MJP Journal of Education and Teaching Learning
Vol.4, No.1 (2026): 57 – 63
https://jurnalilmiah.co.id/index.php/MJPJETL

Self-Regulated Learning Instructional Design to Manage Cognitive Load in Mathematics

[1)*] Eka Sri Irawati, [2)] Surya Sari Faradiba

[1, 2)] Department of Magister's Mathematics Education, University of Islam Malang

Correspondence Author: +628133277XXXX

Article Info

Keywords:

ADDIE;
Self-Regulated Learning;
Cognitive Load;
Generative Processing;
PLS-SEM

ABSTRACT

This study aims to develop an ADDIE-based mathematics instructional design using a Self-Regulated Learning (SRL) approach to control extraneous cognitive load and facilitate students' generative processing. This study employs the R&D method, utilizing the ADDIE model (consists: analysis, design, development, implementation, and evaluation stage). The research subjects consisted of four validators, one teacher, and 70 students selected through purposive sampling. Research instruments included a validation sheet, an SRL questionnaire, a cognitive load scale, and a test based on generative processing indicators. Data were analyzed descriptively to evaluate validity, practicality, and effectiveness, and inferentially using PLS-SEM to examine relationships among variables. The results indicate that the developed design possesses very high validity with an average score of 85.5, high practicality at 84.25%, and effectiveness as evidenced by an N-Gain score of 0.47 (moderate category). Additionally, students' extraneous cognitive load was found to be at a low level. The SEM results reveal that Self-Regulated Learning has a positive effect on generative processing and a negative effect on extraneous cognitive load, while extraneous cognitive load acts as a significant mediating variable. Therefore, the ADDIE-based instructional design integrated with SRL is proven to be feasible and effective in improving the quality of mathematics learning.

Informasi Artikel

Kata Kunci:

ADDIE;
Self-Regulated Learning;
Cognitive Load;
Generative Processing;
PLS-SEM

ABSTRAK

Penelitian ini bertujuan untuk mengembangkan desain instruksional matematika berbasis model ADDIE dengan pendekatan Self-Regulated Learning (SRL) untuk mengendalikan extraneous cognitive load dan memfasilitasi generative processing siswa. Penelitian ini menggunakan metode R&D dengan tahapan ADDIE yang meliputi analysis, design, development, implementation, dan evaluation. Subjek penelitian terdiri dari empat validator, satu guru, dan 70 siswa yang dipilih secara purposive sampling. Instrumen penelitian meliputi lembar validasi, angket SRL, skala cognitive load, dan tes berbasis indikator generative processing. Analisis data dilakukan secara deskriptif untuk menilai validitas, kepraktisan, dan efektivitas, serta secara inferensial menggunakan pendekatan Structural Equation Modeling berbasis Partial Least Squares (PLS-SEM) untuk menguji hubungan antar variabel. Hasil penelitian menunjukkan bahwa desain yang dikembangkan memiliki tingkat validitas sangat tinggi dengan skor rata-rata 85,5, kepraktisan sangat baik sebesar 84,25%, serta efektivitas yang ditunjukkan melalui peningkatan hasil belajar dengan nilai N-Gain sebesar 0,47 (kategori sedang). Selain itu, extraneous cognitive load siswa berada pada kategori rendah. Penelitian ini membuktikan bahwa Self-Regulated Learning berpengaruh positif terhadap generative processing dan berpengaruh negatif terhadap extraneous cognitive load, serta extraneous cognitive load memiliki sebagai variabel mediasi yang signifikan. Dengan demikian, desain instruksional berbasis ADDIE dengan pendekatan SRL terbukti layak dan efektif dalam meningkatkan kualitas pembelajaran matematika.

Article History

Received : 15/04/2026
Revised : 04/05/2026
Accepted : 21/07/2026

✉ ***Corresponding Author:*** (1) Eka Sri Irawati, (2) Department of Magister's Mathematics Education, (3) University of Islam Malang, (4) Jl. Mayjen Hariyono Jl. Tata Surya No.193, Kec. Lowokwaru, Kota Malang, East Java, 65144 Indonesia, (5) Email: ekasriirawati123@gmail.com

1. Introduction

Mathematics education plays a crucial role in developing students' logical, analytical, and systematic thinking skills. However, in practice, mathematics instruction still tends to focus on procedures and the mechanical solving of problems, thereby failing to foster a deep conceptual understanding. This situation leads students to memorize solution steps rather than understand concepts, resulting in low proficiency in elaborating, organizing, and integrating information. In fact, meaningful learning requires generative processing, an active process of constructing new knowledge based on students' existing cognitive structures [1].

