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Development of SIMAS Learning Media on the Water Cycle to Enhance Students' Learning Independence

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ABSTRACT

The rapid development of digital technology has transformed learning practices in schools, encouragin teachers to use innovative media to increase student engagement and independence. Traditional methods c teaching elementary school students about the water cycle often make them passive and overly dependent o teachers. This research uses the ADDIE development model, which includes five stages: Analysis, Desig Development, Implementation and Evaluation. Data were collected through expert validatio questionnaires, observations, interviews and pre-test/post-test assessments involving 47 Year 5 student from two primary schools in Purworejo Regency: SDN Kebongunung (the experimental class) and SDN Maron (the control class). The results showed that SIMAS is valid, practical and effective. Expert validatio showed that the media were very valid in terms of content, design, and appearance. Teachers and student rated SIMAS as being easy to use, visually appealing and helpful in understanding abstract concepts. T-tes results showed a significant difference ($p < 0.05$) between the experimental and control classes, proving tha SIMAS effectively improves learning independence. Students using SIMAS demonstrated greate motivation, initiative, and time management skills than those using conventional learning method Qualitative data supports these results, showing that SIMAS fosters an interactive and enjoyable learnin environment. Teachers in the experimental classes reported that this medium reduced teacher dominanc and encouraged active student participation. In conclusion, SIMAS has been proven to be a valid, practica and effective digital learning medium. It helps teachers implement digital pedagogy and strengthen students' learning independence.

Keywords: *learning independence; digital Learning media; addie model; simas; water cycle*

ABSTRAK
Perkembangan teknologi digital yang pesat telah mengubah praktik pembelajaran di sekolah dan mendorong guru untuk menggunakan media inovatif yang dapat meningkatkan keterlibatan serta kemandirian belajar siswa. Pembelajaran IPA di sekolah dasar pada topik siklus air dengan metode tradisional sering membuat siswa pasif dan terlalu bergantung pada guru. Metode Penelitian menggunakan model pengembangan ADDIE yang meliputi lima tahap: Analysis, Design, Development, Implementation, dan Evaluation. Data dikumpulkan melalui validasi ahli, angket, observasi, wawancara, serta tes pretest–posttest dengan melibatkan 47 siswa kelas V dari dua sekolah dasar di Kabupaten Purworejo, yaitu SDN Kebongunung sebagai kelas eksperimen dan SDN 1 Maron sebagai kelas kontrol. Hasil penelitian menunjukkan bahwa SIMAS memenuhi kriteria valid, praktis, dan efektif. Validasi ahli menunjukkan media sangat valid dari segi isi, desain, dan tampilan. Guru dan siswa menilai SIMAS mudah digunakan, menarik secara visual, dan membantu memahami konsep abstrak. Hasil uji-t menunjukkan perbedaan signifikan ($p < 0,05$) antara kelas eksperimen dan kontrol, yang membuktikan bahwa SIMAS efektif meningkatkan kemandirian belajar. Siswa pengguna SIMAS menunjukkan motivasi, inisiatif, dan kemampuan manajemen waktu lebih baik dibandingkan pembelajaran konvensional. Data kualitatif mendukung hasil tersebut, menunjukkan bahwa SIMAS menciptakan suasana belajar interaktif dan menyenangkan. Guru di kelas eksperimen melaporkan bahwa media ini mengurangi dominasi guru dan mendorong partisipasi aktif siswa. Kesimpulannya, SIMAS terbukti valid, praktis, dan efektif sebagai media pembelajaran digital. Media ini membantu guru menerapkan pedagogi digital dan memperkuat kemandirian belajar siswa.
Kata Kunci: kemandirian belajar; media pembelajaran digital; model addıe; simas; siklus air

INTRODUCTION

The rapid development of digital technology has encouraged schools to redesign learning practices toward more interactive and student-centered environments. Within the Independent Curriculum, the independence dimension of the Pancasila Student Profile positions learners as active agents who plan, monitor, and evaluate their own learning. However, classroom realities show that these expectations are not yet fully achieved. Science learning—particularly abstract topics such as the water cycle—remains dominated by teacher-centered explanations that limit students' self-regulated learning (SRL). A preliminary survey in the Loano District of Purworejo Regency revealed that 65.2% of students relied heavily on teacher guidance, indicating weak initiative, limited ability to monitor learning progress, and low independence in solving learning tasks.

From a theoretical perspective, SRL consists of three central processes: forethought (goal setting, planning, activating prior knowledge), performance control (strategy use, self-monitoring), and self-reflection (evaluation and adaptive decisions) (Zimmerman, 2002; Pintrich, 2004). Learning media can strengthen SRL when they facilitate opportunities for exploration, feedback, and self-evaluation. Complementing this, the Cognitive Theory of Multimedia Learning (CTML) emphasises that students learn more effectively through integrated verbal–visual representations, interactive elements, and structured segmentation that reduce cognitive load and enhance learning engagement. Supporting empirical evidence also shows that e-learning readiness significantly predicts students' ability to regulate their learning, as digitally prepared learners demonstrate stronger goal-setting, monitoring, and evaluative skills (Ucar & Ugurhan, 2023). These theoretical and empirical considerations

suggest that well-designed digital platforms hold strong potential to enhance independent learning in elementary science education.

