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A Digital Portfolio Based Formative Assessment Model in the Merdeka Curriculum: Effects on Elementary Students' Self-Regulated Learning and Academic Achievement

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Abstract

The Merdeka Curriculum positions formative assessment as a strategic instrument for competency development, yet its implementation in elementary schools remains hindered by conventional approaches lacking sustained reflection and feedback. This study examines the impact of a digital portfolio-based formative assessment model on students' self-regulation and learning outcomes. A quasi-experimental nonequivalent control group pretest-posttest design, enriched with exploratory qualitative components, was applied to 142 fifth-grade students from two public elementary schools in Sleman Regency. Instruments included a learning outcome test (α=0.87), a Self-Regulated Learning questionnaire (α=0.91), a digital portfolio rubric, and interview guidelines. Data were analyzed using ANCOVA and thematic analysis. Results indicated significant improvements in self-regulation ($F(1,139)=48.32$, $p<0.001$, $\eta^2=0.26$) and learning outcomes ($F(1,139)=31.15$, $p<0.001$, $\eta^2=0.18$) in the experimental group. Qualitative analysis revealed four SRL-promoting mechanisms: structured goal planning, visual progress monitoring, feedback-based reflection, and strategy adaptation. The novelty lies in integrating the formative assessment cycle with self-regulation phases within a measurable digital portfolio ecosystem, alongside providing an adoptable operational model. This model is recommended as an instrument to strengthen the Pancasila Student Profile through reflective and autonomous learning.

INTRODUCTION

The Merdeka Curriculum positions formative assessment as an integral component of the learning process, emphasizing the continuous development of students' competencies rather than merely measuring learning outcomes at the end of instruction. This paradigm aligns with the concept of *assessment for learning*, which highlights the importance of continuous feedback, student reflection, and instructional adjustment as essential mechanisms for improving learning quality (Kemendikbudristek, 2022). Within this framework, assessment is no longer viewed solely as an evaluation tool but as an ongoing process that enables both teachers and students to monitor and understand learning progress.

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Despite this policy direction, the implementation of formative assessment in Indonesian primary schools continues to face pedagogical and technical challenges. Preliminary observations conducted between August and October 2023 in four public primary schools in the Special Region of Yogyakarta revealed that 78.4% of teachers still relied primarily on written summative tests as their main assessment instrument. Only 21.6% incorporated portfolios into classroom assessment, and even then, portfolio use was largely administrative, consisting merely of collections of student assignments without structured reflection or systematic feedback. These findings indicate that formative assessment, as envisioned in the Merdeka Curriculum, has not yet been implemented optimally.

These observations were further supported by a preliminary survey involving 120 fifth-grade students, which revealed relatively low levels of self-regulated learning (SRL). The overall mean SRL score was 2.8 on a five-point scale, with the lowest scores observed in students' ability to monitor their learning progress (2.4) and adapt learning strategies (2.6). Moreover, students' performance in contextual reasoning tasks in Science (*Ilmu Pengetahuan Alam dan Sosial*—IPAS) and Mathematics showed that only 41.3% achieved the proficient level. These findings suggest a considerable gap between the reflective learning principles promoted by the Merdeka Curriculum and primary students' capacity for self-regulated learning.

A substantial body of previous research has established the effectiveness of formative assessment and digital portfolios in enhancing learning. Black and Wiliam (1998) and Heritage (2010) demonstrated that specific, timely, and continuous formative feedback significantly improves students' academic achievement, with reported effect sizes ranging from 0.40 to 0.70. Furthermore, Barrett (2020) and Yancey (2021) argued that digital portfolios function not only as repositories of student work but also as metacognitive learning environments that enable learners to document their progress, receive multimodal feedback, and construct learning identities through sustained reflection.

From the perspective of educational psychology, Zimmerman's (2000) and Pintrich's (2004) Self-Regulated Learning (SRL) theory explains that successful learning depends largely on students' ability to regulate their own learning through three interconnected phases: forethought (goal setting and strategic planning), performance (self-monitoring and self-control), and self-reflection (self-evaluation and strategy adaptation). Subsequent studies by Dent and Koenka (2016) and Panadero (2017) further confirmed that self-regulated learning is positively associated with academic achievement, particularly in learning environments requiring higher-order thinking and learner autonomy.

