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The Influence of Self-Regulated Learning on Science Learning Resilience: The Moderating Role of Gender

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Abstract

This study was conducted in response to the relatively low levels of self-regulated learning and science learning resilience among students in several Madrasah Tsanawiyah located in Batetangnga Village, as well as differences in learning characteristics based on gender. The research aims to examine the effect of self-regulated learning on students' science learning resilience and to investigate whether gender moderates this relationship. A quantitative correlational research design was employed involving 124 students by random sampling. Data were collected using a Likert-scale questionnaire and analyzed through descriptive statistics, simple linear regression, and Moderated Regression Analysis (MRA). The findings revealed that self-regulated learning has a positive and statistically significant effect on science learning resilience (B = .496, β = .469, p < .001). Furthermore, gender was found to significantly moderate the relationship between self-regulated learning and science learning resilience, as indicated by the significant interaction effect (p < .001). These results suggest that students with higher levels of self-regulated learning tend to demonstrate greater resilience in science learning, while the strength of this relationship varies according to gender.

Keywords: Gender, Influence, Resilience of Science Learning, Self-Regulated Learning, Students of Madrasah Tsanawiyah.

INTRODUCTION

Education and learning fundamentally occur through processes of teaching and training among individuals (Akhmad et al., 2022). In the context of Madrasah Tsanawiyah (MTs), learning requires students not only to acquire academic knowledge but also to develop the ability to regulate their own learning and respond constructively to academic challenges. This is particularly important in science learning, which involves understanding scientific concepts, completing assignments, participating in practical activities, and solving problems that may not be immediately understood. Such demands require students to plan and organize their learning, maintain motivation, monitor their progress, and persist when facing difficulties. These abilities are closely related to self-regulated learning, which enables students to actively manage their thoughts, motivation, and learning behaviors, while persistence in dealing with academic difficulties reflects an important aspect of learning resilience.

Learning resilience refers to students' capacity to respond adaptively to

academic adversity, maintain their commitment to learning, and recover from difficulties or setbacks (Cassidy, 2016). In science learning, resilience is particularly important because students may encounter difficult concepts, demanding assignments, unsuccessful learning experiences, and academic evaluations. Students with stronger resilience are more likely to maintain their efforts and adapt to academic difficulties, whereas students with lower resilience may experience greater difficulty sustaining their engagement when confronted with learning challenges. Therefore, self-regulated learning and learning resilience are closely connected, as students' ability to regulate their learning may support their persistence and adaptive responses when facing academic difficulties.

One factor that may contribute to students' learning resilience is self-regulated learning (SRL). Self-regulated learning refers to students' active involvement in regulating their cognition, motivation, and behavior in order to achieve learning goals (Panadero, 2017; Zimmerman, 2002). It involves processes such as planning, monitoring, controlling, and evaluating learning activities. Through self-regulation, students can identify learning difficulties, select appropriate strategies, manage their learning time and resources, and evaluate the effectiveness of their learning approaches. These processes are particularly relevant to science learning because students frequently encounter conceptual difficulties and learning tasks that require sustained effort. Previous research has demonstrated that self-regulated learning strategies are associated with academic achievement and learning outcomes across educational contexts (Broadbent & Poon, 2015; Donker et al., 2014; Jansen et al., 2019).

The relationship between self-regulated learning and academic resilience has also received empirical support. Li (2024) found a positive association between academic resilience and self-regulated learning among rural middle school students, indicating that students with higher resilience tended to demonstrate better self-regulated learning. Although the direction of the relationship examined by Li (2024) differs from that of the present study, both findings indicate a positive association between self-regulated learning and academic resilience. Similarly, Pareallo et al. (2024) reported a positive relationship between self-regulated learning and academic resilience among students completing their undergraduate theses. In science education, Tarumasely (2022) found that self-regulated learning was associated with students' science learning outcomes. More recent research has further demonstrated an association between self-regulated learning, academic resilience, learning motivation, and

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academic well-being (Srem-Sai et al., 2025). These findings suggest that self-regulated learning is relevant not only to students' academic performance but also to their capacity to persist and adapt when facing academic difficulties.

