SCIENCE : Jurnal Inovasi Pendidikan Matematika dan IPA
Vol. 4 No. 4 November-Januari 2025
E-ISSN : 2797-1031
P-ISSN : 2797-0744
Online Journal System : https://jurnalp4i.com/index.php/science

INDONESIAN HIGH SCHOOL STUDENTS' METACOGNITIVE AWARENESS BY GENDER AND GRADE: VALIDATING MAI USING IRT ANALYSIS

AI NURLAELASARI RUSMANA
Department of Science Education, Universitas Pendidikan Indonesia
e-mail: airusmana@upi.edu

ABSTRAK

Metakognisi memiliki peranan penting dalam mendorong keberhasilan akademik dan regulasi diri siswa. Penelitian ini mengeksplorasi kesadaran metakognisi siswa SMA di Indonesia dalam pembelajaran sains, dengan fokus pada variabel gender dan tingkat kelas. Dengan menggunakan Metacognitive Awareness Inventory (MAI), salah satu instrumen metakognisi yang paling banyak digunakan, data pada penelitian ini dikumpulkan dari 185 siswa SMA Indonesia jurusan sains di kelas 10 dan 11 dari sekolah negeri dan swasta. Penelitian ini menggunakan kerangka Item Response Theory (IRT) atau teori respon butir untuk menguji validitas dan reliabilitas instrumen ini pada R dengan paket TAM. Analisis validitas mencakup uji dimensi instrumen, kecocokan item, dan uji reliabilitas terhadap 19 butir MAI. Adapun analisis lanjutan menggunakan two-way ANOVA pada IBM SPSS Statistics versi 29 untuk mengevaluasi perbedaan kesadaran metakognisi berdasarkan gender dan tingkat kelas. Hasil analisis IRT mengonfirmasi kesesuaian instrumen MAI untuk mengukur kesadaran metakognisi siswa SMA, dengan mengidentifikasi dua dimensi: pengetahuan tentang kognisi (knowledge of cognition) dan regulasi kognisi (regulation of cognition). Semua item MAI menunjukkan kecocokan dengan kerangka IRT serta indeks reliabilitas item dan person pada setiap dimensi berada dalam kategori cukup hingga baik. Terkait kesadaran metakognisi siswa SMA, siswa Perempuan umumnya menunjukkan kesadaran metakognisi lebih tinggi dibandingkan siswa laki-laki, terutama pada dimensi regulasi kognisi. Temuan ini sejalan dengan penelitian sebelumnya yang menyoroti pengaruh faktor biologis dan sosial dalam membentuk perbedaan gender dalam metakognisi. Selain itu, siswa kelas 10 menunjukkan kesadaran metakognisi yang lebih tinggi pada dimensi pengetahuan tentang kognisi dibandingkan siswa kelas 11. Hal ini juga menunjukkan bahwa siswa yang lebih muda cenderung lebih sering terlibat dalam aktivitas reflektif dan mempertahankan rasa ingin tahu yang kuat sehingga mendorong perkembangan metakognisinya.
Kata Kunci: analisis IRT, metacognitive awareness inventory, siswa SMA, validitas.

ABSTRACT

Metacognition is significant in fostering students' academic success and self-regulated learning. This study explores the metacognitive awareness of Indonesian high school students in science learning, with a focus on the effects of gender and grade level. Using the Metacognitive Awareness Inventory (MAI), a widely utilized self-report instrument, data were collected from 185 Indonesian high school students, majoring in science, across 10th and 11th grades in public and private schools. To ensure the validity and reliability of the instrument within this context, the study employed an Item Response Theory (IRT) framework using the TAM package in R. The analysis examined dimensionality, item fit, and reliability metrics, ensuring the suitability of the 19-item MAI subset. Subsequent analyses using two-way ANOVA in IBM SPSS Statistics 29 evaluated differences in metacognitive awareness across gender and grade levels. IRT analysis confirmed the suitability of the MAI for measuring high school students' metacognitive awareness, identifying two dimensions: knowledge of cognition and regulation of cognition. All items showed good fit to the IRT framework, and item as well as person reliability across dimensions was fair to good categories. With regards to high school students'

metacognitive awareness, female students generally demonstrated higher awareness than male students, particularly in regulation of cognition dimension. The findings align with prior research emphasizing the influence of biological and social factors on establishing gender differences in metacognition. Additionally, 10th-grade students demonstrated greater metacognitive awareness in the knowledge of cognition dimension than 11th graders, suggesting that younger students may engage more in reflective practices and maintain a stronger innate curiosity, which fosters metacognitive development.
Keywords: high school students, IRT analysis, metacognitive awareness inventory, validity.