Although research on formative assessment, digital portfolios, and self-regulated learning has expanded considerably, several gaps remain within the context of Indonesian primary education. Chen and Huang (2022) investigated the effects of digital portfolios on learning motivation but did not comprehensively examine their influence on self-regulated learning. Wiliam (2018) proposed the formative

assessment cycle; however, its integration into digital learning environments suitable for primary school students has received limited attention. Meanwhile, Subekti et al. (2023) explored formative assessment within the implementation of the Merdeka Curriculum using a qualitative descriptive approach, providing limited empirical evidence regarding the effectiveness of specific assessment models. Consequently, further research is needed to integrate formative assessment, self-regulated learning, and digital portfolios into a unified instructional model evaluated through rigorous experimental methods.

The novelty of this study lies in the development of a digital portfolio-based formative assessment model that explicitly integrates the formative assessment cycle—including goal setting, feedback, reflection, and revision—with Zimmerman's three phases of Self-Regulated Learning. This integration is operationalized through digital portfolio features such as version history, comment threads, reflection prompts, and progress dashboards, all of which are specifically designed to facilitate students' self-regulation processes. Furthermore, this study adopts a quasi-experimental design using Analysis of Covariance (ANCOVA) complemented by qualitative evidence documenting the development of students' self-regulated learning. The study also produces practical instructional resources, including digital portfolio rubrics, structured reflection templates, and data-driven feedback protocols that can be readily implemented by primary school teachers within the Merdeka Curriculum.

Based on the empirical evidence, theoretical foundations, and identified research gaps, this study aims to examine the effects of the proposed digital portfolio-based formative assessment model on improving primary school students' self-regulated learning, particularly their abilities to set learning goals, monitor learning progress, reflect on their performance, and adapt learning strategies. In addition, the study investigates the model's impact on students' cognitive achievement in Science (IPAS) and Mathematics through analyses of pretest–posttest scores, normalized gain scores, and cognitive achievement distributions. It also explores the mechanisms underlying the development of self-regulated learning through analyses of students' reflective journals, feedback interactions, and in-depth interviews. The findings are expected to contribute theoretically to the advancement of technology-enhanced formative assessment while providing an evidence-based and practical instructional model for primary school teachers implementing the Merdeka Curriculum.

RESEARCH METHOD

This study employed a mixed-methods approach using a sequential explanatory design, integrating quantitative and qualitative data in consecutive phases to obtain a comprehensive understanding of the effectiveness of a digital portfolio-based formative assessment model. The quantitative phase adopted a nonequivalent control group pretest–posttest quasi-experimental design to examine the model's effects on students' self-regulated learning and academic achievement.

Subsequently, the qualitative phase was conducted to explore the mechanisms through which self-regulated learning developed during the intervention. This design was selected because it combines the strengths of statistical analysis with in-depth exploration of students' learning experiences (Creswell & Plano Clark, 2018).

The study population consisted of all fifth-grade students enrolled in public primary schools in Sleman Regency, Indonesia. Participants were selected using purposive sampling combined with a matching technique based on pretest scores of self-regulated learning, baseline academic achievement, and demographic characteristics. The study involved two schools: SDN A, comprising 72 students assigned to the experimental group, and SDN B, comprising 70 students assigned to the control group, resulting in a total sample of 142 participants. The sample size exceeded the minimum requirement determined through G*Power analysis ($\alpha = 0.05$, statistical power = 0.95, effect size = 0.25), which indicated a minimum sample of 128 participants. All students participated after obtaining written parental informed consent as well as official approval from the participating schools and the local education authority.

Data were collected using several research instruments that had undergone validity and reliability testing. Academic achievement was measured using a 30-item achievement test developed according to the learning outcomes specified in the Merdeka Curriculum and the revised taxonomy of Anderson and Krathwohl (2001). The test demonstrated satisfactory content validity (CVR = 0.85–0.92) and internal consistency (Cronbach's α = 0.87). Students' self-regulated learning was measured using a questionnaire adapted from the Motivated Strategies for Learning Questionnaire (MSLQ) and Zimmerman's Self-Regulated Learning framework. The instrument consisted of 28 items and demonstrated excellent composite reliability (CR = 0.91). In addition, a digital portfolio assessment rubric was employed to evaluate artifact completeness, quality of reflection, revision based on feedback, and technology utilization, with an inter-rater reliability coefficient (Cohen's κ) of 0.82. Supporting qualitative data were obtained through classroom observations and structured interviews to identify students' self-regulation processes, perceptions of formative feedback, and challenges encountered during the implementation of the instructional model.

