International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulfindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
IJEVSS

Reflective Journals To Improve Chemistry Students' Self-Efficacy: A Systematic Literature Review

Stevi Sarundayang
Chemistry Departement, Faculty of Mathematics and Natural Sciences, Indonesia
Parlan Parlan*
Chemistry Departement, Faculty of Mathematics and Natural Sciences, Indonesia
Sumari Sumari
Chemistry Departement, Faculty of Mathematics and Natural Sciences, Indonesia
Habiddin Habiddin
Chemistry Departement, Faculty of Mathematics and Natural Sciences, Indonesia
I Wayan Dasna
Chemistry Departement, Faculty of Mathematics and Natural Sciences, Indonesia

Corresponding Author: parlan.fmipa@um.ac.id

Abstract

Complex chemistry learning often triggers academic anxiety and lowers students' self-efficacy. Reflective journals are present as pedagogical instruments to facilitate self-regulation and metacognition. The Systematic Literature Review (SLR) aims to synthesize empirical findings regarding the effectiveness of reflective journals in improving students' self-efficacy in chemistry learning. Adopting the PRISMA guidelines, a comprehensive search was conducted on academic databases for publications from 2016 to 2025. The results of the synthesis show that reflective journal interventions consistently strengthen the affective, metacognitive, and self-regulatory domains which have a direct impact on improving students' self-efficacy in solving complex chemical problems.

Keywords: Chemistry education, metacognition, reflective journal, self-efficacy, systematic literature review.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulfindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
IJEVSS

INTRODUCTION

Chemistry learning, both at the secondary and tertiary levels, inherently has a high level of complexity and is often considered challenging by many students. The characteristics of this discipline demand simultaneous cognitive mastery to relate macroscopic, microscopic and symbolic phenomena , combined with procedural complexity when conducting experiments in the laboratory . This stressful and demanding learning environment has the potential to erode students' affective aspects, especially (Agustian et al., 2022)(Alt & Raichel, 2020)(Alt, Raichel, & Naamati-Schneider, 2022) self-efficacy or multidimensional confidence in their ability to organize actions to achieve desired learning outcomes.

Self-efficacy, which is rooted in social cognitive theory, is defined as a person's assessment or belief in his or her ability to organize and execute a series of actions in order to achieve a desired outcome. In the science education landscape, this affective aspect has proven to be one of the strongest predictors of student academic performance. Its manifestation can be seen in the dynamics of learning behavior in the classroom; Students with (Artioli et al., 2021)(Alt & Raichel, 2020; Avargil, 2019) high self-efficacy tend to choose challenging tasks, persist in the face of difficulties, and be adept at regulating their learning strategies In contrast, low self-determination causes students to tend to avoid academic challenges and get stuck on the use of less adaptive cognitive strategies. Therefore, a learning strategy or instrument is needed that is able to recover these affective aspects.(Bressington, Wong, Lam, & Chien, 2018; Colomer, Serra-Saurina, Cañabate, & Serra, 2018)

As one of the pedagogical intervention efforts to overcome these challenges, the use of reflective journals is beginning to be widely integrated into the educational curriculum to build students' self-awareness and metacognition. Through this written document writing routine, students are guided to independently evaluate their understanding, identify knowledge gaps, and regulate negative emotions and learning strategies that arise during the chemistry learning process.(Fitriyana, Wiyarsi, Sugiyarto, & Ikhsan, 2021; Graham, Bohn-Gettler, & Raigoza, 2019)(Colomer et al., 2018; Gungor et al., 2022)

This practice acts as a transformational mechanism as it directs students to essential self-reflection and metacognitive calibration. Through this process, students learn to step back to monitor their own thought processes, recognize academic success, and evaluate less effective strategies. This activity transforms a passive learning process into an independent, proactive action. When students realize the gradual improvement in competencies they achieve, this

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

awareness will directly strengthen (Jaiswal, Lyon, Zhang, & Magana, 2021)(Kadum & Karpudewan, 2025)their self-efficacy as well as their confidence to succeed on subsequent chemistry tasks.(Gungor et al., 2022)

Although the positive impact of reflective journals on metacognition and self-efficacy has been widely recognized by a wide range of individual studies, their application in chemistry education in the field is still sporadic and varied. Most previous research has tended to focus on evaluating cognitive learning outcomes in general. To the best of the author's knowledge, there has been no systematic literature review (SLR) that specifically maps how specific dimensions of reflective writing moderate student self-efficacy reinforcement in complex chemistry learning landscapes.

To address this literature gap, this Systematic Literature Review study aims to integrate and synthesize empirical evidence regarding the effectiveness of the use of reflective journals in improving students' self-efficacy in chemistry learning. In particular, the study focused on mapping the instructional characteristics of reflective journals, evaluating their influence on specific components of self-efficacy, and identifying key factors that moderate the success of such interventions. Through this comprehensive approach, this research is expected to make a new theoretical contribution to the psychology literature of science education while offering valuable practical guidance for chemistry educators in designing adaptive reflective learning strategies.

METHOD

Research Design

This study uses the design of the *Systematic Literature Review* (SLR) adapted to the reporting guidelines of PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) 2020. This systematic review aims to identify, evaluate, and synthesize the empirical literature related to the influence of reflective journals on students' *self-efficacy* abilities in chemistry learning.

