

MRAS: NEW FINDINGS ON A TEACHER REFLECTION INSTRUMENT BASED ON DIGITAL AWARENESS AND AI ETHICS

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Abstrak

Perkembangan teknologi digital dan meluasnya penggunaan kecerdasan buatan dalam pendidikan menuntut guru memiliki kemampuan refleksi yang tidak hanya berorientasi pedagogik, tetapi juga mencakup kesadaran teknologi dan kepekaan etis. Penelitian ini bertujuan mengembangkan serta memvalidasi Meta-Reflective Awareness Scale sebagai instrumen untuk mengukur kesadaran meta-reflektif guru dalam konteks pembelajaran yang didukung kecerdasan buatan. Instrumen disusun dalam bentuk kuesioner dan divalidasi melalui penilaian ahli, pengujian reliabilitas, analisis faktor eksploratori, serta pemodelan struktural berbasis Partial Least Squares. Hasil analisis menunjukkan bahwa instrumen memiliki konsistensi internal yang sangat baik dan struktur faktor yang memadai. Dua dimensi utama teridentifikasi, dengan kesadaran etis yang muncul sebagai komponen yang paling dominan dalam membentuk kesadaran reflektif guru. Analisis model struktural mengonfirmasi hubungan yang kuat antara kesadaran etis dan kesadaran digital, yang menunjukkan bahwa orientasi moral berperan penting dalam kesiapan guru memanfaatkan teknologi pembelajaran. Temuan ini menegaskan bahwa refleksi guru pada era pembelajaran berbasis kecerdasan buatan perlu dipahami sebagai proses terpadu yang menghubungkan aspek kognitif, digital, dan etis. Secara praktis, instrumen ini dapat digunakan untuk mendukung asesmen dan pengembangan profesional guru.

Kata Kunci: refleksi guru; kesadaran meta-reflektif; MRAS; literasi digital; etika AI; PLS-SEM.

Abstract

The rapid development of digital technologies and the growing use of artificial intelligence in education require teachers to engage in reflective practices that integrate pedagogical reasoning, technological awareness, and ethical sensitivity. This study aims to develop and validate the Meta-Reflective Awareness Scale, an instrument designed to examine teachers' meta-reflective awareness in technology-supported learning environments. The instrument was administered through a survey and validated using expert review, reliability testing, exploratory factor analysis, and structural modeling based on the Partial Least Squares approach. The findings indicate that the instrument demonstrates strong internal consistency and a well-defined factor structure. Two core dimensions were identified, with ethical awareness emerging as the most prominent component shaping teachers' reflective profiles. The structural analysis confirms a strong relationship between ethical awareness and digital awareness, suggesting that moral orientation plays a central role in teachers' readiness to engage with educational technologies. These results highlight the importance of understanding teacher reflection as an integrated process that connects cognitive, digital, and ethical dimensions. Practically, the instrument offers a useful framework for assessing reflective competence and supporting professional development in technology-enhanced educational contexts.

Keywords: teacher reflection; meta-reflective awareness; MRAS; digital literacy; AI ethics; PLS-SEM.

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INTRODUCTION

Reflective ability constitutes one of the primary foundations in the development of teachers' pedagogical competence. Through reflection, teachers not only evaluate their teaching experiences but also reconsider their ways of thinking, examine instructional decisions, and design continuous improvements in learning practices. Reflection enables teachers to understand the interrelationships among learning objectives, instructional strategies, and students' responses, ensuring that teaching practices are not merely routine but adaptive and grounded in professional awareness.

Over the past several decades, the development of digital technology has brought significant changes to how teachers design, implement, and reflect on learning. This transformation has been further accelerated by the emergence of artificial intelligence (AI) in various forms, such as online learning platforms, data-driven learning management systems, recommendation algorithms, and automated assessment tools. Within this context, teachers' reflective activities are no longer limited to conventional pedagogical experiences but have evolved into analytical processes that require an understanding of how technology influences learning processes, social interactions in the classroom, and instructional decision-making dynamics.

