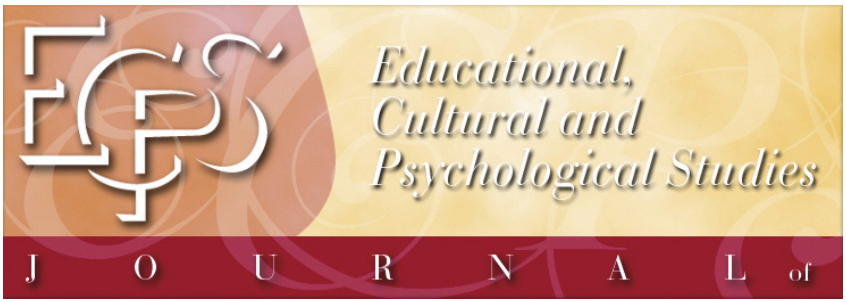



31
June 2025




Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

## Note di Ricerca
## Research Notes




Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

# Discovering the Relationship: Self-Efficacy, Metacognitive Awareness, and Science Learning Processes in Indonesian Science Classrooms*

**Rizky Agassy Sihombing [1, 2] - Naufal Rabah Wahidin [1]**
**Adi Rahmat [3] - Nanang Winarno [1] - Yanti Hamdiyati [3]**
**Shiang-Yao Liu [2]**

[1] *Universitas Pendidikan Indonesia - Department of Science Education*
[2] *National Taiwan Normal University, Graduate Institute of Science Education*
[3] *Universitas Pendidikan Indonesia - Department of Biology Education*

DOI: https://doi.org/10.7358/ecps-2025-031-siho

rizkyagassy@upi.edu
naufalrabah@upi.edu
adirahmat@upi.edu
nanang_winarno@upi.edu
yhamdiyati@upi.edu
liusy@ntnu.edu.tw

SCOPRIRE LA RELAZIONE: AUTOEFFICACIA, CONSAPEVOLEZZA METACOGNITIVA E PROCESSI DI APPRENDIMENTO DELLE SCIENZE NELLE AULE INDONESIANE

* R.A. Sihombing: idea formulation, research design, software utilization, data representation, formal examination, initial drafting - review & editing of the manuscript. N.R. Wahidin: research design, idea formulation, formal examination. A. Rahmat: conceptualization, resources, writing - review & editing. N.Winarno: conceptualization, resources, writing - review & editing. Y. Hamdiyati: conceptualization, resources, writing - review & editing, lecturer. S.-Y. Liu: conceptualization, resources, writing - review & editing. The authors declare no conflict of interest.

## Abstract

*This study aimed to analyze students' profiles using the Self-Efficacy Metacognition Learning Inventory – Science (SEMLI-S) based on gender and grade level, and to explore the relationship between self-efficacy, metacognitive awareness, and science learning processes. The research involved 221 junior high school students in Indonesia, aged 13 to 16, from Grades 7 to 9. The SEMLI-S instrument demonstrated strong internal consistency, with Cronbach's alpha values above 0.60. The overall average of students' metacognitive orientation was 68.4%, categorized as «Very Good.» In terms of gender, female students scored slightly higher (70.08%) than males (68.2%), both within the «Very Good» category. Based on grade level, Ninth-Grade students showed the highest score (75.5%), followed by Seventh-Grade (71.1%), while Eighth-Grade was slightly lower at 67.6%, categorized as «Good.» The findings emphasize the importance of personalized interventions that account for students' developmental stages. The study also highlights the need to integrate metacognitive training into science education and underlines the educator's role in fostering reflective and self-regulated learning. The study enhances understanding of how curriculum and teaching strategies can strengthen metacognition and self-efficacy in science.*

*Keywords:* Learning processes; Metacognitive awareness; Science learning; Self-efficacy.

## 1. Introduction

Self-efficacy, as a form of intrinsic motivation, significantly impacts students' learning experiences, self-awareness, and academic performance (Nia *et al.*, 2023; Zhao & Cao, 2023). Students with high self-efficacy manage learning more effectively through better self-evaluation and metacognitive regulation (Schunk & DiBenedetto, 2021; Yu & Deng, 2022). It enhances motivation, persistence, and outcomes (Belletti & Vaillant, 2022; Hidajat *et al.*, 2023), and when combined with metacognition, strengthens students' ability to organize learning (Belletti & Vaillant, 2022). Based on Bandura's theory, self-efficacy predicts problem-solving abilities, especially in complex subjects like science (Huang *et al.*, 2022; Heng & Chu, 2023). Anwar (2022) highlights that confidence, awareness, and motivation key elements of self-efficacy are essential for overcoming learning challenges.

Metacognition involves thinking, memory, learning, motivation, and cognitive development, and plays a central role in managing the learning process (Mason *et al.*, 2022). It is closely linked to higher-order thinking skills by regulating and organizing cognitive functions (Sarıçoban &

Kirmizi, 2020). Özçakmak *et al.* (2021) describe it as self-communication about strategies and task demands throughout learning. Schraw and Dennison (cit. in Çakıci, 2018) define metacognitive awareness as psychological processes guiding thinking, while Flavell (cit. in Jia *et al.*, 2019) views it as the ability to monitor and control one's own thought processes, forming a cognitive foundation for engaging with scientific concepts.