Search Strategy

Literature searches are conducted comprehensively through the search of scholarly articles on major academic databases, including *Semantic Scholar*, *PubMed*, *Google Scholar*, and other relevant sources. The search strategy used a combination of 20 unique searches with a

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

focus on *the keywords "reflective journals"*, *"self-efficacy"*, and *"chemical learning"* in various educational contexts by utilizing Boolean operators (AND, OR). The search is strictly limited to articles published in the time span between 2016 to 2025.

PRISMA Selection Stages

The literature selection process is carried out systematically through four main stages of the PRISMA protocol. In the first stage, namely *Identification*, the initial search yielded a total of 962 potential articles from various predetermined academic databases. In the second stage, namely *Screening*, the first stage of evaluation involves the elimination of articles without abstracts and duplication, thus reducing the number of articles to 434 manuscripts. In the third stage, namely *Eligibility*, an in-depth evaluation of semantic feasibility was carried out on abstracts and the content of the whole text, where articles with low semantic relevance were excluded, leaving 198 potential articles. In the final stage, namely Inclusion, the final quality selection is focused on the articles with the highest level of relevance and quality in the domain of chemistry learning, which ultimately establishes the 50 main articles to be comprehensively analyzed.

Data Extraction and Analysis

Data from 50 articles that met the criteria were systematically extracted based on several key parameters. The extraction parameters included demographic characteristics and publication context, such as the distribution of the year of publication, the classification of education level, and the geographical distribution. Methodological data extraction includes the classification of research designs, self-efficacy measurement instruments used, and reflective journal analysis techniques. Furthermore, the parameters of pedagogical intervention are categorized based on the format of the journal structure, the integration of learning models such as *Inquiry-Based Learning* (IBL) or Project (PjBL), and the duration and frequency of reflection. The collected data were synthesized thematically to decipher the causal dynamics between metacognitive writing practices and students' academic self-efficacy, where the entire flow of this screening is visually illustrated in Figure 1 below.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

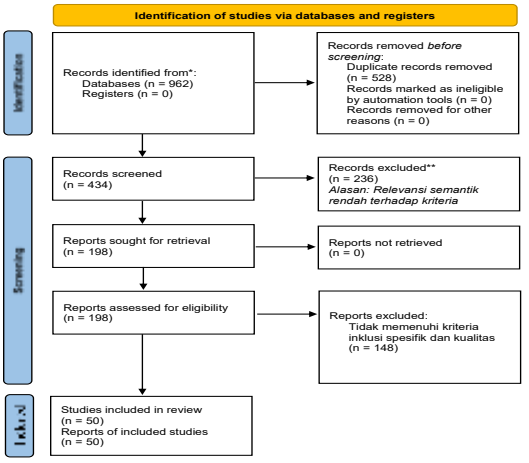


Figure 1. PRSIMA 2020 Diagram

RESULT AND DISCUSSION

Demographic Characteristics and Publication Context

An analysis of the distribution of the year of publication shows a significant escalation in the production of academic literature in the time range of 2020 to 2022. The surge in quantity in the period represents a shift in global focus towards the development of metacognitive independence instruments, which coincided with an emergency restructuring to remote and hybrid learning formats during the pandemic. In contrast, the 2016–2019 period showed a constant but low number of publications, indicating an early phase of exploration of the integration of reflective journals in empirical science education. Meanwhile, the decrease in quantity in the period 2023 to 2025 is a reflection of the transition period towards longitudinally designed studies that require a longer completion cycle. Visual data on the distribution of trends in the research year chronologically are presented comprehensively in Table 1.

Table 1. Distribution of Publication and Reference Years

Year	Quantity	References (Author, Year)
2016	2	Bartimote-Aufflick et al., 2016; Fullana et al., 2016
2017	5	Bressington et al., 2017; Chen et al., 2017; Olakanmi, 2017; Panadero et al., 2017; Vishnumolakala et al., 2017
2018	1	Colomer et al., 2018
2019	3	Avargil, 2019; Coenders and Verhoef, 2019; Graham et al., 2019

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Year	Quantity	References (Author, Year)
2020	12	Alt & Raichel, 2020; Bassachs et al., 2020; Colomer et al., 2020; Guo et al., 2020; Kolil et al., 2020; Menon & Azam, 2020; Mutlu, 2020; Nückles et al., 2020; O'Loughlin & Griffith, 2020; Rahiem, 2020; Veine et al., 2020; Yan et al., 2020
2021	10	Artioli et al., 2021; Chen, 2021; Fitriyana et al., 2021; Foong et al., 2021; Jaiswal et al., 2021; Naibert et al., 2021; Naidoo & Naidoo, 2021; Raković et al., 2021; Sudirman et al., 2021; Tan, 2021
2022	7	Agustian et al., 2022; Alt et al., 2022; Gungor et al., 2022; Guo, 2022; Markula & Aksela, 2022; Nja et al., 2022; Paristiowati et al., 2022
2023	6	Ananda et al., 2023; Machost & Stains, 2023; Nzomo et al., 2023; Pinedo et al., 2023; Rahmawati et al., 2023; Suraworachet et al., 2023
2024	3	Kaya-Capocci et al., 2024; Ripsam & Nerdel, 2024; Strat et al., 2024
2025	1	Kadum & Karpudewan, 2025

Continuing with this annual trend, the mapping of education levels confirms the dominance of intervention implementation in the Higher Education population. The demands of the university curriculum that require regulatory independence, high-level laboratory analysis, and discursive reasoning make the demographics of undergraduate students, professions, and prospective teachers the primary target for metacognitive experiments. On the other hand, Secondary Education (SMA) occupies the second position which is generally focused on mitigating basic laboratory anxiety and adapting inquiry procedures. The proportion of studies at the basic education level was recorded to be very limited, showing that there are obstacles in cognitive capacity in applying narrative reflection instruments to early childhood students, as summarized in Table 2.