Despite these findings, the relationship between self-regulated learning and learning resilience may not necessarily be identical across all students. Gender may represent an important contextual factor in understanding this relationship. Gender should not be understood merely as a biological distinction but also as a social construct involving roles, expectations, and patterns of interaction that may shape students' experiences in educational settings. Such experiences may be associated with differences in motivation, learning strategies, self-regulation, help-seeking, and responses to academic demands. Therefore, examining gender only as a demographic characteristic may provide an incomplete understanding of how students regulate their learning and respond to academic challenges.

Empirical studies support the relevance of gender in research on self-regulated learning. Weis et al. (2013) examined gender differences in school achievement and highlighted the role of self-regulation in understanding differences in academic outcomes. Similarly, Liu et al. (2021) in a study involving 400 high school students, found significant gender differences in self-regulated online learning, with female students demonstrating higher levels in the overall construct and several dimensions of self-regulated learning. Virtanen and Nevgi (2010) also identified gender differences in self-regulated learning strategies among higher education students. These findings suggest that gender may be associated not only with differences in academic outcomes but also with differences in the learning-regulation processes through which students respond to academic demands.

In science education, Setiawati and Arsana (2018) investigated the influence of learning motivation and gender on science learning achievement among students in a bilingual junior high school in Denpasar. Their findings showed that gender did not have a significant effect on students' science learning achievement ($p > 0.05$). This finding is important because it indicates that gender differences in science learning outcomes cannot necessarily be assumed to exist across educational contexts. However, their study focused on science learning achievement rather than the relationship between self-regulated learning and learning resilience. Moreover, the absence of a significant gender effect on achievement does not determine whether gender changes the strength of the relationship between self-regulated learning and learning resilience. Thus, comparing academic achievement between

male and female students is conceptually different from examining whether gender moderates the relationship between two learning-related variables.

The urgency of the present study is further supported by preliminary information obtained from MTs DDI Kanang and MTs Ma'arif NU Kanang. Several students were reported to experience difficulties in managing study time, selecting appropriate learning strategies, and maintaining consistency when learning difficult science material. These difficulties may affect students' ability to persist and recover when confronted with academic challenges. Preliminary information also indicated differences in self-regulated learning and learning resilience between male and female students. These conditions indicate a gap between the expected learning condition, in which students are able to regulate their learning and persist in facing academic difficulties, and the conditions observed in the research setting. Therefore, investigating the relationship between self-regulated learning and learning resilience while considering gender is important for obtaining a more comprehensive understanding of students' responses to academic challenges in science learning.

Although previous studies have examined self-regulated learning, academic resilience, and gender differences, limited research has examined whether gender moderates the relationship between self-regulated learning and science learning resilience among Madrasah Tsanawiyah students. Previous research has predominantly examined self-regulated learning and resilience as directly related constructs or investigated gender differences in self-regulated learning and academic achievement separately. Less attention has been given to whether the relationship between self-regulated learning and resilience varies according to gender, particularly in the context of science learning at the Madrasah Tsanawiyah level. This gap is important because understanding differences in the strength of this relationship may provide a more precise basis for developing learning strategies that respond to students' diverse needs.

Therefore, this study aims to examine the influence of self-regulated learning on students' science learning resilience and to investigate whether gender moderates the relationship between self-regulated learning and science learning resilience. Rather than treating gender merely as a basis for comparing male and female students, this study examines gender as a moderating variable to determine whether the relationship between self-regulated learning and science learning resilience differs between the two groups. The findings are expected to contribute empirical evidence concerning the role of

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self-regulated learning in strengthening students' resilience in science learning and provide a basis for developing learning practices that support students in regulating their learning and persisting in the face of academic challenges.

METHOD

This study employed a quantitative approach with a correlational research design. It aimed to examine the effect of self-regulated learning on students' science learning resilience and to determine whether gender moderates this relationship. The study used a non-experimental design without treatment or manipulation of the research variables.