INTRODUCTION

Metacognition, often referred to as "thinking about thinking" (Flavell, 1979), an individual awareness of and understanding of their own and other's thoughts. Metacognition has two primary aspects, Knowledge of Cognition (KoC) and Regulation of Cognition (RoC). KoC refers to the individual awareness of their cognitive processes, including understanding what they know, how they learn, and strategies they use for their learning. KoC includes declarative knowledge (knowing about oneself as learner), procedural knowledge (knowing how to use strategies), and conditional knowledge (knowing when and why to use strategies. RoC, on the other hand, involves the processes through which learners plan, monitor, and evaluate their understanding and performance (Kallio et al., 2018; Locatelli, 2019; Ratebi & Amirian, 2013).

Metacognition is significant for students' learning as it is not only enhancing academic performance, but also fosters the development of self-regulated learning, where students take charge of their educational journeys by setting goals, selecting strategies, and assessing their progress (Stanton et al., 2021). Many research highlighted the significance of metacognition, indicating that students who engage in metacognitive practices such as self-assessment and reflective thinking tend to achieve higher academic outcomes and demonstrate better comprehension and retention of material (Craig et al, 2020; Perry et al., 2018).

Metacognition is a complex and difficult variable to observe and measure (Craig et al., 2020). There are a lot of assessments developed to measure students' metacognition, yet, the most practical and efficient instrument is self-report questionnaire (Craig et al., 2020) such as Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994), Junior Metacognitive Awareness Inventory (JMAI; Sperling et al., 2002), Metacognitive Skills Scale (MSS; Altindag & Senemoglu, 2013), Awareness of Independent Learning Inventory (AILI; Meijer et al., 2013), and Metacognition Self-Assessment Scale (MSAS; Pedone et al., 2017).

From the list of self-report questionnaires, one of the earliest and widely used instrument is the MAI (Metacognitive Awareness Inventory), originally developed by Schraw and Dennison (1994) to assess the extent to which undergraduate students are aware of and can regulate their cognitive processes. Developed from Flavell's metacognition framework, this instrument added information management and debugging to join planning, monitoring and evaluation as subcomponents of regulation of cognition (Craig et al., 2020). Therefore, metacognition in Schraw and Dennison's framework (1994) consisted of metacognitive knowledge and metacognitive experiences. The former are divided into three components: declarative, procedural, and conditional while the later consisted of five components which are planning, monitoring, information management, debugging, and evaluation. This instrument has since been adapted for various educational contexts, providing valuable insights into students' metacognitive abilities and fostering strategies to enhance their learning outcomes. This instrument is also used in this study to assess Indonesian high school students' metacognitive awareness in science learning.

Numerous studies have investigated the influence of variables such as gender and educational level on student's metacognition (Ekici et al., 2019; Garzón et al., 2020). Regarding gender, findings are inconsistent: some studies report no significant differences between men and women (Deliany & Cahyono, 2020; Ekici et al., 2019), while others suggest that women exhibit higher metacognitive abilities than men (Akin, 2016; Veloo et al., 2014). Concerning educational level, research indicates notable differences across grade levels, with some studies suggesting that older students typically demonstrate higher metacognitive awareness compared to their younger counterparts (Bakkaloglu, 2020; Ekici et al., 2019) and others favoring lower levels (Harding et al., 2019). Given the inconsistent findings about the influences of these two variables on metacognition, this research contributes to the existing knowledge by exploring the relationship between metacognitive awareness, gender, and grade level among a sample of 185 Indonesian high school students from public and private schools.

The purpose of the present study was to understand Indonesian high school students' metacognitive awareness with examination of the effect of gender and grade level. To this aim, we examined the differences of metacognitive awareness among high schoolers by 2-way ANOVA. In addition, we examined how gender and grade level affected students' metacognitive awareness. Before analyzing students' metacognitive awareness, the validity and reliability of the instrument for measuring metacognitive awareness (MAI) was examined using item response theory (IRT) framework. From the background, two research questions of this study are:

1. How are the validity inferences of Metacognitive Awareness Inventory (MAI) questionnaire using IRT Analysis?
2. How does metacognitive awareness differ among high school students across gender and grade level?