One of the primary factors affecting low conceptual understanding is the high cognitive load students experience during learning. According to Cognitive Load Theory, irrelevant cognitive load (extraneous cognitive load) can hinder information processing in working memory [2]. Recent research indicates that unstructured presentation of material, the use of complex media, and unclear instructions can increase students' cognitive load and reduce the effectiveness of learning [3]. Therefore, a learning design is needed that can optimally manage cognitive load so that students can focus their cognitive resources on conceptual understanding.

Additionally, low levels of active student engagement in the learning process remain a significant issue. Many students lack the ability to independently manage their learning processes, leading them to adopt a passive role in learning. In this context, Self-Regulated Learning (SRL) emerges as a relevant approach to enhance the quality of learning. SRL emphasizes students' ability to plan, monitor, and evaluate their learning processes independently, which has been shown to positively influence learning outcomes and students' cognitive engagement [4]. Recent studies also indicate that SRL plays a crucial role in helping students manage cognitive load and enhance learning effectiveness [5].

On the other hand, the quality of learning is largely determined by the instructional design used. The ADDIE model is one of the systematic instructional design models widely used in instructional development [6]. This model comprises five stages, namely analysis, design, development, implementation, and evaluation, which enable instructional development to be conducted in a structured manner [7]. However, research integrating the ADDIE model with the SRL approach and cognitive load management within a single instructional design remains limited.

Therefore, this study aims to develop an ADDIE-based mathematics instructional design incorporating the Self-Regulated Learning (SRL) approach to control extraneous cognitive load and facilitate students' generative processing. Unlike previous studies that tended to examine Self-Regulated Learning, cognitive load, and learning outcomes separately, this study offers novelty through the development of an instructional design model that integrates these three aspects simultaneously within a single ADDIE-based learning framework. Specifically, this study is one of the few that explicitly combines the Self-Regulated Learning approach with the management of extraneous cognitive load to facilitate generative processing in mathematics learning.

The novelty of this study lies in two main aspects. First, the development of an instructional design that is not only oriented toward learning outcomes but also toward students' internal cognitive mechanisms through the integration of self-regulation and cognitive load management. Second, the use of the Structural Equation Modeling (SEM) approach to empirically test the relationship between Self-Regulated Learning, extraneous cognitive load, and generative processing within the context of an ADDIE-based instructional design. Thus, this study not only produces a viable instructional product but also offers an integrative conceptual model that contributes both theoretically and empirically to the development of mathematics education.

2. Method

This study is a Research and Development (R&D) study aimed at developing an ADDIE-model-based mathematics instructional design using a Self-Regulated Learning (SRL) approach to control extraneous cognitive load and facilitate students' generative processing [8]. The ADDIE model was used because it provides a systematic framework for learning development through five stages: analysis, design, development, implementation, and evaluation. This study focuses not only on product development but also on testing the relationships among the variables involved in the learning process.

The research subjects consisted of four validators (two subject matter experts and two instructional design experts), one mathematics teacher, and 70 students as the test group, selected using purposive sampling. The research procedure was conducted in accordance with the ADDIE model. In the analysis phase, learning needs were identified through curriculum analysis, student characteristics, and learning problems identified via observation, a pre-test questionnaire, and interviews with the teacher. This phase yielded information regarding learning gaps, the level of extraneous cognitive load, and students' Self-Regulated Learning (SRL) status.

In the design phase, an instructional design was developed that included the formulation of learning objectives based on generative processing, the development of SRL-based learning strategies such as goal setting, self-monitoring, and reflection, and the creation of a simple material structure to reduce cognitive load. Additionally, research instruments were developed in this phase, including an SRL questionnaire, a cognitive load scale, and a test based on generative processing indicators as shown in Table 1.