The study was conducted during the 2025/2026 academic year at MTs DDI Kanang and MTs Ma'arif NU Kanang in Batetangnga Village, Polewali Mandar Regency, West Sulawesi, Indonesia. The population consisted of 180 students from the two schools. A total of 124 students were selected using the Slovin formula with a 5% margin of error. Proportional random sampling was employed to ensure proportional representation from each school, followed by random selection of participants.

The study variables consisted of self-regulated learning as the independent variable (X), science learning resilience as the dependent variable (Y), and gender as the moderating variable (Z). Data were collected using structured questionnaires with a four-point Likert scale. The self-regulated learning instrument was developed based on Zimmerman's (1989) framework, covering metacognition, motivation, and behavior. The science learning resilience instrument was based on Cassidy's (2016) framework, covering perseverance, reflecting and adaptive help-seeking, and negative affect and emotional response. The instruments were reviewed and validated by experts before being administered to the participants.

Data were analyzed using IBM SPSS Statistics version 22. Descriptive statistics and independent-samples t-tests were used to describe the research variables and examine differences in self-regulated learning and science learning resilience between male and female students. Prior to hypothesis testing, normality, linearity, and homogeneity tests were conducted.

Simple linear regression analysis was used to examine the effect of self-regulated learning on science learning resilience. Moderated Regression Analysis (MRA) was subsequently employed to determine whether gender moderated the relationship between self-regulated learning and science learning resilience. Gender was dummy-coded as 0 = male and 1 = female. Self-regulated learning scores were mean-centered before constructing the interaction term (SRL_C × Gender_Dummy). The moderation model included

SRL_C, Gender_Dummy, and their interaction term. A statistically significant interaction coefficient ($p < 0.05$) indicated a moderating effect of gender. All statistical tests were evaluated at a 5% significance level ($\alpha = 0.05$).

RESULT AND DISCUSSION

The mean of Science Resilience Learning score was 91.59 for female students and 85.77 for male students, while the mean science learning resilience score was 86.95 for female students and 76.89 for male students (Table 1). These descriptive differences provide an initial indication that students' learning regulation and resilience varied across gender groups. However, these mean differences should be interpreted cautiously because higher scores among female students do not necessarily imply that gender itself is the direct cause of differences in learning regulation or resilience.

Table 1. Self-Regulated Learning and Science Learning Resilience by Gender

Gender	N	SRL Mean	Resilience Mean
Male	61	85.77	76.89
Female	63	91.59	86.95
Total	124		

The descriptive pattern is theoretically consistent with the concept of self-regulated learning proposed by Zimmerman (2002), in which learners actively regulate their cognition, motivation, and behavior through processes of forethought, performance, and self-reflection. Students who are able to establish learning goals, monitor their progress, regulate their motivation, and evaluate their learning strategies may have greater opportunities to maintain effective learning behavior when facing academic difficulties. This process is particularly relevant to science learning because students are required to understand complex concepts, solve problems, interpret information, and persist when their initial attempts are unsuccessful. Recent evidence also indicates that self-regulated learning is an important educational resource that can be developed through appropriate learning support. Jansen et al. (2019), through a meta-analysis, found that interventions designed to support self-regulated learning were effective in improving both students' self-regulated learning activity and academic achievement, although the relationship between SRL activity and achievement was only partially mediated. This finding supports the view that SRL is an important learning process while also indicating that other factors may influence students' academic outcomes.

The higher mean of SRL among female students in the present study is also consistent with previous international research. Liu et al. (2021), in a study of high school students, reported significant gender differences in self-regulated online

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learning, with female students showing higher levels of overall self-regulated learning and several dimensions of the SRL process. Similarly, Virtanen and Nevgi (2010) found gender differences in several self-regulated learning strategies among higher education students. More recent research has continued to demonstrate that gender may be associated with differences in students' self-regulatory learning experiences. Oinas et al. (2022), using a large sample of secondary school students, reported differences in students' self-regulated learning experiences in the context of distance learning. These studies suggest that gender differences may occur in particular learning-regulation processes, although the magnitude and pattern of these differences can vary according to educational context and the dimensions of SRL being measured.