Table 2. Distribution of Education and Reference Levels

Education Level	Quantity	References (Author, Year)
Higher Education / University	29	Agustian et al., 2022; Alt & Raichel, 2020; Alt et al., 2022; Artioli et al., 2021; Bartimote-Aufflick et al., 2016; Bressington et al., 2017; Chen, 2021; Chen et al., 2017; Colomer et al., 2018; Colomer et al., 2020; Foong et al.,

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Education Level	Quantity	References (Author, Year)
		2021; Fullana et al., 2016; Graham et al., 2019; Gungor et al., 2022; Guo et al., 2020; Jaiswal et al., 2021; Kolil et al., 2020; Menon & Azam, 2020; Naibert et al., 2021; Naidoo & Naidoo, 2021; O'Loughlin & Griffith, 2020; Paristiowati et al., 2022; Rahiem, 2020; Strat et al. 2024; Sudirman et al., 2021; Suraworachet et al., 2023; Tan, 2021; Veine et al., 2020; Vishnumolakala et al., 2017
Secondary Education (SMA)	8	Ananda et al., 2023; Avargil, 2019; Coenders & Verhoef, 2019; Fitriyana et al., 2021; Kaya-Capocci et al., 2024; Nzomo et al., 2023; Olakanmi, 2017; Rahmawati et al., 2023
Multi-Level/Systematic Review	6	Guo, 2022; Nückles et al., 2020; Panadero et al., 2017; Pinedo et al., 2023; Raković et al., 2021; Yan et al., 2020
Primary & Junior Secondary Education	3	Bassachs et al., 2020; Markula & Aksela, 2022; Mutlu, 2020
Teacher / Educator Education	3	Machost & Stains, 2023; Nja et al., 2022; Ripsam & Nerdel, 2024
Pra-Universitas	1	Kadum & Karpudewan, 2025

In addition to level characteristics, geographic distribution demonstrates the adoption of reflective practices that are transnational and transcontinental. Some of the literature is a systematic review or meta-analysis that aggregates global data without a single geographical specification, one of which was conducted by Panadero et al.[5] For empirical research in certain regions, the United States and Indonesia occupy the top position as the most contributors. Research from Indonesia in-depth explores pedagogical efficacy through the integration of socio-cultural values (ethnochemistry) and technological adaptation in developing countries. Meanwhile, the United States and the European region (such as Spain, the Netherlands, and Germany) dominate the implementation of high-tech-based experiments, particularly in testing the effectiveness of computational modeling, interactive learning analytics, and virtual reality

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

laboratory environments. The global geographical mapping of the included literature is described in Table 3.

Table 3. Geographic Distribution and References

Country/Region	Quantity	References (Author, Year)
Various Countries (Systematic/Meta)	14	Agustian et al., 2022; Artioli et al., 2021; Bartimote-Aufflick et al., 2016; Bressington et al., 2017; Guo, 2022; Guo et al., 2020; Nückles et al., 2020; O'Loughlin & Griffith, 2020; Panadero et al., 2017; Pinedo et al., 2023; Raković et al., 2021; Strat et al. 2024; Suraworachet et al., 2023; Yan et al., 2020
Indonesia	6	Ananda et al., 2023; Fitriyana et al., 2021; Paristiowati et al., 2022; Rahiem, 2020; Rahmawati et al., 2023; Sudirman et al., 2021
United States & North America	6	Chen et al., 2017; Graham et al., 2019; Jaiswal et al., 2021; Machost & Stains, 2023; Menon & Azam, 2020 (AS & Kanada); Naibert et al., 2021; Naidoo & Naidoo, 2021
Spain & Southern Europe	4	Bassachs et al., 2020; Colomer et al., 2018; Colomer et al., 2020 (Spanish & Lithuania); Fullana et al., 2016
Malaysia	3	Foong et al., 2021; Kadum & Karpudewan, 2025; Tan, 2021
Israel	3	Alt & Raichel, 2020; Alt et al., 2022; Avargil, 2019
The Netherlands	2	Coenders & Verhoef, 2019; Gungor et al., 2022
Turkey	2	Kaya-Capocci et al., 2024; Mutlu, 2020
Nigeria	2	Nja et al., 2022; Olakanmi, 2017
Country/Single Regional Entity	8	Chen, 2021 (Taiwan); Ripsam & Nerdel, 2024 (Germany); Veine et al., 2020 (Norway); Nzomo et al., 2023 (Kenya); Kolil et al., 2020 (India); Vishnumolakala et al., 2017 (Australia & Qatar); Markula & Aksela, 2022 (Europe/Southwest Asia)

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Research Methodological Characteristics

Viewed from a methodological aspect, the characteristics of the research design applied by the reviewed articles show a rich diversity of empirical approaches. Quantitative approaches and *mixed-methods* dominate the spectrum of research methodologies to measure the statistical significance of interventions while capturing the depth of students' affective perceptions qualitatively. In contrast, studies that purely use qualitative methods focus on in-depth narrative analysis to explore students' conceptual development over time. A detailed classification of the various methodologies adopted by the 50 main articles is mapped in Table 4.