These changes in the learning landscape position teachers in a role that is both strategic and complex. On the one hand, digital technology and AI offer opportunities to enhance learning effectiveness through personalization, classroom management efficiency, and access to extensive learning resources (The and Latifah, 2025). On the other hand, the use of technology also entails risks, including overreliance on automated systems, reduced professional autonomy for teachers, and ethical concerns related to data privacy, algorithmic transparency, and potential system bias. Consequently, teachers are required to make decisions that are critical, flexible, and ethically oriented to ensure that the use of technology remains aligned with educational goals.

In this context, teachers' reflective practice needs to extend beyond instructional evaluation alone. Reflection in the digital era requires teachers to develop critical digital literacy, recognize the risks and limitations of technology, and demonstrate ethical sensitivity in the use of AI-based tools and systems. Teachers must not only ask whether a technology is effective, but also whether it is fair, safe, and responsible for learners. Thus, reflection becomes a metacognitive process that simultaneously integrates pedagogical, digital, and ethical dimensions.

A number of previous studies indicate that traditional models of reflection—which focus on instructional experience and self-evaluation—are not fully adequate to address the challenges of digital learning. These models generally do not explicitly incorporate considerations related to data privacy, information security, algorithmic bias, or the social impacts of automated technologies. Recent research also emphasizes that teachers need to understand how technology shapes classroom interaction patterns, influences power relations in learning, and generates new moral dilemmas that are absent in conventional learning contexts.

Various AI literacy programs developed in several countries demonstrate that the enhancement of teachers' technological competence can occur alongside the strengthening of ethical awareness. However, research findings also indicate that teachers' readiness to engage with AI-based learning remains highly varied. Differences in professional experience, levels of technological proficiency, and institutional support result in some teachers being able to use technology reflectively, while others remain hesitant or defensive. In Indonesia, this situation is reflected in the diverse responses of teachers to the use of AI in learning. Some perceive AI as an opportunity for innovation, while others exercise caution due to limited digital literacy and concerns about ethical implications.

These conditions indicate a gap between the demands of teacher reflection in the digital era and the availability of instruments capable of comprehensively mapping reflective awareness. Existing reflection instruments generally continue to focus on conventional pedagogical reflection or basic digital literacy and therefore do not fully represent the complexity of teacher reflection in digitally mediated and AI-influenced learning environments. As a result, efforts to assess teachers' reflective readiness often fail to capture the integrated relationships among cognitive, digital, and ethical aspects.

In response to this need, this study develops the Meta-Reflective Awareness Scale (MRAS), an instrument designed to measure teachers' meta-reflective awareness within the context of technology- and AI-based learning. MRAS integrates three main dimensions—reflective awareness, digital awareness, and ethical awareness—into a single, comprehensive measurement framework. This instrument aims to map how teachers analyze the practice of technology use, assess its social impacts and risks, recognize potential system biases, and ensure that the utilization of AI remains aligned with professional values and educational responsibility.

From a scientific perspective, this study offers novelty by integrating three dimensions of reflection that have typically been examined separately. MRAS has the potential to enrich the study of teacher reflection by providing a perspective that is more relevant to the challenges of digital learning and educational technology ethics. Practically, this instrument can be used in teacher professional assessment, evaluation of digital and AI literacy training programs, and the design of continuous professional development initiatives. In addition, MRAS can support the development of educational policies that are more sensitive to ethical issues and responsibilities in the use of learning technologies.

Based on this foundation, the present study focuses on the central research question of whether the Meta-Reflective Awareness Scale (MRAS) is valid and reliable as an instrument that reflects the integration of pedagogical, digital, and ethical dimensions in teacher reflection within technology-based learning environments. In line with this question, the purpose of this study is to develop and examine the validity and reliability of MRAS as a measurement tool that is relevant to the demands of digital learning and the responsible use of artificial intelligence.