METHODS

The data were collected from public and private high schools in West Java, Indonesia. There were 185 participants in this study, consisting of 30% (55) male and 70% (135 female high schoolers. Of these 185 students, 59% and 41% were 10th and 11th graders, respectively. All high school students are majoring in science, therefore, the metacognitive awareness measured in this study is in the context of science learning.

To assess students' metacognitive awareness, this research used MAI (Metacognitive Awareness Inventory), an extensively used self-report instrument designed to measure individuals' metacognitive awareness. In the present study, 19 items from the original 52-item MAI instrument were selected to minimize respondent burden, particularly for high school students, while ensuring representativeness of its two-dimensional (Knowledge and Regulation of Cognition) and eight-dimensional theoretical models (declarative, procedural, and conditional knowledge, planning, information management and debugging strategies, monitoring, and evaluation). All 19 items ranged from 1, strongly disagree, to 5, strongly agree, indicating that the higher scores of students, the higher metacognitive awareness of them.

Regarding data analyses, to validate the MAI questionnaire in Indonesian high school context, the current study uses IRT framework via TAM package in R. The validity and reliability evidence examined in this analysis includes the instrument dimensionality, item fit, and reliability (EAP/item and WLE/person reliability). Moreover, two-way ANOVA analysis in IBM SPSS Statistics 29 was performed to address the second research question about the difference of gender and grade level on high school student's metacognitive awareness.

SCIENCE : Jurnal Inovasi Pendidikan Matematika dan IPA
Vol. 4 No. 4 November-Januari 2025
E-ISSN : 2797-1031
P-ISSN : 2797-0744
Online Journal System : https://jurnalp4i.com/index.php/science

RESULT AND DISCUSSION

MAI Validity using IRT Analysis

The validity test was conducted to confirm that the MAI instrument effectively measures high school students' metacognitive awareness as intended. First of all, the dimensionality test is conducted to determine whether the test is unidimensional (measuring one construct) or two-dimensions model as suggested by Schraw and Dennison (1994). To decide the best model, the deviance for one-dimension and two-dimension model and their values of Akaike Information Criterion (AIC) are compared. Table 1 shows the deviance and AIC values of two-dimension model (deviance = 8326.175; AIC = 8590.175) are lower than one-dimension model (deviance = 8554.336; AIC = 8602.336) indicating the two-dimension model is a better fit than unidimensional (Bond & Fox, 2015; Neumann et al., 2011).

Table 1. The dimensionality test of MAI

Models	Dimension	Log likelihood	Deviance	N par	AIC
One-dimension	All items	-4277.168	8554.336	24	8602.336
Two-dimensions	1. Knowledge			132	8590.175
	2. Regulation	-4163.088	8326.175		

Secondly, the item fit or the item quality measuring how well each item in MAI questionnaire aligns with the IRT framework, is measured. Poor item fit reveals when items behave unexpectedly such as an item may be interpreted differently by students and elicit inconsistent responses, and vice versa. In IRT framework, item fit is expressed by the weighted mean square (MNSQ)/infit MNSQ and the unweighted mean square (MNSQ)/outfit MNSQ. According to Wright and Linacre (1994), the acceptable values of weighted (infit) and unweighted (outfit) MNSQ is between 0.5 and 1.5, otherwise is misfitting items/outliers. Shown in Table 2, all 19 MAI items used in this study are fit with the benchmark.

Table 2. The item fit and reliability of MAI instrument

Item	Item-fits		Reliability		
	Weighted MNSQ	Unweighted MNSQ	EAP reliability	WLE reliability	Cronbach's alpha
KoC 1 - I know what kind of information is most important to learn	0.962	0.967			
KoC 2 - I know what the teacher expects me to learn	1.092	1.070			
KoC 3 - I have control over how well I learn	0.668	0.658			
KoC 4 - I am a good judge of how well I understand something	0.990	0.992	0.775	0.685	0.690
KoC 5 - I am aware of what strategies I use when I study	0.792	0.784			
KoC 6 - I can motivate myself to learn when I need to	1.059	1.079			