Table 1. Variables, Indicators, and Research Instruments

Variabel	Indicators	Instruments
Self-Regulated Learning (SRL)	Planning (*goal setting*), monitoring (*self-monitoring*), and self-evaluation	Self-Regulated Learning (SRL) Questionnaire
Extraneous Cognitive Load (ECL)	Clarity of instructions, presentation complexity, and information redundancy	Cognitive Load Measurement Scale
Generative Processing (GP)	Elaboration, organization, and concept integration	Generative Processing-Based Test

The development phase involved creating SRL-based products in the form of modules or Student Worksheets (LKPD), which were subsequently validated by experts and revised based on validator feedback to ensure the products' suitability. The implementation phase was carried out through a limited pilot test with students over three sessions, which included administering a pretest, implementing SRL-based learning, and administering a posttest and questionnaire. This phase aimed to obtain data regarding the practicality, effectiveness, and level of students' extraneous cognitive load. Subsequently, the evaluation phase was conducted formatively at each stage of development and summatively after implementation to assess the overall quality of the product.

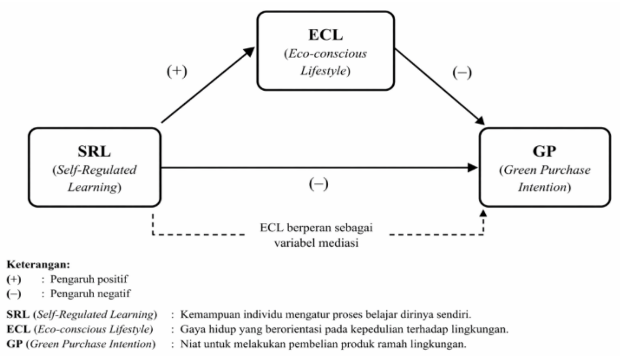

Figure 1. Conceptual Research Model where SRL has a positive effect on GP and a negative effect on ECL, while ECL has a negative effect on GP and serves as a mediating variable.

Research data were collected through observation, interviews, questionnaires, and tests. Data analysis was conducted using two approaches: descriptive and inferential analysis. Descriptive analysis was used to assess the validity, practicality, and effectiveness of the product, including the calculation of learning gains using N-Gain. Meanwhile, inferential analysis was conducted using a Partial Least Squares-based Structural Equation Modeling (PLS-SEM) approach to test the relationships between variables, including the influence of Self-Regulated Learning on generative processing, the influence of extraneous cognitive load, and the mediating effects among these variables [9]. Testing was performed using the bootstrapping technique with a significance criterion of p-value < 0.05.

Figure 2. The ADDIE Model Flowchart illustrates the research stages: analysis, design, development, implementation, and evaluation

Thus, this research method not only produces a viable learning product but also provides empirical testing of a conceptual model that integrates instructional design, Self-Regulated Learning, cognitive load, and generative processing, thereby offering a more comprehensive analysis compared to conventional experimental research.

3. Result and Discussion

3.1. Analysis Phase (Analysis of Learning Needs)

The analysis phase was carried out through three main activities: curriculum analysis, analysis of student characteristics, and analysis of learning problems. The curriculum analysis involved reviewing the core competencies and learning indicators for mathematics to identify gaps between curriculum requirements and classroom teaching practices. Next, the analysis of student characteristics was conducted on 70 students using observation techniques and a pre-test questionnaire focused on learning styles, conceptual understanding levels, and independent learning habits. Additionally, the analysis of learning problems was conducted through interviews with teachers and a review of the instructional materials used.

The analysis results indicate that mathematics instruction remains procedure-oriented, causing students to struggle with deep conceptual understanding. Furthermore, students also experience high cognitive load caused by unclear instructional guidance and complex presentation of materials. On the other hand, students' Self-Regulated Learning (SRL) abilities remain relatively low, as evidenced by their limited capacity to plan, monitor, and evaluate the learning process. These findings align with Cognitive Load Theory, which states that the presentation of unstructured information can increase extraneous cognitive load [2], as well as Self-Regulated Learning theory, which emphasizes the importance of self-regulation in improving the quality of learning [4].

Based on these results, the analysis phase yielded several key outputs: the identification of learning needs, the primary challenges faced by students, and the foundation for designing an instructional design based on Self-Regulated Learning to reduce cognitive load and enhance students' generative processing.

3.2 Design Phase (Instructional Design)

The design phase was conducted based on the results of the learning needs analysis identified in the previous phase. Activities in this stage include formulating learning objectives, designing learning strategies based on Self-Regulated Learning (SRL), organizing the material structure, and developing research instruments. Learning objectives are formulated by referring to generative processing indicators, which include the ability to elaborate, organize, and integrate concepts, so that learning focuses not only on procedures but also on deep conceptual understanding.