METHOD

This study employed an instrument development design aimed at producing the Meta-Reflective Awareness Scale (MRAS) as a valid and reliable measurement tool for mapping teachers' meta-reflective awareness within a learning ecosystem influenced by digital technology and artificial intelligence. The research approach combined expert judgment and quantitative analysis to ensure that the resulting instrument not only met psychometric standards but also aligned with teachers' reflective needs in technology-based learning contexts. The initial stage of development was conducted through content review by three experts with expertise in education, instructional technology, and digital ethics. The experts were asked to examine the clarity of indicator formulation, the relevance of the substance, and the appropriateness of the instrument's coverage with respect to the three core dimensions of MRAS, namely reflective awareness, digital awareness, and ethical awareness. The feedback provided was used to refine the wording of the statements and to strengthen the alignment between the indicators and the measured constructs.

After the expert validation process was completed, the instrument was piloted with 193 teachers from early childhood education, elementary, junior high, and senior high/vocational high school levels across four provinces, namely Banten, Java, Lombok, and Aceh. Participants were selected using purposive sampling based on two main criteria: having at least two years of teaching experience and having used digital technology or AI-based systems in teaching or professional

reflection activities. The diversity of respondents' backgrounds was considered to test the instrument's ability to capture teachers' reflective profiles across varied educational contexts.

The MRAS instrument was developed in the form of a five-point Likert questionnaire comprising thirty operational indicators. The Reflective Awareness dimension was designed to measure teachers' ability to review their thinking processes and teaching experiences; the Digital Awareness dimension assessed understanding related to technology use and the risks of digital dependency; while the Ethical AI Awareness dimension described teachers' moral sensitivity toward the implications of using artificial intelligence systems in learning. The questionnaire was administered both online and offline, and completion was carried out independently within approximately ten to twelve minutes. All data were collected without personal identifiers to maintain confidentiality and minimize potential social bias.

The collected data were analyzed through a series of statistical procedures to obtain evidence of the instrument's validity and reliability. Reliability testing was conducted using Cronbach's Alpha and Composite Reliability as indicators of internal consistency. The initial factor structure was explored through Exploratory Factor Analysis (EFA) using the Principal Axis Factoring method with Promax rotation. Data suitability for factor analysis was examined using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test. The EFA results were subsequently confirmed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with the assistance of SmartPLS software. Measurement model evaluation included examination of factor loadings, Average Variance Extracted (AVE), Composite Reliability, the Fornell-Larcker Criterion, and the Heterotrait-Monotrait Ratio (HTMT). The structural model was tested through analysis of path coefficients, t-statistics, and p-values obtained from bootstrapping techniques to determine the significance of relationships among constructs.

All research procedures were conducted in accordance with ethical principles in educational research. Participants were given the opportunity to provide informed consent after receiving information about the research objectives, the types of data collected, and assurances of confidentiality. No physical or psychological risks were imposed on respondents, and all data were managed anonymously. Through systematic development procedures, the MRAS instrument is considered to have a solid empirical foundation for describing teachers' meta-reflective awareness in digital learning environments and the increasingly widespread use of artificial intelligence.

RESULT

This section presents the empirical findings from the development and validation process of the Meta-Reflective Awareness Scale (MRAS) obtained from data collected from 193 teachers. The analysis of the research results includes an overview of respondent characteristics, descriptive statistics of the items, reliability testing, factor analysis feasibility, the results of Exploratory Factor Analysis (EFA), and the evaluation of the PLS-SEM model encompassing both the measurement model and the structural model. All findings were analyzed to address the research questions, particularly those related to the feasibility and consistency of the MRAS construct as a measurement instrument.

The research respondents consisted of 193 teachers from early childhood education to senior high/vocational high school levels across four provinces, namely Banten, Java, Lombok, and Aceh. All respondents had experience using digital technology or artificial intelligence-based systems in instructional activities or professional reflection. The diversity in educational levels and regional backgrounds provides a relatively heterogeneous profile, thereby supporting the testing of the MRAS across varied educational contexts.