Table 4. Research Design Distribution

Research Design	Quantity	References (Format: Author, Year)
Quantitative	12	Avargil, 2019; Bassachs et al., 2020; Bressington et al., 2017; Chen et al., 2017; Colomer et al., 2018; Fitriyana et al., 2021; Graham et al., 2019; Kadum & Karpudewan, 2025; Kolil et al., 2020; Naibert et al., 2021; Nja et al., 2022; Ripsam & Nerdel, 2024
Qualitative	9	Chen, 2021; Coenders & Verhoef, 2019; Foong et al., 2021; Fullana et al., 2016; Markula & Aksela, 2022; O'Loughlin & Griffith, 2020; Paristiowati et al., 2022; Rahiem, 2020; Rahmawati et al., 2023
Mixed Method	9	Alt & Raichel, 2020; Alt et al., 2022; Ananda et al., 2023; Gungor et al., 2022; Jaiswal et al., 2021; Kaya-Capocci et al., 2024; Menon & Azam, 2020; Mutlu, 2020; Naidoo & Naidoo, 2021; Nzomo et al., 2023; Olakanmi, 2017; Sudirman et al., 2021; Suraworachet et al., 2023; Tan, 2021; Veine et al., 2020; Vishnumolakala et al., 2017; Yan et al., 2020
Systematic Review / Meta-analysis	6	Agustian et al., 2022; Artioli et al., 2021; Bartimote-Aufflick et al., 2016; Guo, 2022; Guo et al., 2020; Machost & Stains, 2023; Nückles et al., 2020; Panadero et al., 2017; Pinedo et al., 2023; Raković et al., 2021; Strat et al., 2024

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

In line with the diversity of designs, the *self-efficacy* measurement instruments used in the literature vary widely to ensure the validity of affective data. The majority of quantitative studies adapt standardized questionnaires that have been validated internationally, such as *the Motivated Strategies for Learning Questionnaire* (MSLQ), *the Chemistry Self-Efficacy Scale* (CSES), or *the Science Teaching Efficacy Belief Instrument* (STEBI) to measure the teaching beliefs of future instructional agents. On the other hand, some studies use a Likert scale developed specifically for a specific chemical material, or use qualitative portfolio assessments to confirm students' academic confidence strengthening. The variety of these affective measurement instruments is documented in Table 5.(Kolil, Muthupalani, & Achuthan, 2020)

Table 5. Self-Efficacy Measurement Instruments

Types of Measurement Instruments	Quantity	Main References (Format: Author, Year)
Specific Questionnaires/Surveys (MSLQ, STEBI, CSE, Liket)	17	Avargil, 2019; Bressington et al., 2017; Colomer et al., 2018; Fitriyana et al., 2021; Graham et al., 2019; Gungor et al., 2022; Kadum & Karpudewan, 2025; Kaya-Capocci et al., 2024; Kolil et al., 2020; Menon & Azam, 2020; Naibert et al., 2021; Naidoo & Naidoo, 2021; Nja et al., 2022; Nzomo et al., 2023; Olakanmi, 2017; Ripsam & Nerdel, 2024; Suraworachet et al., 2023; Vishnumolakala et al., 2017; Yan et al., 2020
Not directly measured (portfolio focus/qualitative variables)	12	Ananda et al., 2023; Bassachs et al., 2020; Chen, 2021; Chen et al., 2017; Coenders & Verhoef, 2019; Foong et al., 2021; Fullana et al., 2016; Markula & Aksela, 2022; Mutlu, 2020; Paristiowati et al., 2022; Rahiem, 2020; Rahmawati et al., 2023; Sudirman et al., 2021; Tan, 2021; Veine et al., 2020
Varied (Systematic Review / Meta Data Review)	7	Agustian et al., 2022; Alt & Raichel, 2020; Alt et al., 2022; Artioli et al., 2021; Bartimote-Aufflick et al., 2016; Guo, 2022; Guo et al., 2020; Machost & Stains, 2023; Nückles et al., 2020; O'Loughlin &

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

		Griffith, 2020; Panadero et al., 2017; Pinedo et al., 2023; Raković et al., 2021; Strat et al., 2024

The process of exploring the impact of reflective journals also requires systematic writing manuscript data analysis techniques. The distribution of analysis methods shows that qualitative approaches, such as *thematic analysis* using software-based coding rubrics, are the main methods to decipher the depth of students' metacognitive reflection. In experimental studies, such qualitative coding data are often combined with inferential statistical analysis to see a direct correlation between reflection values and post-intervention self-efficacy scores. A summary of the analysis method of this journal is presented in Table 6.