From the research conducted by Yu and Deng (2022), it is found that there is a difference between male and female self-efficacy. Differences in the level of self-efficacy and metacognition in male and female students can affect the performance and learning outcomes of each student. Meanwhile, in a study conducted by Akbayir and Topçul (2021), it was found that the academic achievement and level of metacognitive awareness of secondary school students differed significantly in terms of gender. Female students are more successful than male students. In addition, the level of metacognitive awareness of female high school students was higher than that of male students. In addition, a significant relationship was also found between logical thinking ability and gender. However, research (Garzón *et al.*, 2020) stated that there is no gender consensus regarding metacognitive skills at various school levels, as some studies found that women have better metacognitive skills compared to male.

Educational practices in Indonesia face challenges in enhancing students' awareness of learning processes, skill development, and the use of effective strategies (Madhakomala *et al.*, 2022). Studies show that students' metacognitive skills remain low in various schools across the country (Diella & Ardiansyah, 2017), indicating a gap between current methods and expected outcomes. However, research by Willison *et al.* (2023) reveals that strengthening self-efficacy and metacognitive abilities can positively influence students' overall learning, suggesting the potential for improvement through targeted interventions.

The SEMLI-S, developed by Thomas *et al.* (2008), is a valid and reliable instrument for measuring self-efficacy, metacognition, and learning processes. It has been applied in various educational contexts, including undergraduate biology students in Indonesia (Palennari *et al.*, 2018), preservice elementary teachers in Turkey (Gökalp & Kirbulut, 2013), and high school students in Nigeria and Kenya (Ajaja & Agboro-Eravwoke, 2017; Catherine, 2017). However, despite its broad use, there is still a lack of research utilizing the SEMLI-S to assess middle school students.

The main educational problems in Indonesia include low student awareness of the learning process, limited motivation to develop abilities, and a lack of understanding of effective learning strategies. Addressing these issues requires the ability to organize learning, which can be supported by


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

integrating self-efficacy and metacognition into the learning process. These concerns form the basis of the research questions guiding this study.

How is the profile of students' results in the SEMLI-S based on gender and grade levels in secondary school? How is the relationship between self-efficacy, metacognitive and learning processes in science education?

## 2. Materials and methods

This study utilized a survey-based research model based on Creswell and Clark (2018) framework. Survey research involves quantitatively describing trends, attitudes, or opinions of a population by studying a sample. It employs questionnaires or structured interviews to collect standardized data, aiming to generalize findings from the sample to the broader population through cross-sectional or longitudinal studies. Additionally, it adopts a correlational approach to explore the relationship among the sample's scores obtained from three different data collection tools. The aim is to investigate the self-efficacy, metacognitive awareness, and learning processes of secondary school students in science, as well as to explore the relationships among these variables.

### 2.1. *Participant*

This study involved 221 junior secondary school students aged 13-16 from Grades 7 to 9 across nine schools in Bandung and Medan, Indonesia. The research used convenience sampling, a non-random technique involving participants selected based on accessibility, location, availability, and willingness to participate (Etikan *et al.*, 2016). Sample distribution details are presented in *Table 1*.

*Table 1. – Distributions of the samples.*

| | | *f* | % |
|---|---|---|---|
| Gender | Female | 132 | 69.7 |
| | Male | 89 | 40.3 |
| Class | Seventh-Grade | 50 | 22.6 |
| | Eight-Grade | 151 | 68.3 |
| | Ninth-Grade | 20 | 9.04 |
| | Total | 221 | 100 |


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

In *Table 1* we present a snapshot of the demographics of our respondents. The sample consists of 221 science students, with a notable gender distribution – 89 (40.3%) identified as male, and 132 (59.7%) as female. Additionally, the distribution across grades reveals that 50 (22.6%) students are in Seventh-Grade, 151 (68.3%) are in Eighth-Grade, and 20 (9.04%) are in Ninth-Grade.

### 2.2. *Data collection tools*

This research used a case study approach combining surveys, classroom observations, and interviews. The survey employed the Self-Efficacy Metacognition Learning Inventory – Science (SEMLI-S), developed by Thomas *et al.* (2008), which consists of 30 items across five sub-scales: Science Learning Self-Efficacy (SE), Learning Risks Awareness (AW), Constructivist Connectivity (CC), Monitoring Evaluation & Planning (MEP), and Control of Concentration (CO). The SEMLI-S was suitable for assessing metacognitive orientations of secondary science students. Survey responses were collected using a 5-point Likert scale, then scored and presented as percentages, with item classifications aligned to the five metacognitive dimensions outlined in *Table 2*.