The results of the descriptive statistics indicate that all MRAS items demonstrated a tendency toward positive responses. The mean response values ranged from 3.808 to 4.570, with standard deviations between 0.81 and 1.08. The lowest mean value was observed for indicator DA6, while the highest mean was shown by indicator EA6. This pattern suggests that teachers generally possess relatively high levels of reflective, digital, and ethical awareness. Nevertheless, variations in responses across several indicators indicate that teachers' understanding of certain risks associated with the use of digital technology remains diverse.

Table 1. Summary of MRAS Reliability

Componen	Value
Item Number	30
Cronbach's Alpha	0,981
Lower Item (CITC)	DA6 = 0,537
Status	Reliabel

The results of the reliability testing show that Cronbach's Alpha reached 0.981 for the 30 MRAS items. All items met the reliability criteria, with the lowest Corrected Item–Total Correlation value recorded at 0.537 for item DA6. No items were eliminated, as all values exceeded the minimum acceptable threshold in accordance with Table 1.

The Kaiser–Meyer–Olkin (KMO) value of 0.966 indicates excellent sample adequacy. The Bartlett test shows a value of $\chi^2 = 6680.022$; $df = 435$; $p < 0.001$, indicating that the correlation matrix is suitable for factor analysis, as shown in Table 2.

Table 2. KMO and Bartlett's Test

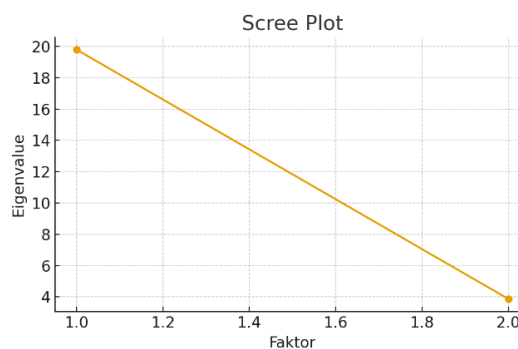
Indicator	Value
KMO	0,966
Chi-Kuadrat Bartlett	6.680.022
df	435
Significance	< 0,001

Factor analysis using the Principal Axis Factoring method with Promax rotation yielded two main factors with a total variance of 68.780%. The first factor explained 64.91% of the variance, while the second explained 3.87%. The decreasing eigenvalue pattern on the scree plot indicates a break in the second factor, supporting a two-factor structure.

Table 3. Total Variance Explained

Factor	% Variance	% Cumulative
Factor 1	64,91%	64,91%
Factor 2	3,87%	68,78%

Most items loaded strongly on their respective factors. The highest loadings came from items EA7, EA5, and EA4, while DA6 had the lowest loading but remained within the acceptable range, as shown in Table 3.



Graph 1. Scree Plot of Exploratory Factor Analysis

The pattern of decreasing eigenvalues is shown in the scree plot (Graph 1), which indicates a clear break point in the second factor. This confirms the two-factor structure as shown in the total variance table.

The pattern of decreasing eigenvalues is shown in the scree plot (Graph 1), which indicates a clear break point in the second factor. This confirms the two-factor structure as shown in the total variance table.

The results in Table 4 indicate that most items have strong factor loadings. Three items from the digital ethics dimension—EA7, EA5, and EA4—were the items with the largest contributions to the main factor, thus confirming that the ethical awareness aspect is the most dominant component in the instrument structure. Items RA2 and DA5 also had high loading values, thus still making significant contributions to the formation of the reflective and digital factors. Meanwhile, DA6 was the item with the lowest level, but its value was still within the acceptable limits.