The intervention was implemented over 12 weeks in the experimental group using the digital portfolio-based formative assessment model. Each learning cycle began with students establishing individual learning goals and uploading their initial work to digital platforms such as Google Sites or Padlet. Teachers and peers subsequently provided written and audio feedback through comment threads, after which students completed structured reflections using the What? – So What? – Now What? framework before revising their work. At the end of each cycle, students presented their learning progress and updated their progress dashboards to monitor their achievement. In contrast, the control group received conventional classroom

instruction supported by paper-based formative assessment without the systematic use of digital portfolios.

Quantitative data analysis began with preliminary assumption testing, including the Shapiro–Wilk test for normality, Levene's test for homogeneity of variance, and linearity assessment. Subsequently, Analysis of Covariance (ANCOVA) was performed using pretest scores as the covariate to control for baseline differences between groups. The magnitude of the intervention effect was determined using partial eta squared (η^2) with IBM SPSS Statistics version 26. Qualitative data, including students' reflective journals, feedback threads, classroom observations, and interview transcripts, were analyzed using Braun and Clarke's (2006) thematic analysis, comprising six stages: data familiarization, initial coding, theme generation, theme review, theme definition, and report production. Finally, quantitative and qualitative findings were integrated through methodological triangulation to explain how and why the digital portfolio-based formative assessment model influenced students' self-regulated learning and academic achievement. Throughout the study, ethical principles were strictly observed, including participant confidentiality, anonymity, the right to withdraw from the study at any time, and secure data management.

RESULTS AND DISCUSSION

Effects on Students' Self-Regulated Learning

Descriptive and inferential analyses revealed significant differences in the development of self-regulated learning (SRL) between the experimental and control groups.

Table 1. Pretest and Posttest Statistics of Students' Self-Regulated Learning

Group	n	Pretest (M ± SD)	Posttest (M ± SD)	F(1,139)	p-value	η^2
Experimental	72	2.81 ± 0.42	3.94 ± 0.38	48.32	<0.001	0.26
Control	70	2.79 ± 0.45	3.12 ± 0.41			

ANCOVA confirmed that the posttest differences remained statistically significant after controlling for pretest scores ($p < 0.001$), with a large effect size ($\eta^2 = 0.26$). The greatest improvements were observed in the indicators of progress monitoring (+31.4%) and strategy adaptation (+28.7%). Qualitative findings further revealed that the version history and progress dashboard features embedded in the digital portfolio functioned as external scaffolds that facilitated the internalization of students' metacognitive awareness. As one participant (E-12) explained:

> *"Previously, whenever I received a low score, I simply forgot about it. Now I can review my first version, my teacher's comments, and my reflection notes, so I know exactly what I need to change in my learning."*

These findings support Zimmerman's (2000) theory that self-regulated learning is not an innate ability but a skill that can be systematically developed through structured cycles of feedback and reflection.

Effects on Cognitive Learning Outcomes

Table 2. Pretest and Posttest Statistics of Cognitive Learning Outcomes

Group	n	Pretest (M ± SD)	Posttest (M ± SD)	F(1,139)	p-value	η^2
Experimental	72	64.2 ± 8.7	78.5 ± 6.4	31.15	<0.001	0.18
Control	70	63.8 ± 9.1	70.3 ± 7.8			

ANCOVA demonstrated a significant effect of the intervention on students' cognitive achievement ($p < 0.001$, $\eta^2 = 0.18$). Item-level analysis showed the greatest improvements in analytical thinking (+24.3%) and evaluation skills (+19.8%), whereas the remembering domain increased by only 8.1%. These results indicate that the formative assessment cycle enhanced higher-order cognitive processing rather than merely improving factual recall.

Within the digital portfolio environment, students revised their work based on detailed formative feedback instead of simply receiving grades. This process aligns with Heritage's (2010) concept of *assessment for learning*, which positions feedback as a bridge between learners' current performance and intended learning goals. Unlike students in the control group, who generally received generic feedback such as *"needs more practice,"* those in the experimental group received rubric-based comments, for example:

> *"Your understanding of proportional concepts is accurate; however, your interpretation of the graph does not yet include the appropriate time units."*

Such targeted feedback directly guided students' cognitive revisions and supported deeper conceptual understanding.

Mechanisms of Self-Regulated Learning within the Digital Portfolio Ecosystem

Thematic analysis of 24 student reflection documents and feedback threads identified four mechanisms that promoted the development of self-regulated learning.