*Table 2. – Self-Efficacy Metacognition Learning Inventory – Science items for each category.*

| Subject research | Indicator | Number of survey items on SEMLI-S | Descriptions |
|---|---|---|---|
| Self-Efficacy | Self-Efficacy | 6 | Explores students' confidence in being able to achieve learning/ course objectives. |
| | Learning Risk Awareness | 5 | Explores students' awareness of situations that may interfere with their learning. |
| Metacognitive | Constructivist Connectivity | 7 | Explores whether students make connections between information and knowledge across science learning environments. |
| | Monitoring, Evaluation & Planning | 9 | Explores important, traditional strategies for learning science. |
| | Control of Concentration | 3 | Explores whether students control their level of concentration. |


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

This study employed classroom observations and interviews to examine factors influencing students' metacognitive development, with a focus on self-efficacy in science learning. Using participant observation, the researcher recorded student behaviors and metacognitive processes during one class session with a checklist and recording tools. To enhance data reliability, semi-structured interviews were conducted with three purposively selected students, using eight open-ended questions on metacognitive awareness and self-efficacy. This flexible format enabled rich, detailed responses (Ary *et al.*, 2010). Thematic analysis was applied, aligning findings with SEMLI-S dimensions, and identifying key patterns and individual variations. Researcher reflexivity and cross-validation with quantitative data supported interpretive validity. Although limited in scope, the interviews provided valuable contextual insights.

### 2.3. *Data analysis*

The data were analyzed using SPSS, including descriptive statistics, correlations, and Cronbach's alpha to assess the internal consistency of SEMLI-S dimensions. Cronbach's alphas were used to assess the internal consistency of SEMLI-S dimensions in the dataset, with a focus on reliability. The scores obtained are converted into a 0-100 scale, which will then be categorized using a rating scale modification shown in *Table 3*.

*Table 3. – Assessment category of SEMLI-S test.*

| Category | Scale |
|---|---|
| Excellent | 85-100 |
| Very Good | 68-84 |
| Good | 51-67 |
| Medium | 34-50 |
| Low | 17-33 |
| Very Low | 0-16 |

The research questions guided the analysis of data from classroom observations and open-ended interviews, focusing on students' self-efficacy and metacognitive profiles. Interview transcripts were analyzed by summarizing and comparing individual experiences based on the SEMLI-S dimensions, including awareness, control, evaluation, planning, monitoring, and self-efficacy (Thomas *et al.*, 2008). Open-ended responses were repeatedly reviewed and coded according to response frequency and relevance to the research questions.


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

## 3. Results

### 3.1. *The profile of students in the SEMLI-S based on gender and grade levels in secondary school*

The SEMLI-S used a 5-point Likert scale to assess how frequently students engaged in specific metacognitive activities, with 1 meaning «Never or Almost Never» and 5 meaning «Always or Almost Always». Higher scores indicated greater engagement in a given dimension. For example, a self-efficacy score above 3 suggested students felt confident more than half the time. The five-dimensional abbreviations, outlined in *Table 4*, are used throughout the analysis.

*Table 4. – Abbreviations for the SEMLI-S metacognitive dimensions.*

| SEMLI-S dimension | Overall | Pre-SEMLI-S |
|---|---|---|
| Constructivist Connectivity | CC | CC1 |
| Monitoring, Evaluation & Planning | MEP | MEP1 |
| Self-Efficacy | SE | SE1 |
| Learning Risks Awareness | AW | AW1 |
| Control of Concentration | CO | CO1 |

The Cronbach's alpha values in this study were consistent with those reported by Thomas *et al.* (2008), indicating acceptable internal consistency across all SEMLI-S sub-scales. All dimensions scored above 0.60, with the overall scale at 0.85. Sub-scale values included 0.91 for constructivist connectivity (CC), 0.89 for monitoring, evaluation and planning (MEP), 0.87 for self-efficacy (SE), 0.80 for learning risks awareness (AW), and 0.79 for control of concentration (CO). These results confirm the SEMLI-S instrument's reliability and suitability for use in this research context, as shown in *Table 5*.

*Table 6* shows no consistent pattern of metacognitive orientation across groups, with SEMLI-S scores ranging from 3.08 to 4.10. However, Seventh- and Ninth-Grade students consistently scored higher than Eighth-Grade students across all sub-scales. Female students generally scored higher than males, except in the SE and AW sub-scales, although overall metacognitive orientations between genders were relatively equal. Statistical tests were conducted to examine the significance of these variations, and the results are detailed in *Table 6*.


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

*Table 5. – The number of items and the Cronbach's alphas for the Pre-SEMLI-S scores by dimension.*

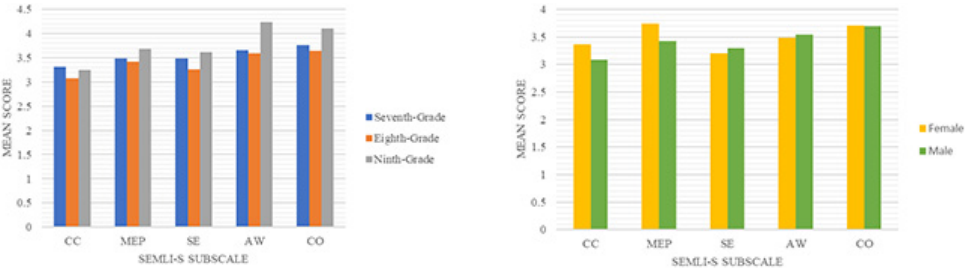
| Dimension | Number of items | Cronbach's alpha | |
|---|---|---|---|
| | | From Thomas *et al.* (2008) | Pre-SEMLI-S (n = 221) |
| CC | 7 | 0.84 | 0.91 |
| MEP | 9 | 0.84 | 0.89 |
| SE | 6 | 0.85 | 0.87 |
| AW | 5 | 0.77 | 0.80 |
| CO | 3 | 0.68 | 0.79 |