Table 4. Highest Loading Items on EFA

Item	Loading
EA7	0,902
EA5	0,892
EA4	0,886
RA2	0,854
DA5	0,852
DA6	0,542

The results of the measurement model evaluation indicate that all indicators of the MRAS construct have met the criteria for convergent validity. The indicator loading values are above the acceptable threshold, while the Average Variance Extracted values indicate that each construct is able to explain an adequate proportion of the variance of its indicators. In addition, the obtained Composite Reliability values demonstrate a very high level of internal consistency, indicating that the measured constructs can be considered reliable.

The results of the convergent validity evaluation of the measurement model show that all MRAS constructs meet the established criteria. As presented in Table 5, the Average Variance Extracted values for each construct are above the acceptable threshold, indicating that the indicators adequately represent their respective constructs. Furthermore, the Composite Reliability values for all three constructs demonstrate a very good level of internal consistency, confirming that all constructs are valid and reliable.

Table 5. Summary of Convergent Validity (Loading, AVE, CR)

Construct	AVE	CR	Interpretation
Reflective Awareness	0.672	0.954	Valid & reliabel
Digital Awareness	0.611	0.938	Valid & reliabel
Ethical Awareness	0.704	0.958	Valid & reliabel

The discriminant validity of the measurement model was tested using the Fornell–Larcker criteria and the Heterotrait–Monotrait approach. Based on the results presented in Table 6, the square root of the Average Variance Extracted for each construct was higher than the correlation between the other constructs. This finding indicates that each construct in the MRAS has clear conceptual differences and does not overlap, thus discriminant validity can be declared fulfilled.

Table 6. Fornell–Larcker criteria

Construct	RA	DA	EA
RA	0.820		
DA	0.743	0.781	
EA	0.768	0.812	0.839

The AVE root value (diagonal) is higher than the correlation between constructs, indicating that each construct has a different conceptual identity as shown in Table 7.

Table 7. HTMT Index

Construct Correlation	HTMT
RA – DA	0.771
RA – EA	0.812
DA – EA	0.854

All HTMT values were <0.90, thus discriminant validity met the criteria. Thus, the three MRAS constructs do not overlap conceptually.

The model explains 75.2% of the variance in DA ($R^2 = 0.752$), which is considered strong. Bootstrapping results indicate that the Ethical Awareness (EA) construct has a very strong influence on Digital Awareness (DA):

$$\beta = 0.867; t = 29.771; p < 0.001.$$

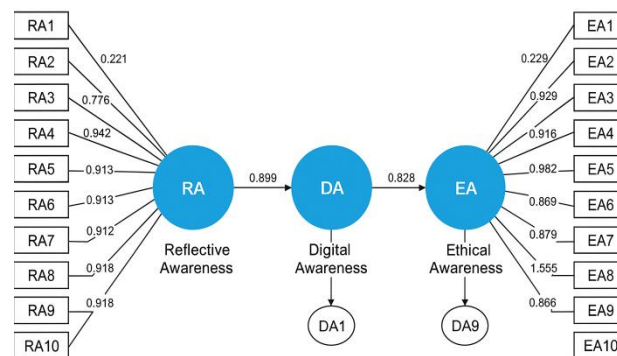


Figure 1. PLS-SEM MRAS model

DISCUSSION

The findings of this study provide a deeper understanding of how teachers conceptualize the reflective process within a learning ecosystem that is increasingly digitalized and enriched by artificial intelligence technologies. In this context, reflection is no longer understood merely as an activity of evaluating teaching experiences, but has evolved into a higher-order thinking process that requires teachers to integrate pedagogical considerations, an understanding of digital technology, and ethical sensitivity regarding the use of AI. Empirical findings from Exploratory Factor Analysis (EFA) and Structural Equation Modeling–Partial Least Squares (SEM-PLS) analyses confirm that these three aspects are interrelated and form a pattern of professional reflection that is more complex than that of previous eras.