Table 6. Distribution of Reflective Journal Analysis Methods

Analysis Method	Quantity	References (Format: Author, Year)
Qualitative Analysis (Rubric, Thematic Coding, *Focus Group*)	14	Ananda et al., 2023; Bassachs et al., 2020; Chen, 2021; Coenders & Verhoef, 2019; Foong et al., 2021; Fullana et al., 2016; Markula & Aksela, 2022; Menon & Azam, 2020; Mutlu, 2020; O'Loughlin & Griffith, 2020; Paristiowati et al., 2022; Rahiem, 2020; Rahmawati et al., 2023; Sudirman et al., 2021; Tan, 2021; Veine et al., 2020
Experimental Quantitative Analysis (*T-test*, ANOVA, PLS-SEM)	10	Avargil, 2019; Bressington et al., 2017; Chen et al., 2017; Colomer et al., 2018; Fitriyana et al., 2021; Graham et al., 2019; Gungor et al., 2022; Kadum & Karpudewan, 2025; Kaya-Capocci et al., 2024; Kolil et al., 2020; Naibert et al., 2021; Nja et al., 2022; Nzomo et al., 2023; Olakanmi, 2017; Ripsam & Nerdel, 2024
Systematic Review / Meta-analysis	7	Agustian et al., 2022; Artioli et al., 2021; Bartimote-Aufflick et al., 2016; Guo, 2022; Guo et al., 2020; Machost & Stains, 2023; Nückles et al., 2020; Panadero et al., 2017; Pinedo et al., 2023; Raković et al., 2021; Strat et al., 2024
Blending Methods / Clustering Algorithms / Time Series Analytics	5	Alt & Raichel, 2020; Alt et al., 2022; Jaiswal et al., 2021; Naidoo & Naidoo, 2021; Suraworachet et al., 2023; Yan et al., 2020

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Characteristics of Pedagogical Intervention

The pedagogical mechanism of this intervention is strongly influenced by the format of the reflective journal structure presented to students, which is generally complemented by *reflective prompts*. The characteristics of this form of reflective journal instruction are summarized in Table 7.

Table 7. Reflective Journal Format

Journal Format Categories	Quantity	References (Format: Author, Year)
Structured/Semi-structured (*Prompts*, Rubrics, Self-Assessment)	18	Alt & Raichel, 2020; Alt et al., 2022; Avargil, 2019; Bassachs et al., 2020; Bressington et al., 2017; Chen et al., 2017; Colomer et al., 2018; Foong et al., 2021; Gungor et al., 2022; Guo, 2022; Jaiswal et al., 2021; Mutlu, 2020; Naidoo & Naidoo, 2021; Nückles et al., 2020; Pinedo et al., 2023; Suraworachet et al., 2023; Vishnumolakala et al., 2017; Yan et al., 2020
Free/Unstructured (Open Diaries, Portfolios, Blogs)	10	Artioli et al., 2021; Chen, 2021; Coenders & Verhoef, 2019; Fullana et al., 2016; Markula & Aksela, 2022; Menon & Azam, 2020; O'Loughlin & Griffith, 2020; Rahiem, 2020; Rahmawati et al., 2023; Tan, 2021
Varied (Systematic Review / Meta-analysis)	8	Agustian et al., 2022; Bartimote-Aufflick et al., 2016; Guo et al., 2020; Machost & Stains, 2023; Panadero et al., 2017; Raković et al., 2021; Strat et al. 2024; Veine et al., 2020

The effectiveness of this reflective writing increases significantly when it is harmoniously integrated with specific science learning models, such as Inquiry-Based Learning (IBL), Project-Based Learning (PjBL), or POGIL (*Process Oriented Guided Inquiry Learning*) models. In addition, these interventions are plural integrated in the post-practicum activities of the chemistry laboratory, in line with the reinforcement of tutor-based self-efficacy and virtual technology. Data on the relevance of this pedagogical model when reviewed across studies are presented in TABLE 8(Menon & Azam, 2021)(Naibert, Duck, Phillips, & Barbera, 2021)

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Table 8. Learning Model Integration

Learning Model Categories	Quantity	References (Format: Author, Year)
Laboratory Inquiry & Ecosystem (IBL, POGIL)	12	Agustian et al., 2022; Chen, 2021; Coenders & Verhoef, 2019; Jaiswal et al., 2021; Kolil et al., 2020; Mutlu, 2020; Naidoo & Naidoo, 2021; Nja et al., 2022; Nzomo et al., 2023; Rahmawati et al., 2023; Strat et al. 2024; Vishnumolakala et al., 2017
General Learning, Academic Writing, & Professional Evaluation	10	Alt & Raichel, 2020; Alt et al., 2022; Artioli et al., 2021; Bartimote-Aufflick et al., 2016; Bressington et al., 2017; Chen et al., 2017; Fullana et al., 2016; Menon & Azam, 2020; Sudirman et al., 2021; Suraworachet et al., 2023
***Project-Based Learning* (PjBL), Sustainability Education, & STEAM**	8	Ananda et al., 2023; Bassachs et al., 2020; Colomer et al., 2018; Colomer et al., 2020; Guo et al., 2020; Kaya-Capocci et al., 2024; Markula & Aksela, 2022; Paristiowati et al., 2022
Digital Technology (*Virtual Reality*, AR, *Flipped Classroom*, Hybrid)	6	Fitriyana et al., 2021; Gungor et al., 2022; Naibert et al., 2021; Olakanmi, 2017; Rahiem, 2020; Ripsam & Nerdel, 2024

The final determining factor in the success of this affective transformation is the duration and frequency of implementation of the intervention, where the classification of the implementation time range of all the studies reviewed can be seen in Table 9.