*Table 6. – Differences profile in students' response across class levels and gender in SEMLI-S sub-scales.*

| | Sample | CC | MEP | SE | AW | CO | Average (%) | Category |
|---|---|---|---|---|---|---|---|---|
| Gender | Female (n = 132) | 3.37 | 3.74 | 3.20 | 3.48 | 3.71 | 70.08 | Very Good |
| | Male (n = 89) | 3.08 | 3.42 | 3.30 | 3.54 | 3.70 | 68.2 | Very Good |
| Class | Seventh-Grade (n = 50) | 3.31 | 3.48 | 3.48 | 3.65 | 3.76 | 71.1 | Very Good |
| | Eighth-Grade (n = 151) | 3.08 | 3.42 | 3.26 | 3.59 | 3.64 | 67.6 | Good |
| | Ninth-Grade (n = 20) | 3.25 | 3.68 | 3.61 | 4.23 | 4.10 | 75.5 | Very Good |
| | Overall (n = 221) | 3.15 | 3.45 | 3.34 | 3.66 | 3.71 | 68.4 | Very Good |

Based on data from 221 secondary school students, the overall average metacognitive score was 68.4%. Female students (n = 132) averaged 70.08%, slightly higher than male students (n = 89) at 68.2%. When viewed by grade, Ninth-Grade students (n = 20) showed the highest average at 75.5%, followed by Seventh-Grade (n = 50) at 71.71%, and Eighth-Grade (n = 151) at 67.6%. These results indicate that metacognitive abilities vary across grade levels, with older students generally demonstrating higher engagement. Although female students scored slightly higher on average, gender-based differences in categorized analysis were minimal. *Figures 1a* and *1b* illustrate the distribution of metacognitive sub-scale scores by grade and gender, revealing developmental and gender-related variations.


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4




(a) (b)

*Figure 1. – Comparison of mean SEMLI-S sub-scale scores by grade level (a) and comparison of mean SEMLI-S sub-scale scores by gender (b).*

The results of metacognitive orientations were also analyzed using the SPSS test of the t-test statistic, the results of which can be seen in *Table 7*. Sensitive in different learning environments. Based on the t-test in *Table 7*, it shows differences in metacognitive abilities in different learning environments. Data on metacognitive abilities in male students and female students showed that ($p$ = 0,000 < 0.05) then $H_0$ is accepted and $H_1$ is rejected. In other words, there are significant differences in metacognitive abilities with different gender.

*Table 7. – t-test analysis comparing male and female science students on metacognitive orientations in SEMLI-S sub-scales.*

| | | Test Value = 0 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 95% Confidence interval of the difference | |
| Sub-scales | Gender | N | Mean | df | t | Sig. (2-tailed) | Mean difference | Lower | Upper |
| CC | Male | 89 | 3.08 | 220 | 57.787 | .000 | 20.05882 | 19.3747 | 20.7429 |
| | Female | 132 | 3.37 | | | | | | |
| MEP | Male | 89 | 3.42 | 220 | 63.403 | .000 | 18.31674 | 17.7474 | 18.8861 |
| | Female | 132 | 3.74 | | | | | | |
| SE | Male | 89 | 3.30 | 220 | 48.987 | .000 | 22.07240 | 21.1844 | 22.9604 |
| | Female | 132 | 3.20 | | | | | | |
| AW | Male | 89 | 3.54 | 220 | 64.062 | .000 | 31.12670 | 30.1691 | 32.0843 |
| | Female | 132 | 3.48 | | | | | | |
| CO | Male | 89 | 3.70 | 220 | 58.933 | .000 | 11.13575 | 10.7634 | 11.5081 |
| | Female | 132 | 3.71 | | | | | | |


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

### 3.2. *The relationship between self-efficacy, metacognitive and science learning processes*

Reviewing *Table 8*, it is evident that the kurtosis and skewness values fall within accepted limits, indicating a normal distribution of the data (Tabachnick & Fidell, 2013). Subsequently, an examination of multivariate normality and extreme values was conducted by comparing the mean and trimmed mean. Some outliers were identified in the dataset when means were compared to 5% trimmed means. To satisfy the assumption of multivariate normality, certain data points were excluded from the analysis, resulting in a remaining dataset of 212 observations that met the criteria for multivariate normality.

*Table 8. – Descriptive statistics for the observed variables.*

| Dimension | Mean | 5% Trimmed Mean | SD | Min | Max | Skew. | Kurt. |
|---|---|---|---|---|---|---|---|
| CC | 3.15 | 3.16 | 0.93 | 7.0 | 35.0 | -0.084 | -0.484 |
| MEP | 3.45 | 3.48 | 0.80 | 11.0 | 45.0 | -0.159 | -0.360 |
| SE | 3.34 | 3.36 | 0.86 | 9.0 | 30.0 | 0.004 | -0.516 |
| AW | 3.66 | 3.70 | 0.85 | 9.0 | 25.0 | -0.263 | -0.882 |
| CO | 3.71 | 3.75 | 0.95 | 12.0 | 15.0 | -0.582 | -0.160 |

The study employed correlation analysis to assess the degree of association between variables. The correlations among all variables are presented in *Table 9*. Notably, the table indicates that all correlations are statistically significant, revealing a noteworthy relationship between self-efficacy, metacognitive processes, and learning outcomes in the context of science education.