Furthermore, learning strategies are designed by integrating the core components of Self-Regulated Learning: goal setting, self-monitoring, and learning reflection. The goal-setting component helps students independently plan their learning objectives; self-monitoring enables them to track their understanding during the learning process; and learning reflection allows them to evaluate the learning outcomes achieved. Additionally, the material structure is organized based on the principles of simplifying information, reducing redundancy, and using minimalist visual displays to minimize extraneous cognitive load. To ensure replicability, the SRL strategies were operationalized into concrete components embedded within the Student Worksheets (LKPD). The goal-setting component was implemented at the beginning of each worksheet through a structured section titled "Learning Targets," where students were guided to write specific objectives. The self-monitoring component was integrated within the main activities through guiding prompts and checklists, allowing students to continuously assess their understanding during problem-solving. Meanwhile, the reflection component was

MJP Journal of Education and Teaching Learning
Vol.4, No.1 July (2026): 57-63

placed at the end of each worksheet in the form of reflective questions that guide students to evaluate their learning process. These components were designed in a structured and consistent format across all worksheets.

This structured operationalization is aligned with the instructional design framework employed in this study. This instructional design is based on the ADDIE model, which emphasizes alignment between student needs and learning strategies [7]. Furthermore, the use of generative activities in learning is based on generative learning theory, which states that learning is more meaningful when students actively elaborate on and organize information [10]. Thus, this design phase produces an instructional design blueprint that integrates the principles of SRL, cognitive load management, and enhanced generative processing as the foundation for developing learning products.

3.3 Development Phase (Product Development)

The development stage is carried out based on the instructional design blueprint developed in the previous stage. Activities in this stage include the development of learning products, expert validation, and product revisions based on validator feedback. The developed products consist of modules/Student Worksheets (LKPD) based on Self-Regulated Learning (SRL), designed to facilitate goal-setting, self-monitoring, and learning reflection activities. In the LKPD, these SRL components were explicitly structured, where goal-setting sections were placed at the beginning, self-monitoring prompts were embedded within each task, and reflection activities were provided at the end of each worksheet. Additionally, the visual design of the products is structured simply and systematically to minimize extraneous cognitive load through the presentation of structured and non-redundant information.

The validation process is conducted by four validators, consisting of two subject matter experts and two instructional design experts. Validation aims to assess the product's suitability in terms of content, design, and language. The validation results indicate that the developed products fall into the "highly valid" category.

Table 2. Product Validation Result

Aspect	Score	Category
Content	86.5	Highly Valid
Design	85	Highly Valid
Language	85	Highly Valid
Average	85.5	Highly Valid

The results as shown in Table 2 indicate that the instructional design developed meets the feasibility criteria in terms of both content and presentation. This suggests that the product aligns with the principles of effective instructional design, particularly in reducing extraneous cognitive load through the presentation of simple and well-organized material [2]. Additionally, the integration of Self-Regulated Learning strategies into the instructional product is deemed capable of supporting students' independent learning activities [11].

Based on the validation results, the product was revised by improving several aspects, including simplifying the language, enhancing the clarity of instructions, and adjusting the visual presentation to make it more communicative. Thus, this development phase produced a learning product that is theoretically valid and ready to be tested in the implementation phase.

3.4 Implementation Phase (Product Implementation)

The implementation phase was conducted to test the practicality and effectiveness of the instructional design that had been developed. The implementation was carried out with 70 students over three learning sessions. In the first session, students took a pretest to assess their initial abilities and were introduced to Self-Regulated Learning strategies through goal-setting activities. In the second session, the learning process took place with the application of self-monitoring activities, allowing students to monitor their understanding during the lesson. In the third session, students engaged in learning reflection and were administered a posttest to measure improvements in learning outcomes. During implementation, students actively engaged with these SRL components. They completed goal-setting sections at the beginning of learning, used self-monitoring prompts while solving tasks, and filled in reflection sections at the end of each session

The implementation results indicate an improvement in students' learning outcomes following the use of the SRL-based instructional design. This is evident as shown in Table 3 and Figure 4, which show a comparison of pretest and posttest scores after the implementation of the designed instructional approach.

Table 3. Pretest and Posttest Result

Pretest	Posttest
62,4	80,2

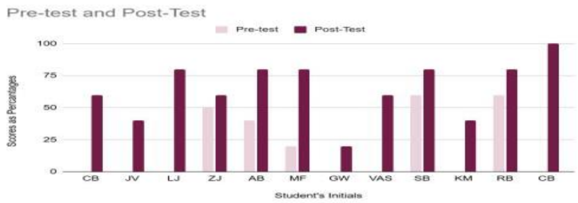

Figure 3. The Improvement of result study

Additionally, the improvement in learning outcomes was analyzed using the N-Gain score.