Therefore, the higher SRL score among female students in the present study should not be interpreted as evidence that female students universally possess better self-regulation. Rather, it may indicate that female students in the present educational context reported greater use of particular self-regulatory processes. Differences in learning strategies, motivation, help-seeking behavior, academic expectations, and learning experiences may contribute to this pattern. This interpretation is important because self-regulation is not a fixed personal characteristic but a process that develops through interaction between learners and their learning environments. Recent evidence supports this interpretation because the effectiveness of SRL is influenced not only by students' regulatory activity but also by motivational and contextual factors as reported by Jansen et al. (2019). Thus, differences between gender groups should be understood within the particular educational context in which the students learn.

The analysis further showed a statistically significant difference in SRL between male and female students, with $t(114.18) = -2.413$ and $p = .017$. Thus, the observed difference in SRL between the two gender groups was statistically significant.

The significant gender difference in SRL is consistent with findings reported by Liu et al. (2021), who found that female students demonstrated higher levels of self-regulated online learning during the COVID-19 lockdown. Weis et al. (2013) also demonstrated that self-regulation is relevant to understanding gender differences in academic outcomes. More recent research by Oinas et al. (2022) further indicates that students' experiences of self-regulated learning may differ across learner characteristics and educational contexts. However, these findings should not be interpreted as evidence that gender directly determines

students' self-regulatory ability. Gender differences in SRL may depend on the learning environment, the particular SRL dimensions assessed, students' motivational characteristics, and the social expectations surrounding learning behavior.

In science learning, differences in self-regulation may become particularly important because students must continuously monitor their understanding and modify strategies when encountering difficult concepts. Students who recognize that their current approach is ineffective may change their strategy, seek assistance, allocate additional time, or use other learning resources. Thus, the significant gender difference observed in this study suggests that the learning-regulation processes experienced by male and female students may differ in the present context, but further research is needed to identify the specific mechanisms underlying these differences. The broader SRL literature also indicates that students benefit when learning environments explicitly support planning, monitoring, strategy use, and reflection rather than assuming that students automatically possess these skills. Jansen et al. (2019) found that interventions supporting self-regulated learning can improve students' SRL activity and academic achievement.

The analysis also revealed a statistically significant difference in science learning resilience between male and female students. Female students obtained a higher mean resilience score (86.95) than male students (76.89), and the difference was statistically significant, $t(117.93) = -4.148$, $p < .001$.

This finding indicates that male and female students differed significantly in their capacity to persist and adapt when facing difficulties in science learning. However, resilience should not be understood as a fixed psychological characteristic determined by gender. Cassidy (2016) conceptualized academic resilience as a multidimensional construct involving perseverance, reflecting and adaptive help-seeking, and negative affect and emotional response. Consequently, differences in resilience may reflect differences in how students respond to academic adversity rather than a direct effect of gender. This perspective is supported by Hunsu et al. (2023), whose meta-analytic review of 239 independent studies demonstrated that academic resilience is associated with a range of risk and protective factors. Their findings reinforce the understanding that resilience is influenced by multiple individual, social, and contextual resources rather than by a single characteristic.

The higher resilience score among female students may be associated with differences in self-regulation, motivation, coping strategies, help-seeking, or

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learning experiences. This interpretation is supported by international research showing that academic resilience is interconnected with other learning-related resources. Srem-Sai et al. (2025), for example, demonstrated significant associations among academic resilience, learning motivation, self-regulated learning, and academic well-being. This suggests that resilience should be understood as part of a broader system of cognitive, motivational, behavioral, and contextual processes rather than as an isolated characteristic of students. Consistent with this view, Hunsu et al. (2023) emphasized the importance of protective factors in understanding academic resilience and students' academic outcomes. Therefore, the gender difference observed in the present study should be interpreted as a pattern of differences within the sample rather than as evidence of an inherent difference in resilience between male and female students.