*Table 9. – Correlation between sub-dimensions.*

| | MEP | SE | AW | CO |
|---|---|---|---|---|
| CC | 0.571** | 0.519** | 0.463** | 0.486** |
| MEP | | 0.610** | 0.443** | 0.568** |
| SE | | | 0.357** | 0.436** |
| AW | | | | 0.415** |

*Table 9* shows strong correlations among the SEMLI-S sub-scales, supported by acceptable Cronbach's alpha values. A particularly high correlation was found between monitoring, evaluation and planning (MEP)

and self-efficacy (SE), with a coefficient of 0.610, suggesting that students with strong MEP skills tend to have higher self-efficacy. This finding is consistent with Thomas *et al.* (2008), who also reported a strong link between MEP and SE, as well as between constructivist connectivity (CC) and MEP, reflecting the interconnected nature of cognitive and learning processes in science education.

The quantitative results indicated statistically significant differences between male and female students across all SEMLI-S sub-scales ($p$ = 0.000), with female students scoring higher in cognitive control (CC), monitoring, evaluation & planning (MEP), and commitment (CO), while male students scored higher in self-efficacy (SE) and awareness of learning risk (AW). These findings are reinforced by qualitative data obtained from semi-structured interviews with three students. For example, one student stated, «*I usually make a summary before exams or assignments … watching educational videos also helps me better understand the topic*». This response reflects strong engagement in planning and monitoring processes, which aligns with the MEP sub-scale. Another student remarked, «*If I understand a certain topic, I feel very confident solving science problems. I often share my findings with my friends*», indicating a clear awareness of learning efficacy, consistent with the high SE scores observed among male students. Furthermore, the quote «*I once felt less confident when my friend could easily answer a question. I overcame it by directly asking the teacher after class*», illustrates awareness of learning risk (AW) and the application of metacognitive strategies to address it. The integration of these quotes helps to contextualize the quantitative score patterns, thereby strengthening the validity of the data through a deeper understanding of students' lived learning experiences.

## 4. Discussions

The analysis of metacognitive orientations revealed that Seventh- and Ninth-Grade students showed higher engagement than Eighth-Grade students, indicating possible developmental differences. Gender-based trends showed that female students generally had higher metacognitive orientations, except in self-efficacy (SE) and learning risks awareness (AW) subscales. However, overall metacognitive abilities between males and females were balanced. This finding contrasts with Erskine (2009), who reported that students involved in metacognitive training performed better academically. It aligns with studies by Zhang (2018), and Ardianingsih & Salim (2019), which found significant gender differences favoring females


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

in metacognitive ability and learning engagement, also noted that female students possess stronger reading comprehension and learning attitudes. Similarly, Fauzi and Ashadi (2019) observed greater learning awareness among females. Meanwhile, higher SE and AW scores among males may reflect role theory perspectives, where male students at higher levels develop stronger confidence and risk-taking traits. These findings highlight the need for gender-responsive metacognitive development strategies.

*Table 6* shows that mean metacognitive orientation scores varied by gender and class level, with Ninth-Grade students scoring the highest. This supports Thomas *et al.* (2008), who found higher metacognitive engagement at advanced school levels, and aligns with Ajaja and Agboro-Eravwoke (2017), who reported no significant differences across sub-scales. In Indonesia, this trend may be influenced by Ninth-Grade students' preparation for national exams, which promotes more strategic learning. Meanwhile, Eighth-Grade students may experience transitional challenges with increased workload but less exam pressure, leading to lower self-regulation. Seventh-Grade students may benefit from the novelty of secondary education, fostering motivation and metacognitive engagement (BSKAP, 2022). These findings highlight how academic context and grade level impact students' metacognitive development.

Differences in metacognitive skill use between male and female students appear nuanced, indicating inconsistent application in learning. Similar scores in the CO sub-scale suggest equal exposure to learning environments, while higher SE and AW scores among male students may reflect role theory, where approaching graduation fosters greater confidence and academic seriousness. In contrast, sociocultural expectations may influence female students' learning priorities differently (Ajaja & Agboro-Eravwoke, 2017). These findings underscore the need for gender-responsive educational strategies that address the distinct strengths and needs of male and female students to enhance self-regulated learning.

All correlations were statistically significant, emphasizing a robust relationship between self-efficacy, metacognitive processes, and learning outcomes in science education. This comprehensive study highlights the importance of tailored interventions, acknowledging developmental and gender-specific metacognitive dynamics. The SEMLI-S tool serves as a valuable resource for educators to identify areas of strength and improvement in students' metacognitive processes. As noted by Jia *et al.* (2019) and Rivai (2022), students' knowledge and control of their cognitive processes enhance learning, making metacognition a key factor that should be deliberately cultivated. The gradual development of metacognition, as confirmed by studies, underscores the importance of age-related differences

and emphasizes the need for ongoing metacognitive growth throughout various stages of education (Bellon *et al.*, 2020).

Metacognitive skills, deemed crucial for evaluating students' learning progress, are emphasized by Suratno *et al.* (2019) as pivotal for future success, fostering independence and instilling responsibility in students. Ajaja and Agboro-Eravwoke (2017) underscore the importance of analyzing students' metacognitive skills to explore and understand cognitive awareness. Metacognitive awareness, stemming from higher-order thinking skills, aims to continually develop self-awareness in metacognition.