SCIENCE : Jurnal Inovasi Pendidikan Matematika dan IPA
Vol. 4 No. 4 November-Januari 2025
E-ISSN : 2797-1031
P-ISSN : 2797-0744
Online Journal System : https://jurnalp4i.com/index.php/science

Item	Item-fits		Reliability		
	Weighted MNSQ	Unweighted MNSQ	EAP reliability	WLE reliability	Cronbach's alpha
KoC 7 - I know when each strategy I use will be most effective	0.983	0.972			
RoC 1 - I find myself using helpful learning strategies automatically.	0.969	0.981			
RoC 2 - I periodically review to help me understand important relationships.	0.935	0.934			
RoC 3 - I think about what I really need to learn before I begin a task.	0.948	0.952			
RoC 4 - I set specific goals before I begin a task.	0.999	0.983			
RoC 5 - I try to translate new information into my own words.	1.200	1.190			
RoC 6 - I use the organizational structure of the text to help me learn.	0.817	0.821			
RoC 7 - I ask myself if what I'm reading is related to what I already know.	1.013	0.997	0.864	0.846	0.853
RoC 8 - I summarize what I've learned after I finish.	0.799	0.805			
RoC 9 - I ask myself if I learned as much as I could have once I finish a task	1.324	1.247			
RoC 10 - I change strategies when I fail to understand	0.983	0.984			
RoC 11 - I re-evaluate my assumptions when I get confused.	0.922	0.909			
RoC 12 - I stop and go back over new information that is not clear.	1.395	1.386			

Last, the internal consistency of the instrument (reliability) is also examined. In IRT framework, the reliability is represented by the expected a posteriori/plausible value - item (EAP/PV) and the weighted maximum likelihood estimation - person (WLE) reliabilities, respectively. The item reliability (EAP) indicates the replicability of item placements along the pathway if these items were given to other same-sized samples of people who behaved in the same way. Meanwhile, person reliability (WLE) indicates the replicability of person ordering if this sample of people were given other tests measuring the same construct. Analogous to Cronbach's alpha in CTT framework, both EAP and WLE indices are bounded by 0 and 1 with higher values indicating better reliability. The WLE reliability index close to 1 means the test is effectively distinguishing between test taker's abilities, whereas a high EAP reliability index suggests the item difficulties are well-defined and stable across different groups of test takers. Both EAP and WLE reliabilities were described as poor (. <67), fair (.67 - .80), good (.81 - .91), very good (.91 - .94), and excellent (>.94) according to Fisher (2007). Shown in Table 2, the EAP value of two dimensions is .775 (Knowledge) and .864 (Regulation), indicating fair to good reliability. Likewise, the WLE reliability of two dimensions were in fair to good categories with the values range from .685 to .846. In addition, the reliability result aligns with Cronbach's alpha's values which are in the range of fair to good (.690 - .853) reliabilities of all dimensions of MAI. In conclusion, based on the evidence of validity and reliability analyzed using IRT framework, the MAI instrument is valid and reliable.

The Effect of Gender and Grade Level on High School Students' Metacognitive Awareness

To examine the gender and grade level effect in students' metacognitive awareness on two-dimensions of MAI, two-way ANOVA was run. Table 3 below presents two-way ANOVA results about the effect of gender and grade level on high school students' metacognitive awareness and its interaction effect. In addition, Figure 1 depicts the mean difference of person measure (individual students' score) of metacognitive awareness.

Table 3. Effects of gender and grade level on students' metacognitive awareness

Dimensions	Gender		Grade Level		Gender x Grade Level	
	F	η_p^2	***F***	η_p^2	***F***	η_p^2
Knowledge of Cognition	.05	<.01	6.89**	.04	.66	<.01
Regulation of Cognition	14.11***	.07	.41	<.01	.09	<.01

Note: *p < .05, **p < .01, ***p < .001

As presented in Table 3, gender had significant effect on regulation of cognition [$F(1,181)$ = 14.11, p < .001, ηp^2 = .07]. Female students' metacognitive awareness is significantly higher than that of males in regulation of cognition. [Male (M = 1.82, SD = 0.89); Female (M = 2.43, SD = 0.99)]. On the other hand, grade level had significant effect on knowledge of cognition [$F(1,181)$ = 6.89, p < .01, ηp^2 = .04] where 10th graders in high school has a generally higher metacognitive awareness on knowledge of cognition compared to their senior, 11th graders [10th graders (M = 2.30, SD = 1.01); 11th graders (M = 1.95, SD = 0.82)].