One of the most significant findings is the strong contribution of the Ethical Awareness (EA) dimension within the MRAS structure. Indicators such as EA7, EA5, and EA4 demonstrate very high loadings, indicating that moral considerations are central to teachers' reflective processes when engaging with digital technologies and artificial intelligence systems. Teachers consistently perceive that the use of digital tools cannot be separated from issues of data integrity, algorithmic fairness, student privacy protection, and professional responsibility in utilizing AI. This result is consistent with developments in contemporary digital ethics theory, which position educators as value guardians and moral decision-makers in increasingly automated classroom environments. Accordingly, the findings affirm that reflective competence in the digital era relies not only on pedagogical analysis but also on the ability to consider the ethical and social implications of technology use.

However, descriptive findings reveal another dynamic that warrants attention. Although ethical awareness appears strong, several items within the Digital Awareness (DA) dimension—particularly indicator DA6—show relatively lower values. This finding suggests that some teachers have not yet fully recognized the potential for cognitive dependence on technology, especially when using automated recommendation systems or algorithm-driven learning platforms. The concept of cognitive offloading explains that certain human thinking functions may be transferred to digital devices. If this phenomenon is not accompanied by reflective awareness, teachers' professional autonomy in making instructional decisions may be diminished. This finding indicates that teachers' digital literacy needs to be enhanced not only in technical terms, but also in terms of critical awareness of how technology influences thinking processes and decision-making.

Factor analysis through EFA yielded two main factors that underpin the MRAS structure, namely Meta-Reflective Ethical–Cognitive Awareness and Digital Reflective Self-Regulation. The first factor represents the integration of reflective thinking, moral evaluation, and the ability to assess technological risks. This structure illustrates that teacher reflection functions not only to review teaching strategies, but also to understand the social and moral consequences of the technological decisions they make. The second factor reflects teachers' capacity to consciously regulate their use of technology, including assessing the extent of their reliance on digital tools and controlling the intensity of technology use in learning activities. This factor aligns with various theories of self-regulation that emphasize the importance of metacognitive awareness and behavioral control in responding to dynamic learning environments.

The PLS-SEM findings further reinforce this structure. The structural model indicates that Ethical Awareness has a very strong influence on Digital Awareness, with a coefficient of $\beta = 0.867$ and an R^2 value of 0.752. This result offers new insight that mature digital literacy is determined not only by technical competence but also by teachers' moral orientation. Teachers with higher levels of ethical awareness tend to be better able to assess the potential risks of AI use, to be more selective in utilizing digital data, and to exercise greater caution in relying on automated system recommendations. Thus, the findings demonstrate that the development of teachers' digital competence is strongly influenced by their ability to understand the ethical implications of educational technology use.

The reliability of MRAS also shows very high consistency, with a Cronbach's Alpha value of 0.981. Nevertheless, psychometric literature notes that excessively high reliability may indicate potential item redundancy. Despite this, stable item–total correlations suggest that each indicator continues to make an important conceptual contribution to the construct. Further analyses using item response theory approaches or confirmatory factor analysis with larger samples would help strengthen the clarity of the indicator structure.

From a methodological perspective, the fulfillment of convergent validity, discriminant validity, and composite reliability within the PLS-SEM model confirms that MRAS possesses a robust latent structure. However, this study still leaves room for further analyses, such as testing measurement invariance across educational levels or geographic regions. Such analyses are important to ensure that the instrument can be applied consistently across broader and more diverse groups of teachers.

This study also has several limitations. The use of self-report instruments may introduce social desirability bias, particularly for indicators related to moral issues and ethical responsibility. In addition, the study sample does not fully represent the diversity of the Indonesian teacher population, indicating the need for further testing with larger samples or longitudinal studies to assess the stability of the construct over time.

From a practical standpoint, MRAS has considerable potential as a diagnostic tool for mapping teachers' readiness to engage in technology- and AI-based learning. Schools and educational institutions can use teachers' reflective profiles to design more targeted professional development programs, such as training in digital ethics, technology risk management, or self-regulation strategies in digital tool use. Moreover, MRAS can support the development of more comprehensive digital literacy policies by integrating cognitive, ethical, and self-regulatory aspects simultaneously.