Tabel 4. N-Gain Result

N-Gain	Category
0,47	Sedang

An improvement in learning outcomes with an N-Gain score of 0.47 as shown in Table 4 indicates moderate effectiveness; however, this finding not only indicates the success of the intervention but also reveals that the optimization of generative processing has not yet been fully maximized. When compared to the study by [12], an improvement in the moderate category indicates that the generative activities implemented likely have not fully fostered deep conceptual integration. This may be due to the limited duration of the implementation, which lasted only three sessions, so the process of internalizing Self-Regulated Learning strategies has not developed optimally. Furthermore, an analysis of extraneous cognitive load shows that students' cognitive load falls into the low category as shown in Table 5.

Tabel 5. Cognitive Load Result

Value	Category
2,13	Rendah

MJP Journal of Education and Teaching Learning
Vol.4, No.1 July (2026): 57-63

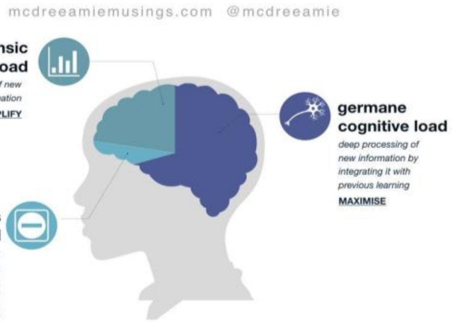

Figure 4. Cognitive Load Graphic

The finding that extraneous cognitive load falls into the low category indicates that the instructional design developed successfully reduced irrelevant cognitive load. However, when compared to the study by [13], a low level of cognitive load does not always directly result in a high improvement in learning outcomes. In the context of this study, although the cognitive load was low, the improvement in learning outcomes was only in the moderate category. This indicates that reducing cognitive load alone is insufficient; it must be balanced with higher-order cognitive activities such as concept elaboration and integration. Additionally, the application of Self-Regulated Learning strategies has been proven to enhance students' active engagement in the learning process [14].

Thus, the implementation phase yielded empirical data showing that an ADDIE-based instructional design with an SRL approach demonstrates good practicality and effectiveness in real-world learning contexts.

3.5 Evaluation Phase (Evaluation and Model Testing)

The evaluation phase was conducted to comprehensively assess the quality of the product and test the relationships among variables within the research model. The evaluation was conducted using two approaches: descriptive analysis and inferential analysis. Descriptive analysis was used to assess the validity, practicality, and effectiveness of the product, while inferential analysis was performed using a Partial Least Squares-based Structural Equation Modeling (PLS-SEM) approach to test the relationships and mediating effects among the research variables [15].

The PLS-SEM analysis was conducted in several stages: an outer model evaluation to test the validity and reliability of the constructs, and an inner model evaluation to test the relationships among variables. The analysis results indicated that all constructs met the criteria for validity and reliability, making them suitable for use in structural model testing.

In addition to testing path significance, the structural model was also evaluated by examining the coefficient of determination (R^2), predictive relevance (Q^2), effect size (f^2), and model fit via the Standardized Root Mean Square Residual (SRMR).

Tabel 6. Structural Model Evaluation (Inner Model)

Indicator	Variable	Value	Criteria	Interpretation
R^2	Generative Processing (GP)	0.61	Moderate–Strong	Good
R^2	Extraneous Cognitive Load (ECL)	0.45	Moderate	Adequate
Q^2	Model	0.37	> 0	Has predictive relevance
SRMR	Model	0.068	< 0.08	Good Fit
f^2	SRL → GP	0.28	Moderate	Significant effect
f^2	ECL → GP	0.21	Moderate	Significant effect
f^2	SRL → ECL	0.17	Small–Moderate	Significant effect

Based on Table 5, the R^2 value for the generative processing variable of 0.61 indicates that Self-Regulated Learning and extraneous cognitive load account for a moderate to strong proportion of the variance in generative processing. Meanwhile, the R^2 value for extraneous cognitive load of 0.45 indicates a moderate contribution from Self-Regulated Learning. The Q^2 value of 0.37 (> 0) indicates that the model has good predictive ability. Additionally, the SRMR value of 0.068, which is below the 0.08 threshold, indicates that the model has a good fit.