SCIENCE : Jurnal Inovasi Pendidikan Matematika dan IPA
Vol. 4 No. 4 November-Januari 2025
E-ISSN : 2797-1031
P-ISSN : 2797-0744
Online Journal System : https://jurnalp4i.com/index.php/science

Furthermore, Cohen (1969) categorize the partial eta squared (ηp^2) as small (.01), medium (.06), and large (.14) effect. Accordingly, the effect of gender on high school students' metacognitive awareness (regulation of cognition) is medium. Meanwhile, the effect of grade level on students' knowledge of cognition is small (<.06). Moreover, this recent study did not find any significant interaction effect between gender and grade level on two dimensions of metacognitive awareness.

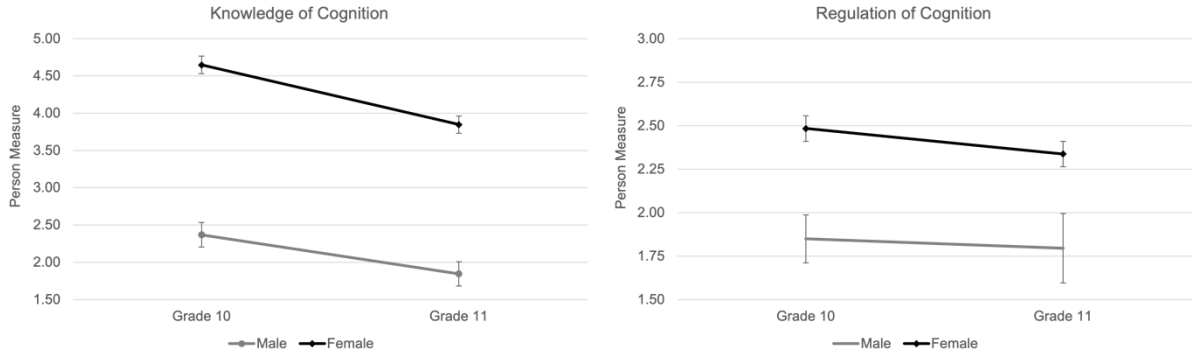

Figure 1. The interaction effect of gender and grade level on high school students' metacognitive awareness

Like the findings of this study, research on metacognition has consistently highlighted notable gender differences in the regulation of cognition. Females often show higher levels of metacognitive awareness compared to their male counterparts (Kleitman & Gibson, 2011; Sholihah et al., 2021; Pokay & Blumenfeld, 2012). This disparity can be attributed to combined interplay of biological and social factors. Biologically, researcher (Abedini, 2021) suggests that inherent differences in brain structure and function may contribute to variations in metacognitive abilities. According to Abedini's study (2021), females often outperform males in tasks requiring verbal and emotional processing, which could enhance their metacognitive capabilities (Abedini, 2021). This biological predisposition may facilitate a more nuanced understanding of their cognitive processes, leading to higher metacognitive awareness.

Furthermore, socially, the environment in which individuals are raised plays a significant role in shaping their metacognitive skills. Gender socialization often encourages females to engage in reflective practices and self-regulation, which are critical components of metacognitive awarenes (Aşikcan & Saban, 2018). Their study found that metacognitive awareness levels were influenced by their social experiences, with females exhibiting higher awareness due to societal expectations that promote introspection and emotional intelligence (Aşikcan & Saban, 2018). In many cultures, females are encouraged to be organized, detail-oriented, and reflective, traits that align with metacognitive behaviors. These societal norms might reinforce their tendency to self-regulation. Moreover, the educational context itself can impact metacognitive awareness. Studies (Callan et al., 2016; Sukarelawan et al., 2021; Veloo et al., 2014; Wu, 2014) have shown that female students often utilize metacognitive strategies more frequently and effectively than males. These strategies include planning, monitoring, and evaluating their own learning, which are essential for optimizing academic performance. This trend indicates that educational practices emphasizing metacognitive strategy instruction may benefit females disproportionately, thereby enhancing their awareness and application of these strategies (Sukarelawan et al., 2021).