Theoretically, this study contributes to the advancement of teacher reflection research by introducing an instrument capable of capturing reflective dimensions in the digital era that are fundamentally different from traditional pedagogical reflection. The instrument expands the understanding of reflection by incorporating ethical and digital awareness as integral components of teachers' reasoning processes. In the context of rapid technological change, MRAS offers a new conceptual framework that is necessary for examining reflective competence that is more relevant to modern learning ecosystems.

Overall, the findings demonstrate that teacher reflection has evolved into a multidimensional thinking process that integrates morality, digital awareness, and instructional reasoning. MRAS emerges as an instrument capable of empirically and conceptually capturing this reflective dynamic, making it suitable as a new standard for assessing professional reflection in the era of AI-based learning. The integration of EFA and SEM-PLS results shows that the instrument is not only psychometrically robust but also relevant for supporting future transformations in teacher professional development practices.

CONCLUSION

The findings of this study affirm that the Meta-Reflective Awareness Scale (MRAS) is a valid and reliable instrument for describing the level of teachers' meta-reflective awareness within an increasingly digitalized learning ecosystem influenced by artificial intelligence. The research objective of developing and testing the feasibility of the instrument was achieved through the identification of a two-factor structure—ethical–cognitive awareness and digital reflective self-regulation—which was shown to be stable through EFA analysis and strongly confirmed by the PLS-SEM model. The main findings indicate that ethical awareness has a significant influence on digital awareness, demonstrating that moral orientation constitutes an important foundation for teachers in interpreting, using, and controlling technology wisely. In addition, although the instrument demonstrates very high reliability, variation in scores related to the risk of digital dependence indicates the need to strengthen teachers' capacity to maintain a balance between technology utilization and pedagogical autonomy. Overall, MRAS not only fulfills its function as a robust measurement tool but also provides an empirical basis for the development of teacher training programs and the formulation of digital literacy policies that are more ethically oriented. Future research is recommended to conduct cross-group invariance testing, expand the sample scope, and combine additional assessment methods to further strengthen the external validity and model stability of MRAS across diverse educational contexts.

REFERENCES

- Bond, M. (2021). Digital transformation and teachers' reflective practice. *Teaching and Teacher Education*, 105, 103428. <https://doi.org/10.1016/j.tate.2021.103428>
- Broadbent, J., & Poon, W. (2015). Self-regulated learning strategies and academic achievement in online higher education environments: A systematic review. *The Internet and Higher Education*, 27, 1–13. <https://doi.org/10.1016/j.iheduc.2015.04.007>
- Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2nd ed.). Guilford Press.