Category Duration of Intervention	Quantity	References (Format: Author, Year)
Short & Medium Term (1 Practicum Module - 1 Semester)	14	Avargil, 2019; Bressington et al., 2017; Chen et al., 2017; Colomer et al., 2018; Fitriyana et al., 2021; Graham et al., 2019; Jaiswal et al., 2021; Naibert et al., 2021; Naidoo & Naidoo, 2021; Olakanmi, 2017;

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

		Paristiowati et al., 2022; Rahiem, 2020; Suraworachet et al., 2023; Vishnumolakala et al., 2017
Varied (Systematic Review / Meta-analysis)	9	Agustian et al., 2022; Artioli et al., 2021; Bartimote-Aufflick et al., 2016; Guo, 2022; Guo et al., 2020; Nückles et al., 2020; Panadero et al., 2017; Pinedo et al., 2023; Strat et al., 2024
***Cross-sectional* , Rapid Simulation Experiments, & Incidental**	8	Bassachs et al., 2020; Chen, 2021; Coenders & Verhoef, 2019; Gungor et al., 2022; Kadum & Karpudewan, 2025; Kolil et al., 2020; Nja et al., 2022; Nzomo et al., 2023
Long-Term/Longitudinal Routine Intervention (> 1 Semester)	5	Alt & Raichel, 2020; Alt et al., 2022; O'Loughlin & Griffith, 2020; Veine et al., 2020; Yan et al., 2020

Mapping the Characteristics of Reflective Journal Interventions in Chemistry Learning

Continuing the factual data on duration and learning environment in Table 8 and Table 9, the literature synthesis shows that duration variation has a direct correlation with the depth of affective targets. Short- to medium-term interventions (3 to 5 weeks) are generally optimal for evaluating students' immediate responses to specific tasks. Meanwhile, a longitudinal approach that runs throughout a semester or a full academic year has proven to be a major prerequisite for establishing a permanent metacognition-forming habit of regular writing habits.(Naidoo & Naidoo, 2023)(Nückles, Roelle, Glogger-Frey, Waldeyer, & Renkl, 2020)

Further mapping of the operational context proves that this instrument is highly adaptive to be implemented in a broad spectrum of chemistry learning environments. The presence of reflective journals serves as an essential cognitive aid and *scaffolding* that distinguishes it from other disciplines. In a conventional theory classroom setting, this instrument strengthens problem-solving skills, whereas in the (Olakanmi, 2017)*flipped classroom* model, this journal manages the regulation of self-study before face-to-face begins. The most crucial contribution is found in practicum activities in chemistry laboratories. The procedural complexity of the laboratory often triggers excessive cognitive overload and experimental anxiety. Through a reflection routine, students are helped to(O'Loughlin & Griffith, 2020)(Alt et al., 2022)(Panadero,

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Jonsson, & Botella, 2017) *step back*, unravel the complexity of data, and reconstruct their procedural understanding independently.

Reflective Journals as a Catalyst for Metakcognition and Self-Regulation

Conceptually, reflective writing activities work as a transformational bridge that connects cognitive processes to the learner's metacognition level. Regular journal writing effectively provides the cognitive space students need to slow down the pace of learning, process information-dense chemical materials, and foster a sense of (Fitriyana et al., 2021)*ownership* over their academic development. Through the internal dialogue outlined in the writing, students are actively trained to carry out the essential functions of *self-regulated learning*, especially in the aspects of *self-monitoring* and self-evaluation. This routine guides students to detect gaps between actual comprehension targets and academic expectations, so that they are able to proactively modify learning approaches when faced with complex conceptual barriers.(Avargil, 2019)(Gungor et al., 2022)

Furthermore, the reconstruction of the thinking process in the journal facilitates the transformation of concrete experience into an established abstract conceptualization, a process that is in harmony with Kolb's experiential learning cycle and Schön's model of reflective practitioners. Through this medium, students do not just experience physical activity (such as performing laboratory procedures or solving reaction equations), but take a step back to do reflective observations. This dialogical process triggers the thinking(Sudirman, Gemilang, & Kristanto, 2021)(Jaiswal et al., 2021) *and doing dynamics* both when the action is in progress (*reflection-in-action*) and after the activity is completed (*reflection-on-action*), which gradually builds lifelong learning independence.(Veine et al., 2020).