Before testing the research hypotheses, the assumptions of normality, linearity, and homogeneity were examined. The Kolmogorov–Smirnov test indicated that the residuals were normally distributed ($p = .200$). The linearity test showed a significant linear relationship between SRL and science learning resilience ($F = 34.247$, $p < .001$), while the deviation from linearity was not significant ($F = .993$, $p = .500$). The Levene test was also not significant ($F = 3.895$, $p = .051$), indicating that the homogeneity assumption was satisfied. Therefore, the data met the assumptions required for the subsequent regression analyses.

Simple linear regression demonstrated a positive and statistically significant relationship between self-regulated learning and science learning resilience. The regression coefficient was $B = .496$, with a standardized coefficient of $\beta = .469$, $t = 5.859$, and $p < .001$. The regression equation was $Y = 38.023 + 0.496X$.

The positive regression coefficient indicates that higher levels of self-regulated learning were associated with higher levels of science learning resilience. This finding directly addresses the first research objective and provides empirical evidence that students' ability to regulate their learning is related to their capacity to persist and adapt when facing difficulties in science learning. The finding is also consistent with the broader literature showing that SRL is an important resource for successful learning outcomes. Jansen et al. (2019), based on meta-analytic evidence, found that SRL interventions can improve students' SRL activity and academic achievement. Although their study did not directly examine resilience, the finding provides broader empirical support for the role of self-regulatory processes in students' academic functioning.

The finding can be explained through

Zimmerman (2002) social cognitive perspective on self-regulated learning. SRL is a cyclical process involving forethought, performance, and self-reflection. During the forethought phase, students establish goals and plan learning strategies. During the performance phase, students monitor their learning and regulate their motivation and behavior. Finally, during self-reflection, students evaluate the outcomes of their efforts and determine whether their strategies should be maintained or modified. These processes provide students with mechanisms for responding adaptively when learning does not proceed as expected. Recent research continues to support the importance of these processes and emphasizes that effective SRL involves the coordinated use of cognitive, metacognitive, motivational, and behavioral strategies.

This mechanism is particularly relevant to science learning. Science learning frequently requires students to deal with difficult concepts, unfamiliar problems, practical activities, and incorrect answers. A student with stronger self-regulation may respond to an unsuccessful learning experience by identifying the source of the problem, changing the learning strategy, seeking assistance, allocating additional study time, and evaluating the effectiveness of the new strategy. In this way, academic difficulty can function as feedback for subsequent learning rather than as a reason to stop learning. SRL therefore provides cognitive, motivational, and behavioral resources that can support resilient responses to academic adversity. Evidence from SRL research further suggests that students' ability to regulate learning can be strengthened through instructional support. Jansen et al. (2019) found that interventions designed to support SRL can improve students' SRL activity and academic achievement, indicating that SRL should not be viewed merely as an individual characteristic.

The present finding is supported by international research. Imhof et al. (2024) found that self-regulated learning and resilience functioned as important resources for students' competence development under challenging educational conditions. Their findings are particularly relevant because they show that SRL and resilience should not necessarily be treated as interchangeable constructs. Instead, they may represent complementary resources through which students manage demanding learning situations. Similarly, Wang (2021) demonstrated the relevance of self-regulated learning and resilience to students' ability to cope with challenges in learning. Srem-Sai et al. (2025) further reported significant associations among self-regulated learning, academic resilience, learning motivation, and academic well-being. More recent evidence from Suud et al. (2024) also

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highlights the relationship between self-regulated learning and academic resilience, demonstrating that SRL can function within a broader network of factors associated with students' academic adjustment.

The consistency between these findings and the present study strengthens the interpretation that SRL is relevant not only to academic achievement but also to students' capacity to remain engaged when learning becomes difficult. Previous research has demonstrated that SRL strategies are associated with academic achievement and learning outcomes across educational contexts Jansen et al. (2019) further demonstrated through meta-analytic evidence that supporting SRL can improve learning-related outcomes. The present study extends this perspective by showing that SRL is also significantly associated with resilience in science learning among Madrasah Tsanawiyah students.