- Castañeda, L., & Williamson, B. (2021). Assembling digital education governance: Data and algorithms in policy. *Learning, Media and Technology*, 46(3), 290–305. <https://doi.org/10.1080/17439884.2021.1876089>
- Chen, B., & Hong, H. (2022). AI literacy for teachers: A review. *Computers & Education*, 180, 104446. <https://doi.org/10.1016/j.compedu.2022.104446>
- Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis*, 58(1), 7–19. <https://doi.org/10.1093/analys/58.1.7>
- DeVellis, R. F. (2017). *Scale development: Theory and applications* (4th ed.). Sage Publications.
- Dewey, J. (1933). *How we think*. D.C. Heath.
- Dignath, C., Buettner, G., & Langfeldt, H. (2008). How can students learn self-regulated strategies effectively? *Educational Research Review*, 3(2), 101–129. <https://doi.org/10.1016/j.edurev.2008.02.003>
- Ghavifekr, S., & Rosdy, W. A. W. (2015). Teaching and learning with ICT tools. *The International Journal of Information and Learning Technology*, 32(1), 72–85. <https://doi.org/10.1108/IJILT-06-2014-0027>
- Grant, A. M., Franklin, J., & Langford, P. (2002). The Self-Reflection and Insight Scale: A new instrument for assessing private self-consciousness. *Social Behavior and Personality*, 30(8), 821–835. <https://doi.org/10.2224/sbp.2002.30.8.821>
- He, T., & Li, S. (2019). Digital literacy and reflective competence among teachers. *Journal of Educational Computing Research*, 57(7), 1656–1683. <https://doi.org/10.1177/0735633119854037>
- Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial intelligence in education: Promises and implications*. Center for Curriculum Redesign.
- Howard, S. K., Tondeur, J., Ma, J., & Yang, J. (2021). Conceptualizing teacher digital competence. *Computers & Education*, 160, 104024. <https://doi.org/10.1016/j.compedu.2020.104024>
- Kember, D., Leung, D. Y., Jones, A., Loke, A. Y., McKay, K., Sinclair, K., & Yeung, E. (2000). Development of a questionnaire to measure the level of reflective thinking. *Assessment & Evaluation in Higher Education*, 25(4), 381–395. <https://doi.org/10.1080/713611442>
- Kline, R. B. (2015). *Principles and practice of structural equation modeling* (4th ed.). Guilford Press.
- Lai, E. R. (2011). *Metacognition: A literature review*. Pearson.
- Li, L., & Wang, X. (2021). Ethical dimensions of artificial intelligence in education. *AI and Ethics*, 1, 45–60. <https://doi.org/10.1007/s43681-020-00014-9>
- MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. *Psychological Methods*, 4(1), 84–99. <https://doi.org/10.1037/1082-989X.4.1.84>
- OECD. (2019). *OECD skills outlook 2019: Thriving in a digital world*. OECD Publishing. <https://doi.org/10.1787/df80bc12-en>
- Pangrazio, L. (2016). Reconceptualizing critical digital literacy. *Learning, Media and Technology*, 41(2), 181–198. <https://doi.org/10.1080/17439884.2015.1107093>
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research. *Journal of Applied Psychology*, 88(5), 879–903. <https://doi.org/10.1037/0021-9010.88.5.879>
- Pratiwi, M. D. N., Wedi, A., & Praherdhiono, H. (2018). Media pembelajaran standar lembar balik IPA sekolah dasar. *JKTP: Jurnal Kajian Teknologi Pendidikan*, 1(3), 195–204. <https://doi.org/10.17977/um038v1i3p195-204>

- Reise, S. P., Scheines, R., Widaman, K. F., & Haviland, M. G. (2013). Multidimensionality and scale validation in IRT. *Educational and Psychological Measurement*, 73(1), 5–26. <https://doi.org/10.1177/0013164412449831>
- Roll, I., & Wylie, R. (2016). Evolution of metacognitive research in learning environments. *Educational Psychologist*, 51(1), 1–19. <https://doi.org/10.1080/00461520.2015.1122144>
- Schön, D. A. (1983). *The reflective practitioner*. Basic Books.
- Selwyn, N. (2020). Digital technologies and teachers: Future prospects. *British Journal of Educational Technology*, 51(6), 2140–2154. <https://doi.org/10.1111/bjet.12955>
- The, H. Y., & Latifah. (2025). Developing Students' Academic Integrity Through Case Study Learning Practices . *JKTP: Jurnal Kajian Teknologi Pendidikan*, 8(1), 034–045. <https://doi.org/10.17977/um038v8i12025p034>
- Williamson, B. (2020). The datafication of education. *Learning, Media and Technology*, 45(3), 264–279. <https://doi.org/10.1080/17439884.2020.1686011>
- Williamson, B., & Piattoeva, N. (2022). Objectivity as standardization in data-driven education governance. *Educational Philosophy and Theory*, 54(10), 1630–1643. <https://doi.org/10.1080/00131857.2021.1875885>
- Zimmerman, B. J. (2002). Becoming a self-regulated learner. *Theory Into Practice*, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2