very poor category, which is much lower than in previous semesters. This trend shows that metacognitive awareness increases as students gain more learning experience in their study programme. Previous research conducted by Ferrari and Mahalingam (1998) found that metacognitive awareness in older students who have studied in advanced semesters tends to be higher than that of younger students. These findings align with cognitive development theory, which suggests that metacognitive abilities increase over time, particularly when students are exposed to more complex academic tasks (Magid et al., 2015; Svinicki, 1998).

Students from public universities have a higher percentage in the above average (19.1%) and excellent (8.3%) categories compared to private universities, which have only 12.6% and 7.9%, respectively. The percentage of students who fall into the above-average category in public universities is more than double

that of private universities. This difference can be explained by specific characteristics and conditions that cause students to be socialised differently concerning the development of metacognitive awareness in both educational institutions (Clark & Button, 2011). Learning in public universities is more student-centred, utilising active, collaborative, or problem-based learning methods, which can encourage students to think more reflectively and independently. Another research finding indicated that older students and students in the final semester had higher metacognitive awareness levels (Abdelrahman, 2020; Gholami, et al., 2016). Recent studies have shown that metacognitive awareness develops with more reflective learning experiences (Gholami, et al., 2016; Tuononen et al., 2023), especially in the final semesters.

Students from public universities have a higher percentage in the above average (19.1%) and excellent (8.3%) categories compared to private universities, which have only 12.6% and 7.9%, respectively. The percentage of students who fall into the above-average category in public universities is more than double that of private universities. Learning in public universities is more student-centred, employing active, collaborative, or problem-based learning methods that encourage students to think more reflectively and independently. In contrast, private universities are more likely to use traditional or theoretical teaching approaches that place less emphasis on developing metacognitive skills. Other research findings indicate that older students and those in their final semester have higher levels of metacognitive awareness (Babakr et al., 2019; Josephine & Albina, 2023). Recent studies have shown that metacognitive awareness develops through more reflective learning experiences, especially in the final semesters (Dessie et al., 2024).

Limitations of the Study

A cross-sectional research design captures data from only one moment, which restricts the study's ability to observe the progression of students' metacognitive skills over time. This design limits the research, as metacognition is a skill that can grow with continuous learning and practical experience. As a result, the study does not establish causal links in students' metacognitive abilities. Such constraints should be considered when interpreting the results. Future research should employ a longitudinal or mixed-methods design to obtain a more comprehensive picture of the development of metacognition.

Implication of Research Results

The implications of the results for educational psychology contribute to the development of students' metacognitive skills in higher education institutions as they age and gain learning experience. Educators can use the research findings to design curricula that foster metacognitive awareness, starting from the early semesters. The implications of the results are also relevant in supporting students in understanding and managing learning strategies so that they can become more effective independent learners, especially when facing more challenging academic tasks in the future. The results could be applied in other parts of Asia, particularly in countries with similar educational structures or those developing metacognitive awareness in their curricula. Asian countries, including Indonesia, often face challenges in balancing traditional learning methods with more reflective and collaborative approaches. Educational institutions in Asia could consider students' cultural characteristics and learning contexts, integrating activities that encourage reflection and self-management.

Conclusion and Recommendations

The main findings of the study regarding the reliability and validity of the Indonesian version of the MAI based on the Rasch Model analysis show that the instrument has excellent reliability, with an item reliability value of 0.98. The instrument's validity is also supported by the factor analysis results, which reveal one dominant component. Based on the study of early childhood education students' metacognitive awareness, there are significant variations related to age, semester, and university factors. Based on the research findings, educators and curriculum developers are advised to focus more on learning strategies that explicitly encourage students' metacognitive awareness, especially for early childhood teacher training programme students in the early semesters. Curriculum modifications that can be implemented include

integrating activities that enable students to actively develop metacognitive skills, such as reflective discussions, case studies, and project-based assignments that require self-analysis. More collaborative and problem-based teaching methods can also help students become more aware of their thinking, thus increasing metacognitive awareness. A more structured approach is needed for early semester students or younger age groups to guide them in recognising and managing their thinking processes, given that their metacognitive abilities are still at a developmental stage. Universities and teacher training programmes can take advantage of these results by providing additional training for lecturers and instructors to apply metacognitive learning techniques consistently. Moreover, professional development programmes for pre-service teachers can be adjusted to emphasise the importance of metacognitive skills in teaching early childhood so that they not only become effective teachers but can also teach reflective thinking skills to children from an early age.

Conflict of interest

The authors hereby declare that no conflict of interest exists

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