Nevertheless, SRL should not be regarded as the sole determinant of science learning resilience. The regression coefficient indicates a significant relationship, but resilience is a multidimensional process that may also depend on self-efficacy, motivation, social support, coping strategies, family environment, classroom climate, and previous academic experiences. Hunsu et al. (2023), through a meta-analytic review of academic resilience research, similarly demonstrated that multiple risk and protective factors are associated with academic outcomes. Therefore, the present result should be interpreted as evidence that SRL is an important factor associated with science learning resilience rather than as evidence that SRL alone determines whether students become resilient.

The Moderated Regression Analysis (MRA) provided the central finding of the study. The interaction between self-regulated learning and gender was statistically significant, with B = .682, β = .400, t = 4.276, and $p < .001$. This result indicates that gender significantly moderated the relationship between SRL and science learning resilience.

The moderation finding provides a more nuanced explanation than simply stating that female students had higher SRL or higher resilience. A significant SRL × Gender interaction means that the strength of the relationship between self-regulated learning and science learning resilience differed according to gender. Importantly, when gender and the interaction term were included in the regression model, the direct coefficient of SRL was no longer statistically significant ($p = .094$), whereas the interaction term remained significant ($p < .001$). Thus, the central finding is that gender changes the strength of the association between SRL and science learning resilience.

This finding is theoretically important because it suggests that the contribution of self-regulatory processes to resilient learning may not be identical for all students. Previous research has demonstrated that gender differences can occur in self-regulated learning strategies. Liu et al. (2021) found that female students reported higher levels of self-regulated online learning across several phases of the learning process. Virtanen and Nevgi (2010) similarly identified gender differences in particular SRL strategies. More recent evidence also suggests that gender and learning context can be related to differences in students' self-regulated learning experiences. Oinas et al. (2022) reported differences in students' self-regulated learning experiences across learner characteristics and educational contexts. These findings provide a possible theoretical basis for understanding why the relationship between SRL and resilience may vary between male and female students.

However, the significant moderation effect should not be interpreted as evidence that gender itself causes differences in resilience. Gender may function as an indicator of different learning experiences, social expectations, motivational patterns, help-seeking behavior, or other contextual processes. The present study did not directly measure these mechanisms. Therefore, the stronger relationship between SRL and resilience among female students should be interpreted as an empirical pattern within the present sample rather than as a universal psychological difference between males and females. This cautious interpretation is consistent with contemporary resilience research, which emphasizes the role of multiple protective and contextual factors in students' adaptation to academic challenges (Hunsu et al., 2023).

The separate regression analyses provide further clarification of the moderation effect. Among male students, SRL explained 4.4% of the variance in science learning resilience, but the relationship was not statistically significant ($p = .106$). Among female students, SRL explained 44.8% of the variance in science learning resilience, and the relationship was statistically significant ($p < .001$).

Table 2. Contribution of Self-Regulated Learning to Science Learning Resilience Based on Gender

Aspect	Male	Female
R^2	.044	.448
Contribution	4.4%	44.8%
Significance	0.106	< 0.001

The difference between the two groups provides substantive meaning to the significant interaction effect. Among female students, the relatively large R^2 indicates that differences in SRL were strongly associated with differences in science learning resilience in the present

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sample. In contrast, the small and non-significant relationship among male students indicates that SRL alone did not sufficiently explain differences in resilience among male students. The 4.4% value should therefore not be interpreted as a significant contribution because the corresponding significance value was greater than .05.

The substantially stronger relationship among female students may indicate that self-regulatory processes are more closely connected with how female students in this context respond to academic difficulties. This interpretation is broadly consistent with Liu et al. (2021), who found higher levels of self-regulated online learning among female high school students. Oinas et al. (2022) similarly showed that students' self-regulated learning experiences may vary according to learner characteristics and educational contexts. However, the present data cannot determine whether this difference results from motivation, self-efficacy, social support, help-seeking, family expectations, classroom experiences, or other factors. Further research should therefore examine these possible mechanisms rather than attributing the difference directly to gender.