Regarding the effect of grade level on metacognitive awareness, the present study found that the lower grade level of the students, the higher their metacognitive awareness in knowledge of cognition dimension. According to the research by Zimmerman (2002), younger

students tend to engage in reflective practices more readily than older students. They often reflect on their experiences and outcomes, which fosters metacognitive regulation. This reflective nature is crucial for developing self-regulated learning skills, as it allows students to assess their understanding and adjust their strategies accordingly. Besides, younger students are often characterized by their innate curiosity that drives engagement and promotes deeper cognitive processing. This engagement often leads to reflective questioning, a key component of metacognitive awareness. Studies show that younger students frequently ask questions about their learning processes, demonstrating an awareness of their cognitive strategies (Goupil & Proust, 2023; Schraw, 1998).

CONCLUSION

To conclude, the MAI instrument used in this study is valid and reliable to measure Indonesian high school students' metacognitive awareness, according to the IRT framework. Moreover, this study found that gender differences in metacognitive awareness, where female outperformed male in the dimension of knowledge of cognition can be influenced by biological and social factors. Furthermore, in terms of grade comparison, the study found lower graders have higher metacognitive awareness in regulation of cognition compared to their seniors. This can be influenced by their frequent reflective practices in their educational setting as well as their innate curiosity that make them engage in reflective questions as key aspect of metacognitive awareness.

REFERENCES

Abedini, Y. (2021). Metacognition as a core skill for wise decision-making in higher education: investigating gender differences. *Journal of Applied Research in Higher Education, 14*(2), 886-900. https://doi.org/10.1108/jarhe-11-2020-0400

Akin, E. (2016). Examining the Relation between Metacognitive Understanding of What Is Listened to and Metacognitive Awareness Levels of Secondary School Students. *Educational Research and Reviews, 11*(7), 390-401. https://doi.org/10.5897/ERR2015.2616

Altındağ, M., & Senemoğlu, N. (2013). Metacognitive skills scale. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 28*(28-1), 15-26.

Aşıkcan, M. and Şaban, A. (2018). Prospective teachers' metacognitive awareness levels of reading strategies. *Cypriot Journal of Educational Sciences, 13*(1), 23-30. https://doi.org/10.18844/cjes.v13i1.3366

Bakkaloglu, S. (2020). Analysis of Metacognitive Awareness of Primary and Secondary School Students in Terms of Some Variables. *Journal of Education and Learning, 9*(1), 156-163. https://doi.org/10.5539/jel.v9n1p156

Bond, T., & Fox, C. M. (2015). Applying the Rasch model: Fundamental measurement in the human sciences. New York: Routledge.

Callan, G. L., Marchant, G. J., Finch, W. H., & German, R. L. (2016). Metacognition, strategies, achievement, and demographics: Relationships across countries. *Educational Sciences: Theory and Practice, 16*(5), 1485-1502.

Cohen, J. (1969). Statistical power analysis for the behavioral sciences. New York: Academic Press.

Craig, K., Hale, D., Grainger, C., & Stewart, M. E. (2020). Evaluating metacognitive self-reports: systematic reviews of the value of self-report in metacognitive research. *Metacognition and Learning, 15*, 155-213. https://doi.org/10.1007/s11409-020-09222-y

Deliany, Z., & Cahyono, B.Y. (2020). Metacognitive reading strategies awareness and

metacognitive reading strategies use of EFL university students across gender. *Studies in English Language and Education, 7*(2), 421–437. https://doi.org/10.24815/siele.v7i2.17026

Ekici, F., Ulutaş, B., & Atasoy, B. (2019). An investigation of preservice teachers' levels of metacognitive awareness in terms of certain variables. *Bartın University Journal of Faculty of Education, 8*(3), 1035-1054. https://doi.org/10.14686/buefad.566640

Fisher, W. P. Jr (2007). Rasch measurement transaction. Transaction of the Rasch Measurement SIG American Educational Research Association, 21(1), 1095.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906-911. https://doi.org/10.1037/0003-066X.34.10.906

Garzón, D. F. M., Bustos, A. P. H, & Lizarazo, J. O. U. (2020). Relationship between metacognitive skills, gender, and level of schooling in high school students. *Suma Psicológica, 27*(1), 9-17. https://doi.org/10.14349/sumapsi.2020.v27.n1.2