In terms of effect sizes, the effect of Self-Regulated Learning on generative processing ($f^2 = 0.28$) and the effect of extraneous cognitive load on generative processing ($f^2 = 0.21$) fall into the moderate category, while the effect of Self-Regulated Learning on extraneous cognitive load ($f^2 = 0.17$) falls into the small to moderate category. These findings indicate that the developed model is not only statistically significant but also possesses adequate effect sizes and predictive power.

Table 6. Hypothesis Testing Results (Path Coefficients)

Relationship	Coefficient	p-value	Interpretation
SRL → GP	0.52	0.000	Significant
ECL → GP	-0.41	0.001	Significant
SRL → ECL	-0.38	0.002	Significant

The positive effect of Self-Regulated Learning on generative processing ($\beta = 0.52$) indicates that self-regulation plays a significant role in fostering higher-order cognitive activities. This finding is stronger than the results of [16] which showed a moderate effect, suggesting that the integration of SRL into ADDIE-based instructional design contributes more systematically to the learning process. However, this effect is not entirely direct, as extraneous cognitive load was found to act as a partial mediator. This suggests that the effectiveness of SRL depends not only on self-regulation strategies but also on how information is presented in the learning process.

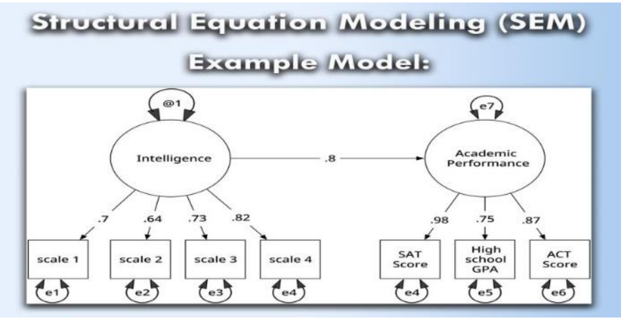

Figure 5. Structural Equation Model (SEM) of the Study

The diagram illustrates the structural relationships among the study variables, namely the influence of SRL on generative processing and cognitive load, as well as the influence of cognitive load on generative processing.

Table 7. Mediation Test Results

Mediation Path	Result	Interpretation
SRL → ECL → GP	Significant	Partial mediation

These results as shown in Table 7 indicate that extraneous cognitive load acts as a mediating variable in the relationship between Self-Regulated Learning and generative processing. This means that improvements in students' self-regulation abilities not only directly enhance generative processing but also through a reduction in irrelevant cognitive load.

These findings align with Self-Regulated Learning theory, which states that self-regulation plays a crucial role in optimizing the learning process [13], as well as Cognitive Load Theory, which emphasizes the importance of managing cognitive load in enhancing learning effectiveness [17]. Furthermore, these results reinforce recent research indicating a significant relationship between self-regulation, cognitive load, and generative processing in learning [16].

The evaluation phase not only demonstrated that the developed instructional design is effective but also provided empirical evidence that integrating Self-Regulated Learning into an ADDIE-based learning design significantly contributes to controlling extraneous cognitive load and enhancing students' generative processing.

Thus, the developed structural model not only meets the goodness-of-fit criteria but also demonstrates strong predictive power, making it suitable for use as an empirical model in explaining the relationships among variables in mathematics learning.

4. Conclusion

Based on the research results, it can be concluded that the development of a mathematics instructional design based on the ADDIE model with a Self-Regulated Learning (SRL) approach successfully produced a valid, practical, and effective learning product. During the development phase, the resulting product met feasibility criteria based on expert validation results, while the implementation phase demonstrated improved student learning outcomes, evidenced by higher posttest scores compared to pretest scores and N-Gain values in the moderate category. Additionally, the analysis results indicated that students' extraneous cognitive load was in the low category, suggesting that the developed instructional design effectively presented information without overburdening students' cognitive capacity.

Furthermore, the results of the analysis using the PLS-SEM approach showed that Self-Regulated Learning has a positive effect on generative processing and a negative effect on extraneous cognitive load. These findings also indicate that extraneous cognitive load acts as a mediating variable in the relationship between SRL and generative processing. Thus, the integration of Self-Regulated Learning strategies into ADDIE-based instructional design not only improves learning outcomes directly but also through a more effective cognitive load management mechanism. Overall, this study contributes to the development of instructional designs that integrate aspects of self-regulation and cognitive management to enhance the quality of mathematics learning more comprehensively.