Metacognitive strategies, instrumental in fostering problem-solving, motivation, and critical thinking, form a cornerstone for academic success among students (Smith *et al.*, 2020). This concept encompasses self-regulation techniques, comprising planning, strategies, knowledge, monitoring, evaluation, and termination, facilitating cognitive enhancement (Thenmozhi, 2019). Beyond students, metacognition holds relevance for educators, with teachers playing a pivotal role in nurturing both intellectual and metacognitive skills among students, thereby fostering independent learning for academic success (Sulaiman *et al.*, 2021). In the realm of science education, the application of metacognitive skills stands as a potent means to cultivate 21st-Century skills and elevate academic outcomes (Fauzi & Sa'diyah, 2019).

Research emphasizes the impact of metacognitive instruction on enhancing problem-solving abilities among students, fostering independence in learning processes by guiding understanding, planning, error recognition, and evaluation (Soodla *et al.*, 2016). Teachers equipped with metacognitive awareness benefit teaching and learning environments (Jiang *et al.*, 2016). Therefore, integrating metacognitive skills into science teaching involves planning curricula, assessing learning objectives, and reflecting on teaching methods, ensuring effective and profound scientific comprehension among students. Moreover, employing metacognitive teaching equips educators to adjust pedagogical strategies and teaching methods to meet diverse student needs (O'Hara *et al.*, 2019). The cultivation of metacognitive knowledge emerges as crucial across student, pre-service teacher, and teacher levels.

Informed by research findings, disparities in metacognition tied to gender and class levels highlight the need for tailored strategies in science education. Diverse learning styles warrant customized approaches, utilizing varied resources like educational apps, online materials, and interactive simulations (Özçakmak *et al.*, 2021). Crucially, fostering a supportive environment that encourages seeking assistance and providing constructive feedback alongside opportunities for self-reflection becomes essential in honing students' metacognitive skills (Hunukumbure *et al.*, 2017).


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

## 5. Conclusions

This study examines the relationship between metacognition, self-efficacy, and learning processes in science education among 221 Indonesian secondary school students aged 13-16 years, using the SEMLI-S instrument. The findings reveal variations in metacognitive engagement across grades and genders, with Seventh- and Ninth-Grade students showing higher engagement than Eighth-Grade students, indicating possible developmental differences. Female students generally demonstrated higher metacognitive orientation, though differences appeared across sub-scales. Significant correlations were found between self-efficacy, metacognitive processes, and science learning, emphasizing the role of cognitive and motivational factors in academic achievement. Interviews with students further supported the importance of individualized strategies and reflective learning experiences. The study highlights the value of integrating metacognitive development into curriculum design, instructional strategies, and teacher training. It advocates for interventions that are sensitive to students' developmental stages and gender-based learning needs, positioning SEMLI-S as an effective tool to support this approach. The findings underscore the need to foster metacognitive growth among students, educators, and teacher candidates to enhance autonomy, problem-solving skills, and science learning outcomes. Ultimately, the research provides meaningful insights for policymakers and educators seeking to improve science education through deliberate cultivation of self-efficacy and metacognitive skills.

## References

Ajaja, O.P., & Agboro-Eravwoke, U.O. (2017). Collection and analysis of students' metacognitive orientations for science learning: A survey of science classrooms in Delta State, Nigeria. *Electronic Journal of Science Education*, *21*(8), 1-20.

Akbayir, K., & Topçul, İ. (2021). The effect of middle school students' metacognitive awareness and logical thinking skills on success in mathematics course. *Education Quarterly Reviews*, *4*(2). https://doi.org/10.31014/aior.1993.04.02.272

Anwar, S.T. (2022). Enhancing science learning through metacognitive awareness. *International Journal of Current Research*, *14*(12), 22977-22980. https://doi.org/10.24941/ijcr.44448.12.2022

Ardianingsih, W., & Salim, R.M.A. (2019). Gender differences in metacognitive awareness of academic reading strategies. *Jurnal Psikologi Teori dan Terapan*, *10*(1), 74-84.
https://doi.org/10.26740/jptt.v10n1.p74-84

Ary, D., Jacobs, L.C., & Sorensen, C. (2010). *Introduction to research in education*. Belmont, CA: Wadsworth.

Ashton, P. (1984). Teacher efficacy: A motivational paradigm for effective teacher education. *Journal of Teacher Education*, *35*, 287-232.
https://doi.org/10.1177/002248718403500507

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman - Times Books - Henry Holt & Co.

Belletti, C., & Vaillant, D. (2022). Self-regulation and learning strategies of beginner and advanced university students. *Cuadernos de Investigación Educativa*, *13*(2).
https://doi.org/10.18861/cied.2022.13.2.3255

Bellon, E., Fias, W., & De Smedt, B. (2020). Metacognition across domains: Is the association between arithmetic and metacognitive monitoring domain-specific? *PLoS ONE*, *15*(3), 1-19.
https://doi.org/10.1371/journal.pone.0229932

BSKAP – Badan Standar, Kurikulum, dan Asesmen Pendidikan (2022). *Panduan pembelajaran dan asesmen: Pendidikan Anak Usia Dini, Pendidikan Dasar, dan Menengah*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia.