Goupil, L., & Proust, J. (2023). Curiosity as a metacognitive feeling. *Cognition, 231*, 105325. https://doi.org/10.1016/j.cognition.2022.105325

Harding, S. M., English, N., Nibali, N., Griffin, P., Graham, L., Alom, B., & Zhang, Z. (2019). Self-regulated learning as a predictor of mathematics and reading performance: A picture of students in Grades 5 to 8. *Australian Journal of Education, 63*(1), 74-97. https://doi.org/10.1177/0004944119830153

Kallio, H., Virta, K., & Kallio, M. (2018). Modelling the components of metacognitive awareness. *International Journal of Educational Psychology, 7*(2), 94. https://doi.org/10.17583/ijep.2018.2789

Kleitman, S., & Gibson, J. (2011). Metacognitive beliefs, self-confidence and primary learning environment of sixth grade students. *Learning and Individual Differences, 21*(6), 728-735. https://doi.org/10.1016/j.lindif.2011.08.003

Meijer, J., Sleegers, P., Elshout-Mohr, M., Daalen-Kapteijns, M. V., Meeus, W., & Tempelaar, D. (2013). The development of a questionnaire on metacognition for students in higher education. *Educational Research, 55*(1), 31-52. https://doi.org/10.1080/00131881.2013.767024

Neumann, I., Neumann, K., & Nehm, R. (2011). Evaluating instrument quality in science education: Rasch-based analyses of a nature of science test. International Journal of Science Education, 33(10), 1373–1405. https://doi.org/10.1080/09500693.2010.511297

Pedone, R., Semerari, A., Riccardi, I., Procacci, M., Nicolò, G., & Carcione, A. (2017). Development of a self-report measure of metacognition: The Metacognition Self-Assessment Scale (MSAS). Instrument description and factor structure. *Clinical Neuropsychiatry: Journal of Treatment Evaluation, 14*(3), 185–194.

Perry, J., Lundie, D., & Golder, G. (2018). Metacognition in schools: What does the literature suggest about the effectiveness of teaching metacognition in schools? *Educational Review, 71*(4), 483-500. https://doi.org/10.1080/00131911.2018.1441127

Ratebi, Z. and Amirian, Z. (2013). The use of metacognitive strategies in listening comprehension by Iranian university students majoring in english: a comparison between high and low proficient listeners. *Journal of Studies in Education, 3*(1), 140. https://doi.org/10.5296/jse.v3i1.2969

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26*(1), 113-125. https://doi.org/10.1023/A:1003044231033

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033

Sholihah, M. A., & Sofiyana, M. S. (2021). Analisis kesadaran metakognitif bagi calon guru di Universitas Islam Balitar. *Analisis kesadaran metakognitif bagi calon guru di Universitas Islam Balitar, 12(*3), 201-2016. https://doi.org/10.17977/um052v12i3p202-206

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of children's knowledge and regulation of cognition. *Contemporary Educational Psychology, 27*(1), 51-79. https://doi.org/10.1006/ceps.2001.1091

Stanton, J. D., Sebesta, A. J., & Dunlosky, J. (2021). Fostering metacognition to support student learning and performance. *CBE—Life Sciences Education, 20*(2), fe3. https://doi.org/10.1187/cbe.20-12-0289

Sukarelawan, M. I., Jumadi, J., Kuswanto, H., Nurjannah, T., Hikmah, F. N., & Ramadhan, M. F. (2021). Implementation of rasch model for mapping students' metacognitive awareness. *Jurnal Pendidikan Fisika Indonesia, 17*(2), 86-93. https://doi.org/10.15294/jpfi.v17i2.27172

Veloo, A., Rani, M. A., & Hariharan, K. (2014). The role of gender in the use of metacognitive awareness reading strategies among biology students. *Asian Social Science, 11*(1). https://doi.org/10.5539/ass.v11n1p67

Wright, B. D., & Linacre, J. M. (1994). Reasonable mean-square fit values. Rasch Measurement Transactions, 8(3), 370.

Wu, J. Y. (2014). Gender differences in online reading engagement, metacognitive strategies, navigation skills and reading literacy. *Journal of Computer Assisted Learning, 30*(3), 252-271. https://doi.org/10.1111/jcal.12054

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice, 41*(2), 64-70. https://doi.org/10.1207/s15430421tip4102_2