Comparison of Approaches: The Effectiveness of Metacognitive Prompts vs Free Journals

Referring to the classification of instructional forms in Table 7, the structure of the instrument design plays a crucial role in determining the quality of the depth of students' reflection. The *unstructured journal* approach without specific guidance has proven to be less effective because the absence of instructional direction often confuses students, triggers additional cognitive load, and results in superficial descriptive writing that simply summarizes mere learning events. In contrast, a semi-structured journal approach integrated with metacognitive(Graham et al., 2019) *prompts* provides a significant transformational impact. The

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

guiding questions act as *scaffolds* that guide the multidimensional exploration of students' learning experiences in the cognitive, affective, and behavioral domains.(Nückles et al., 2020)

The advantages of this prompts-based approach are vital when implemented in abstract chemistry disciplines. The characteristics of chemical matter demand a high cognitive load because it requires students to integrate phenomena simultaneously at three levels of representation: macroscopic (observed phenomena), sub-microscopic (molecular particles), and symbolic (reaction formulas/equations). The use (Alt & Raichel, 2020)*of metacognitive prompts* specifically designed to dissect such representational domains has been shown to optimize student information processing. Question stimuli help unravel the complexity of the material, mitigate conceptual distortions, and ensure abstract particle visualizations can be systematically understood to build complete and meaningful chemistry literacy.(Olakanmi, 2017)

Empirical Evidence: Transforming Self-Efficacy through Reflective Writing

An empirical synthesis of the literature reviewed shows that the strengthening of students' *self-efficacy* confidence through reflective writing is mediated by three main psychological mechanisms. First, this instrument acts as a cathartic space that transforms academic anxiety (*chemophobia*) and practicum frustration for beginners into adaptive strategies through the articulation of negative emotions into a measurable form of written narrative. Second, recording a track record of problem solving on a regular basis contributes directly to the accumulation of(Panadero et al., 2017)(Vishnumolakala, Southam, Treagust, Mocerino, & Qureshi, 2017) *mastery experiences*; Based on the foundation of social cognitive theory, the visualization of independent learning progress in journals provides concrete evidence of the competencies that have been achieved, which directly strengthens the estimation of students' ability to complete the next chemistry task, . In addition, there is a strong positive correlation between deep metacognitive engagement and increased self-perception of science learners. In this mechanism, students who were categorized as active(Artioli et al., 2021)(Bressington et al., 2018)(Colomer et al., 2018) *reflectors* showed high efficiency in deploying adaptive cognitive strategies, in contrast to passive *reflectors* who had a tendency to avoid challenging tasks due to their low level *of self-efficacy*.(Vishnumolakala et al., 2017)(Yan, Chiu, & Ko, 2020)

CONCLUSION

Based on the results of this systematic literature review, it can be concluded that the use of reflective journals has proven to be significantly effective as a transformational mechanism to

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

improve *students' self-efficacy* in complex chemistry learning. Analysis of various empirical studies shows that reflective writing activities are able to bridge students' cognitive and affective domains through the stimulation of metacognitive awareness and structured self-regulation. These interventions were most predominantly implemented at the higher education level and showed consistent success across geographies (particularly the dominance of research in the United States and Indonesia) in reducing academic anxiety due to the complexity of laboratory procedures and the cognitive burden of integrating chemical multi-representations (macroscopic, sub-microscopic, and symbolic). This research provides important pedagogical implications for chemistry educators to integrate *metacognitive prompts-based reflective journals* not just as an additional evaluation instrument, but as a core instructional strategy to build affective resilience, self-efficacy, and student learning independence in a sustainable manner.

Acknowledgments

The authors would like to thank Universitas Negeri Malang for supporting this research project. During the preparation of this manuscript, the authors used Gemini (Large Language Model by Google) for the purposes of rephrasing text, reducing redundancy, and aligning citation numbers. The authors have reviewed and revised the generated content and assume full responsibility for the final version of this publication.

Author Contributions

Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, S.S., P., S.; writing—review and editing, visualization, supervision, project administration, P., S., H., I. W. D. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Agustian, H. Y., Finne, L. T., Jørgensen, J. T., Pedersen, M. I., Christiansen, F. V., Gammelgaard, B., & Nielsen, J. A. (2022). Learning outcomes of university chemistry teaching in laboratories: A systematic review of empirical literature. Review of Education, 10(2). https://doi.org/10.1002/rev3.3360

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Alt, D., & Raichel, N. (2020). Reflective journaling and metacognitive awareness: insights from a longitudinal study in higher education. Reflective Practice, 21(2), 145–158. https://doi.org/10.1080/14623943.2020.1716708

Alt, D., Raichel, N., & Naamati-Schneider, L. (2022). Higher Education Students' Reflective Journal Writing and Lifelong Learning Skills: Insights From an Exploratory Sequential Study. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.707168

Artioli, G., Deiana, L., De Vincenzo, F., Raucci, M., Amaducci, G., Bassi, M. C., … Ghirotto, L. (2021). Health professionals and students' experiences of reflective writing in learning: A qualitative meta-synthesis. BMC Medical Education, 21(1). https://doi.org/10.1186/s12909-021-02831-4

Avargil, S. (2019). Learning Chemistry: Self-Efficacy, Chemical Understanding, and Graphing Skills. Journal of Science Education and Technology, 28(4), 285–298. https://doi.org/10.1007/s10956-018-9765-x

Bressington, D. T., Wong, W. kit, Lam, K. K. C., & Chien, W. T. (2018). Concept mapping to promote meaningful learning, help relate theory to practice and improve learning self-efficacy in Asian mental health nursing students: A mixed-methods pilot study. Nurse Education Today, 60, 47–55. https://doi.org/10.1016/j.nedt.2017.09.019

Colomer, J., Serra-Saurina, L., Cañabate, D., & Serra, T. (2018, August 7). Evaluating Knowledge and Assessment-Centered Reflective-Based Learning Approaches. https://doi.org/10.20944/preprints201808.0151.v1