1. Structured Goal Planning (Forethought Phase)
   The digital reflection template required students to formulate learning goals that were specific, measurable, and time-bound. Consequently, 87% of students in the experimental group established sequential learning goals, compared with only 34% of students in the control group.
2. Visual Progress Monitoring (Performance Phase)
   The portfolio dashboard displayed task completion percentages, revision histories, and progress graphs. These visual representations reduced the cognitive load associated with tracking learning progress, allowing students to allocate greater cognitive resources to understanding instructional content.
3. Feedback-Based Reflection (Self-Reflection Phase)

Teacher and peer comments were directly linked to individual portfolio artifacts, enabling contextual rather than abstract reflection. Students gradually learned to distinguish criticism of their work from criticism of themselves, perceiving feedback as constructive information for improvement rather than personal evaluation.

4. Iterative Strategy Adaptation (Cyclical Reinforcement)
   Each portfolio cycle required students to modify their learning strategies based on evidence gathered from previous performance. As a result, many students shifted from passive learning strategies, such as repeatedly rereading materials, to more active approaches, including concept mapping, recording audio explanations, and peer tutoring.

These mechanisms help explain why the intervention produced a larger effect on self-regulated learning ($\eta^2 = 0.26$) than on cognitive achievement ($\eta^2 = 0.18$). Rather than directly teaching subject content, the digital portfolio strengthened students' metacognitive capacity, which subsequently transferred to improved academic performance. This finding extends Panadero's (2017) framework by providing empirical evidence that self-regulated learning serves as a critical mediator between formative assessment and academic achievement.

Theoretical Discussion, Practical Implications, and Limitations

The integration of quantitative and qualitative findings demonstrates that the digital portfolio-based formative assessment model functions as a cognitive–metacognitive bridge within the implementation of the *Merdeka Curriculum*. Unlike previous studies by Chen and Huang (2022), which primarily examined learning motivation, and Subekti et al. (2023), which focused on descriptive implementation, the present study provides empirical evidence of both the causal effectiveness of the model and the mechanisms through which it enhances self-regulated learning. The findings also address one of the principal objectives of the *Merdeka Curriculum*—promoting learner autonomy—by showing that digital portfolios provide sufficient instructional structure to support independent learning while maintaining the teacher's role as a facilitator.

From a practical perspective, the model can be implemented through three operational steps. First, teachers should receive professional development in designing specific formative feedback and using structured reflection templates. Second, schools should adopt child-friendly and secure digital platforms that support version tracking, such as Google Sites, Padlet, or school-based e-portfolio systems. Third, digital portfolios should be systematically integrated into classroom instruction, with at least one portfolio cycle conducted for each major instructional unit. Educational authorities can further facilitate implementation by providing digital infrastructure, standardized portfolio rubrics, and professional learning communities for teachers.

Despite these contributions, the study has several limitations. The twelve-week intervention period may not have been sufficient to examine the long-term transfer of

self-regulated learning strategies across different subject areas. In addition, the effectiveness of the model depends on teachers' digital literacy and students' access to digital devices outside school. Finally, the findings are primarily applicable to urban elementary school settings, limiting their generalizability. Future research should employ longitudinal designs, integrate AI-supported learning analytics to generate automated formative feedback, and evaluate the effectiveness of the model in schools with limited digital infrastructure.

CONCLUSION

Based on the systematic analysis and discussion, this study successfully achieved its three research objectives with the following key findings. First, the digital portfolio-based formative assessment model had a significant positive effect on elementary students' self-regulated learning ($F(1,139) = 48.32$, $p < 0.001$, $\eta^2 = 0.26$), with the greatest improvements observed in progress monitoring and strategy adaptation. Second, the model significantly enhanced students' cognitive learning outcomes, particularly in the domains of analysis and evaluation ($F(1,139) = 31.15$, $p < 0.001$, $\eta^2 = 0.18$), confirming that the feedback–reflection–revision cycle promotes higher-order cognitive processing. Third, the development of self-regulated learning was facilitated through four integrated mechanisms: structured goal setting, visual progress monitoring, contextual feedback-based reflection, and iterative strategy adaptation, all of which were operationalized through the features of the digital portfolio.

Overall, the proposed model offers a practical and evidence-based framework for implementing the principles of the *Merdeka Curriculum* while strengthening the *Pancasila Student Profile* by fostering learner autonomy and critical reflection. The study contributes to the literature by empirically integrating formative assessment cycles, self-regulated learning theory, and digital portfolio ecosystems into a coherent instructional model, while also providing practical tools that bridge educational theory and classroom practice. To maximize its implementation, teachers should receive professional development in designing effective formative feedback, schools should provide secure and user-friendly digital portfolio platforms, and educational policies should allocate dedicated instructional time for portfolio cycles. Future research is recommended to investigate the long-term effects of the model, examine its applicability across different educational levels and contexts, and explore the integration of AI-assisted feedback within an inclusive digital portfolio framework.

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