The moderation finding also has an important theoretical implication. It suggests that the relationship between learning regulation and resilience is not necessarily uniform across learners. Self-regulated learning may provide students with resources for responding to academic challenges, but the extent to which those resources are translated into resilient behavior may depend on learner and contextual characteristics. This extends the simple assumption that increasing SRL will have identical consequences for all students. The finding is also consistent with the broader resilience literature, which conceptualizes resilience as an outcome associated with interactions among individual protective resources and contextual conditions (Hunsu et al., 2023).

Taken together, the results indicate three interconnected findings. First, female students demonstrated significantly higher SRL and science learning resilience than male students in the present sample. Second, SRL was positively and significantly associated with science learning resilience. Third, gender significantly moderated the relationship between SRL and science learning resilience, with the relationship substantially stronger among female students. These findings address the research objectives by showing not only differences between gender groups but also how gender changes the relationship between two important learning-related constructs.

The findings have important implications for science education

in Madrasah Tsanawiyah. First, self-regulated learning should be developed explicitly through classroom activities rather than treated as a skill that students are expected to possess automatically. Teachers can incorporate goal-setting, learning planning, self-monitoring, strategy evaluation, and reflection into science instruction. These activities may help students develop the cognitive and behavioral resources needed to persist when facing difficult learning tasks. This recommendation is supported by meta-analytic evidence showing that interventions designed to support SRL can improve students' SRL activity and academic outcomes (Jansen et al., 2019).

Second, science learning should provide students with opportunities to respond constructively to mistakes and failure. Teachers can encourage students to identify why an answer is incorrect, consider alternative strategies, seek appropriate assistance, and reflect on the effectiveness of their learning approach. Such activities connect self-regulation with resilience by transforming academic difficulty into an opportunity for adaptation. This approach is consistent with contemporary academic resilience research, which emphasizes the role of protective factors in helping students respond adaptively to academic challenges (Hunsu et al., 2023).

Third, the significant moderation effect suggests that teachers should recognize differences in students' learning needs. This does not mean providing different learning opportunities simply because students are male or female. Instead, teachers should identify which aspects of self-regulation and resilience require support for individual students. Students who experience difficulty initiating learning may require structured goal-setting, whereas students who tend to give up after unsuccessful attempts may benefit from reflection and strategy-adjustment activities.

Finally, the relatively weak and non-significant relationship between SRL and resilience among male students indicates the need to examine other factors that may contribute to their resilience. Future research should consider variables such as self-efficacy, motivation, social support, coping strategies, classroom climate, learning engagement, and digital learning behavior. Examining these variables may provide a more comprehensive explanation of why SRL was strongly associated with resilience among female students but not among male students. This recommendation is consistent with meta-analytic evidence showing that academic resilience is related to multiple protective and risk factors rather than to a single predictor (Hunsu et al., 2023).

Overall, the findings demonstrate that self-regulated learning is an important

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factor associated with science learning resilience, while gender significantly moderates the strength of this relationship. The study therefore contributes to the understanding of science learning resilience by demonstrating that students' ability to regulate their learning should be considered together with differences in learner characteristics and learning contexts. Rather than treating resilience as a fixed student characteristic, the findings support the view that resilient learning can be strengthened through learning processes that help students plan, monitor, evaluate, adapt, and persist when facing academic challenges.

CONCLUSION

The findings have practical implications for science education. Science teachers are encouraged to integrate self-regulated learning strategies into classroom instruction through goal setting, learning planning, self-monitoring, reflection, strategy evaluation, and adaptive help-seeking. These practices may help students develop the capacity to respond constructively to academic difficulties and maintain engagement in science learning. Teachers should also consider students' individual learning needs rather than assuming that the same learning strategies will produce similar outcomes for all students. In particular, support for self-regulation and resilience should be provided to both male and female students according to their respective learning needs.

Future research is recommended to examine other factors that may explain differences in the relationship between self-regulated learning and science learning resilience, such as self-efficacy, learning motivation, social support, help-seeking behavior, classroom climate, coping strategies, and digital learning behavior. Longitudinal or mixed-method studies are also recommended to provide a deeper understanding of how self-regulated learning develops over time and how it contributes to resilient learning across different student groups and educational contexts.

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