Fitriyana, N., Wiyarsi, A., Sugiyarto, K. H., & Ikhsan, J. (2021). The Influences of Hybrid Learning with Video Conference and "Chemondro-Game" on Students' Self-Efficacy, Self-Regulated Learning, and Achievement toward Chemistry. Journal of Turkish Science Education, 18(2), 233–248. https://doi.org/10.36681/tused.2021.62

Graham, K. J., Bohn-Gettler, C. M., & Raigoza, A. F. (2019). Metacognitive Training in Chemistry Tutor Sessions Increases First Year Students' Self-Efficacy. Journal of Chemical Education, 96(8), 1539–1547. https://doi.org/10.1021/acs.jchemed.9b00170

Gungor, A., Kool, D., Lee, M., Avraamidou, L., Eisink, N., Albada, B., … Bitter, J. H. (2022). The Use of Virtual Reality in A Chemistry Lab and Its Impact on Students' SelfEfficacy, Interest, Self-Concept and Laboratory Anxiety. Eurasia Journal of Mathematics, Science and Technology Education, 18(3). https://doi.org/10.29333/ejmste/11814

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Jaiswal, A., Lyon, J. A., Zhang, Y., & Magana, A. J. (2021). Supporting student reflective practices through modelling-based learning assignments. European Journal of Engineering Education, 46(6), 987–1006. https://doi.org/10.1080/03043797.2021.1952164

Kadum, B. M. M., & Karpudewan, M. (2025). Influence of self-efficacy and metacognition on malaysian pre-university students' chemistry academic motivation: the moderating role of gender and locality. Chemistry Education Research and Practice, 26(3), 682–700. https://doi.org/10.1039/D4RP00334A

Kolil, V. K., Muthupalani, S., & Achuthan, K. (2020). Virtual experimental platforms in chemistry laboratory education and its impact on experimental self-efficacy. International Journal of Educational Technology in Higher Education, 17(1). https://doi.org/10.1186/s41239-020-00204-3

Menon, D., & Azam, S. (2021). Investigating Preservice Teachers' Science Teaching Self-Efficacy: an Analysis of Reflective Practices. International Journal of Science and Mathematics Education, 19(8), 1587–1607. https://doi.org/10.1007/s10763-020-10131-4

Naibert, N., Duck, K. D., Phillips, M. M., & Barbera, J. (2021). Multi-institutional Study of Self-Efficacy within Flipped Chemistry Courses. Journal of Chemical Education, 98(5), 1489–1502. https://doi.org/10.1021/acs.jchemed.0c01361

Naidoo, K., & Naidoo, L. J. (2023). Designing teaching and reflection experiences to develop candidates' science teaching self-efficacy. Research in Science and Technological Education, 41(1), 211–231. https://doi.org/10.1080/02635143.2021.1895098

Nückles, M., Roelle, J., Glogger-Frey, I., Waldeyer, J., & Renkl, A. (2020, December 1). The Self-Regulation-View in Writing-to-Learn: Using Journal Writing to Optimize Cognitive Load in Self-Regulated Learning. Educational Psychology Review, Vol. 32, pp. 1089–1126. Springer. https://doi.org/10.1007/s10648-020-09541-1

Olakanmi, E. E. (2017). The Effects of a Flipped Classroom Model of Instruction on Students' Performance and Attitudes Towards Chemistry. Journal of Science Education and Technology, 26(1), 127–137. https://doi.org/10.1007/s10956-016-9657-x

O'Loughlin, V. D., & Griffith, L. M. (2020). Developing Student Metacognition through Reflective Writing in an Upper Level Undergraduate Anatomy Course. Anatomical Sciences Education, 13(6), 680–693. https://doi.org/10.1002/ase.1945

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

Panadero, E., Jonsson, A., & Botella, J. (2017, November 1). Effects of self-assessment on self-regulated learning and self-efficacy: Four meta-analyses. Educational Research Review, Vol. 22, pp. 74–98. Elsevier Ltd. https://doi.org/10.1016/j.edurev.2017.08.004

Sudirman, A., Gemilang, A. V., & Kristanto, T. M. A. (2021). The power of reflective journal writing for university students from the efl perspective. Studies in English Language and Education, 8(3), 1061–1079. https://doi.org/10.24815/siele.v8i3.19105

Veine, S., Anderson, M. K., Andersen, N. H., Espenes, T. C., Søyland, T. B., Wallin, P., & Reams, J. (2020). Reflection as a core student learning activity in higher education - Insights from nearly two decades of academic development. International Journal for Academic Development, 25(2), 147–161. https://doi.org/10.1080/1360144X.2019.1659797

Vishnumolakala, V. R., Southam, D. C., Treagust, D. F., Mocerino, M., & Qureshi, S. (2017). Students' attitudes, self-efficacy and experiences in a modified process-oriented guided inquiry learning undergraduate chemistry classroom. Chemistry Education Research and Practice, 18(2), 340–352. https://doi.org/10.1039/c6rp00233a

Yan, Z., Chiu, M. M., & Ko, P. Y. (2020). Effects of self-assessment diaries on academic achievement, self-regulation, and motivation. Assessment in Education: Principles, Policy and Practice, 27(5), 562–583. https://doi.org/10.1080/0969594X.2020.1827221

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License