Çakıci, D. (2018). Metacognitive awareness and critical thinking abilities of pre-service EFL teachers. *Journal of Education and Learning*, *7*(5), 116-129.
https://doi.org/10.5539/jel.v7n5p116

Catherine, A. (2017). Investigating the relationship between science self-efficacy beliefs, gender, and academic achievement, among high school students in Kenya. *Journal of Education and Practice*, *8*(8), 146-153.

Creswell, J.W., & Clark, P.V.L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Thousand Oaks, CA: Sage.

Diella, D., & Ardiansyah, R. (2017). The correlation of metacognition with critical thinking skills of grade XI students on human excretion system concept. *Jurnal Penelitian dan Pembelajaran IPA*, *3*(2), 134.
https://doi.org/10.30870/jppi.v3i2.2576

Etikan, I., Musa, S.A., & Alkassim, R.S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1-4.
https://doi.org/10.11648/j.ajtas.20160501.11

Fauzi, A., & Ashadi. (2019). An analysis on reading strategies based on metacognitive awareness and gender. *Lingua Pedagogia (Journal of English Teaching Studies)*, *1*(1), 1-16.
https://doi.org/10.21831/lingped.v1i1.23912

Fauzi, A., & Sa'diyah, W. (2019). Students' metacognitive skills from the viewpoint of answering biological questions: Is it already good? *Indonesian Journal of Science Education / Jurnal Pendidikan IPA Indonesia*, *8*(3), 317-327.
https://doi.org/10.15294/jpii.v8i3.19457

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 Psicologica*, *27*(1), 9-17.
https://doi.org/10.14349/sumapsi.2020.v27.n1.2

Heng, Q., & Chu, L. (2023). Self-efficacy, reflection, and resilience as predictors of work engagement among English teachers. *Frontiers in Psychology*, *14*, 116068, 1-13.
https://doi.org/10.3389/fpsyg.2023.1160681

Hidajat, H.G., Hanurawan, F., Chusniyah, T., Rahmawati, H., & Gani, S.A. (2023). The role of self-efficacy in improving student academic motivation. *KnE Social Sciences*, *8*(19), 175-187.
https://doi.org/10.18502/kss.v8i19.14362

Huang, X., Bernacki, M.L., Kim, D., & Hong, W. (2022). Examining the role of self-efficacy and online metacognitive monitoring behaviors in undergraduate life science education. *Learning and Instruction*, *80*(February), 101577.
https://doi.org/10.1016/j.learninstruc.2021.101577

Hunukumbure, A.D., Smith, S.F., & Das, S. (2017). Holistic feedback approach with video and peer discussion under teacher supervision. *BMC Medical Education*, *17*(179), 1-10.
https://doi.org/10.1186/s12909-017-1017-x

Jia, X., Li, W., & Cao, L. (2019). The role of metacognitive components in creative thinking. *Frontiers in Psychology*, *10*, 2404, 1-11.
https://doi.org/10.3389/fpsyg.2019.02404

Jiang, Y., Ma, L., & Gao, L. (2016). Assessing teachers' metacognition in teaching: The teacher metacognition inventory. *Teaching and Teacher Education*, *59*, 403-413.
https://doi.org/10.1016/j.tate.2016.07.014

Madhakomala, R., Hakim, M.A., & Syifauzzuhrah, N. (2022). Problems of education in Indonesia and alternative solutions. *International Journal of Business, Law, and Education*, *3*(3), 135-144.
https://doi.org/10.56442/ijble.v3i3.64


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

Mason, L.A., Thomas, A.K., & Taylor, H.A. (2022). On the proposed role of metacognition in environment learning: Recommendations for research. *Cognitive Research: Principles and Implications*, *7*(1). https://doi.org/10.1186/s41235-022-00454-x

Nia, H.S., Marôco, J., She, L., Khoshnavay, F.F., Rahmatpour, P., Stepanovic, I.I., *et al.* (2023). Student satisfaction and academic efficacy during online learning with the mediating effect of student engagement: A multicountry study. *PLoS ONE*, *18*(10), 1-20. https://doi.org/10.1371/journal.pone.0285315

O'Hara, S., Pritchard, R., & Pitta, D. (2019). Teaching with and for metacognition in disciplinary discussions. *Metacognition in Learning*, 1-19. https://doi.org/10.5772/intechopen.86665

Palennari, M., Taiyeb, M., & Saenab, S. (2018). Profile of students' metacognitive skill based on their learning style. *Journal of Physics: Conference Series*, *1028*, 012030, 1-6. https://doi.org/10.1088/1742-6596/1028/1/012030

Rivai, A.T.O. (2022). Effectiveness of using textbooks based on metacoginitive skills on student's learning outcomes. *Indonesian Journal of Educational Studies (IJES)*, *25*(2), 134-141. https://doi.org/10.26858/ijes.v25i2.39018

Sarıçoban, A., & Kırmızı, Ö. (2020). The correlation between metacognitive awareness and thinking styles of pre-service EFL teachers. *International Online Journal of Education and Teaching (IOJET)*, *7*(3), 1032-1052.