Reference

[1] A. Qonaah, H. Pujiastuti, and A. Fatah, "Pengaruh Model Pembelajaran Generatif Terhadap Peningkatan Kemampuan Komunikasi Matematis Ditinjau Dari Kemampuan Awal Matematis Siswa," *Edumatica J. Pendidik. Mat.*, vol. 9, no. 1, pp. 9–14, 2019.

[2] J. Sweller, P. Ayres, and S. Kalyuga, *Cognitive load theory*. Springer, 2019. doi: 10.1007/978-1-4419-8126-4.

[3] T. Seufert, R. Brünken, and F. Paas, "Cognitive load and learning: Recent developments," *Educ. Psychol. Rev.*, 2024, doi: 10.1007/s10648-024-09890-1.

[4] A. B. H. de Bruin, J. Roelle, S. K. Carpenter, and M. Baars, "Synthesizing cognitive load and self-regulation theory: A theoretical framework and research agenda," *Educ. Psychol. Rev.*, vol. 32, pp. 903–915, 2020, doi: 10.1007/s10648-020-09576-4.

[5] T. Wang, S. Li, and S. Lajoie, "The interplay between cognitive load and self-regulated learning in a technology-rich learning environment," *Educ. Technol. Soc.*, vol. 26, pp. 50–62, 2023.

[6] N. Mariam and C.-W. Nam, "The development of an ADDIE based instructional model for ELT in Early Childhood Education," *Educ. Technol. Int.*, vol. 20, no. 1, 2019.

[7] R. M. Branch, *Instructional design: The ADDIE approach*. Springer, 2009. doi: 10.1007/978-0-387-09506-6.

[8] S. Gustiani, "Research and Development (R&D) Method as a Model Design in Educational Research and its Alternatives," *Holist. J.*, vol. 11, no. 2, 2019.

[9] F. Magno, F. Cassia, and C. M. Ringle, "A brief review of partial least squares structural equation modeling (PLS-SEM) use in quality management studies," *TQM J.*, vol. 36, no. 5, pp. 1242–1251, 2024, doi: 10.1108/TQM-06-2022-0197.

[10] L. Fiorella and R. E. Mayer, "Eight ways to promote generative learning," *Educ. Psychol. Rev.*, vol. 28, no. 4, pp. 717–741, 2016, doi: 10.1007/s10648-015-9348-9.

[11] D. H. Schunk and J. A. Greene, *Handbook of self-regulation of learning and performance*, 2nd ed. Routledge, 2021. doi: 10.4324/9780203839010.

[12] I. Maryanti, Sakinah, and H. F. Situmorang, "Pengaruh Model Pembelajaran Generatif Learning Terhadap Kualitas Pembelajaran," *J. Manaj. Pendidik. Dasar Menengah Dan Tinggi JMP-DMT*, vol. 3, no. 3, pp. 105–113, 2022.

[13] K. Scheiter, "Commentary: How can we come to terms when discussing the role of effort from the perspective of cognitive load theory and theories of self-regulated learning?," *Educ. Psychol. Rev.*, vol. 37, p. 57, 2025, doi: 10.1007/s10648-025-10037-z.

[14] A. B. de Bruin and J. J. van Merriënboer, "Bridging cognitive load and self-regulated learning research: A complementary approach to contemporary issues in educational research," *Learn. Instr.*, vol. 51, pp. 1–9, 2017, doi: 10.1016/j.learninstruc.2017.06.001.

[15] J.-M. Becker, J.-H. Cheah, R. Gholamzade, C. M. Ringle, and M. Sarstedt, "PLS-SEM's most wanted guidance," *Int. J. Contemp. Hosp. Manag.*, vol. 35, no. 1, pp. 321–346, 2023, doi: 10.1108/IJCHM-04-2022-0474.

[16] P. Evans, M. Vansteenkiste, P. Parker, A. Kingsford-Smith, and S. Zhou, "Cognitive load theory and its relationships with motivation: A self-determination theory perspective," *Educ. Psychol. Rev.*, vol. 36, no. 1, p. 7, 2024, doi: 10.1007/s10648-023-09841-2.

[17] F. Paas and J. J. G. van Merriënboer, "Cognitive-load theory: Methods to manage working memory load," *Educ. Psychol.*, vol. 55, no. 1, pp. 1–17, 2020, doi: 10.1080/00461520.2019.1708232.