Schunk, D.H., & DiBenedetto, M.K. (2021). Self-efficacy and human motivation. *Advances in Motivation Science*, *8*, 153-179. https://doi.org/10.1016/bs.adms.2020.10.001

Smith, A.K., Black, S., & Hooper, L.M. (2020). Metacognitive knowledge, skills, and awareness: A possible solution to enhancing academic achievement in African American adolescents. *Urban Education*, *55*(4), 625-639. https://doi.org/10.1177/0042085917714511

Soodla, P., Jõgi, A.L., & Kikas, E. (2016). Relationships between teachers' metacognitive knowledge and students' metacognitive knowledge and reading achievement. *European Journal of Psychology of Education*, *32*(2), 201-218. https://doi.org/0.1007/s10212-016-0293-x

Sulaiman, T., Rahim, S.S.A., Yan, W.K., & Subramaniam, P. (2021). Primary science teachers' perspectives about metacognition in science teaching. *European Journal of Educational Research*, *10*(1), 75-84. https://doi.org/10.12973/eu-jer.10.1.75

Suratno, K.N., Yushardi, D., & Wicaksono, I. (2019). The effect of using synectics model on creative thinking and metacognition skills of junior high school students. *International Journal of Instruction*, *12*(3), 133-150. https://doi.org/10.29333/iji.2019.1239

Thenmozhi, C. (2019). Models of metacognition. *Shanlax International Journal of Education*, *7*(2), 1-4. https://doi.org/10.34293/education.v7i2.303

Thomas, G., Anderson, D., & Nashon, S. (2008). Development of an instrument designed to investigate elements of science students' metacognition, self-efficacy and learning processes: The SEMLI-S. *International Journal of Science Education*, *30*(13), 1701-1724. https://doi.org/10.1080/09500690701482493

Tobin, K. (Ed.). (1993). *The practice of constructivism in science education*. Washington, DC: American Association for the Advancement of Science Press.

Willison, J., Draper, C., Fornarino, L., Li, M., Sabri, T., Shi, Y., & Zhao, X. (2023). Metacognitively ALERT in science: Literature synthesis of a hierarchical framework for metacognition and preliminary evidence of its viability. *Studies in Science Education*, *60*(2), 153-189. https://doi.org/10.1080/03057267.2023.2207147

Yu, Z., & Deng, X. (2022). A meta-analysis of gender differences in e-learners' self-efficacy, satisfaction, motivation, attitude, and performance across the world. *Frontiers in Psychology*, *13*(May), 1-14. https://doi.org/10.3389/fpsyg.2022.897327

Zhang, L. (2018). Gender differences in metacognitive and cognitive strategy use and reading test performance. In L. Zhang, *Metacognitive and cognitive strategy use in reading comprehension* (pp. 131-145). Singapore: Springer. https://doi.org/10.1007/978-981-10-6325-1_6

Zhao, S.R., & Cao, C.H. (2023). Exploring relationship among self-regulated learning, self-efficacy and engagement in blended collaborative context. *Sage Open*, *13*(1), 1-11. https://doi.org/10.1177/21582440231157240

## Riassunto

*Questo studio analizza i profili degli studenti indonesiani utilizzando il Self-Efficacy Metacognition Learning Inventory – Science (SEMLI-S) in base al genere e al livello scolastico, esplorando la relazione tra autoefficacia, consapevolezza metacognitiva e processi di apprendimento scientifico. Sono stati coinvolti 221 studenti di età compresa tra 13 e 16 anni, dalla settima alla nona classe. Il SEMLI-S ha mostrato una buona coerenza interna (alfa di Cronbach > 0,60). L'orientamento metacognitivo medio degli studenti è stato del 68,4% («Molto Buono»), con le ragazze leggermente superiori (70,08%) rispetto ai ragazzi (68,2%). Gli studenti del nono anno hanno ottenuto il punteggio più alto (75,5%), seguiti dal settimo (71,1%), mentre l'ottavo ha raggiunto il 67,6% («Buono»). I risultati evidenziano l'importanza di interventi personalizzati*


Online ISSN 2037-7924 - Print ISSN 2037-7932 - ISBN 978-88-5513-208-4

*che considerino lo sviluppo degli studenti. Lo studio sottolinea la necessità di integrare la formazione metacognitiva nell'educazione scientifica e il ruolo essenziale degli insegnanti nel promuovere l'apprendimento autoregolato. Questi risultati contribuiscono alla comprensione del legame tra metacognizione, autoefficacia e successo scolastico, offrendo spunti per migliorare i curricula e le strategie didattiche in ambito scientifico.*

*Parole chiave:* Apprendimento delle scienze; Autoefficacia; Consapevolezza metacognitiva; Processi di apprendimento.



*How to cite this paper:* Sihombing, R.A., Wahidin, N.R., Rahmat, A., Winarno, N., Hamdiyati, Y., & Liu, S.-Y. (2025). Discovering the relationship: Self-efficacy, metacognitive awareness, and science learning processes in Indonesian science classrooms [Scoprire la relazione: autoefficacia, consapevolezza metacognitiva e processi di apprendimento delle scienze nelle aule indonesiane]. *Journal of Educational, Cultural and Psychological Studies (ECPS)*, *31*, 111-129. https://doi.org/10.7358/ecps-2025-031-siho