However, findings from previous studies indicate that existing learning media for water-cycle topics address only partial aspects of the learning process. Manipulative-based media such as the Magic Box Sikla (Adawiyah et al., 2022) and pop-up books (Ainiyah et al., 2022) help students visualise abstract processes but offer limited flexibility for self-paced learning. Digital modules (Alfie et al., 2023a; 2023b) and diorama-based media (Ani et al., 2024) improve motivation and conceptual understanding yet do not include SRL components such as goal-setting, reflection, or self-assessment. Context-integrated learning materials (Ariyani et al., 2022; Ariyani & Ganing, 2021) remain reliant on teacher facilitation. Meanwhile, Android applications (Fahruji et al., 2022; Defantari & Yulianto, 2024), video media (Inayah et al., 2024), and character-based audiovisual tools (Indrayani & Sumantri, 2021) enhance engagement but still focus primarily on learning outcomes rather than self-regulation. Although computational thinking–based approaches (Azizah et al., 2023) foster student autonomy, they do not specifically address the conceptual characteristics of the water cycle. Overall, a consistent pattern emerges: most existing media support cognitive improvement, yet few embed systematic SRL scaffolds such as goal guidance, self-monitoring tools, or reflective tasks.

Based on this analysis, a clear research gap emerges: although numerous digital media have been developed for water-cycle learning, no existing study has produced a web-based platform that explicitly targets SRL through integrated features of planning, exploration, self-assessment, and reflection for fifth-grade students. Prior studies strengthen conceptual understanding but do not combine SRL theory with CTML principles within a single, unified digital environment. To address this gap, the present research develops SIMAS (Student Independent Water Cycle Site), a platform that integrates SRL components—such as goal prompts, self-paced navigation, embedded self-assessment quizzes, and reflective journals—with CTML-based features including multimedia explanations, segmented videos, educational comics, interactive games, and reduced cognitive load. This theoretical and design integration positions SIMAS as a novel contribution to digital science learning media.

Aligned with the identified research gap, this study aims to develop SIMAS as a valid, practical, and effective web-based learning medium for water-cycle instruction in Grade 5. Furthermore, the study examines the effectiveness of SIMAS in improving students' independent learning behaviours based on SRL indicators—forethought, performance control, and self-reflection. The results of this study are expected to provide practical contributions by supporting teachers in implementing digital pedagogy consistent with the Independent Curriculum and theoretical contributions by enriching SRL-oriented digital learning design grounded in CTML principles.

METHODS

Type and Design

This study employed a Research and Development (R&D) approach using the ADDIE model, which is widely applied in educational product development due to its systematic and sequential structure (Slamet, 2022). The Analysis phase included curriculum review, teacher interviews, and identification of students' difficulties related to water-cycle concepts and self-

regulated learning (SRL). The Design phase produced storyboards, flowcharts, interface mock-ups, and SRL indicators aligned with CTML principles. Development involved producing SIMAS using HTML, Canva, and Scratch, followed by internal testing and expert validation. During Implementation, a quasi-experimental non-equivalent control group design was applied in two schools, with the experimental class using SIMAS across four sessions and the control class receiving conventional instruction under comparable learning conditions. The Evaluation phase consisted of expert validation, practicality assessments, fidelity monitoring, and effectiveness testing through quantitative and qualitative analyses.

Data and Data Sources

The study population comprised all fifth-grade students in Loano District, from which 47 participants were selected through purposive sampling: SDN Kebongunung as the experimental class (n = 24) and SDN 1 Maron as the control class (n = 23). Prior to the intervention, class equivalence was established using pretest scores analysed through independent t-test and ANCOVA pre-checks, which showed no significant baseline differences ($p > 0.05$). To minimise confounding factors, both groups received identical instructional time, learning objectives, and teacher allocation, supported by structured fidelity observations throughout implementation. The research instruments also underwent systematic validation and reliability testing. Expert judgment resulted in a content validity index (CVI) of 0.89, indicating strong content validity. Construct validity was further confirmed through exploratory factor analysis (KMO = 0.812; all factor loadings > 0.50). Reliability testing showed that the SRL questionnaire achieved high internal consistency, with a Cronbach's Alpha of 0.87, exceeding the minimum acceptable threshold of 0.70 for psychological measurement.

Data Collection Technique

Data were collected using validated questionnaires, structured classroom observations, interviews, and expert evaluation sheets. The SRL questionnaire measured six indicators of learning independence—independence, self-confidence, discipline, responsibility, initiative, and self-control—using a 4-point Likert scale. Observation sheets captured student engagement, initiative, and persistence during activities, while teacher interviews explored perceptions of SIMAS practicality and feasibility. Expert validation was conducted to assess content accuracy, interface quality, navigation, and technological feasibility based on BSNP standards. Prior to implementation, class equivalence was ensured through normality tests, homogeneity tests, and pretest comparisons using independent t-tests and ANCOVA pre-check procedures. To minimise confounding variables, both groups received equal instructional time, identical learning objectives, instruction from the same teacher, and were monitored through fidelity-of-implementation observations in every meeting.

Data Analysis

Data were analysed using a combination of quantitative and qualitative procedures. Validation and practicality scores were examined using descriptive statistics, with ≥ 80% indicating acceptable validity and practicality. Effectiveness testing involved several stages: normality analysis using the Shapiro–Wilk test, homoscedasticity testing using Levene's test, adjustment for baseline differences using ANCOVA, and comparison of posttest results using independent t-tests. Effect size (Cohen's d) and 95% confidence intervals were also calculated to strengthen statistical robustness. Qualitative data obtained from interviews and observations were analysed using the Miles and Huberman model, consisting of data reduction, data display, and conclusion verification, to triangulate and complement the quantitative findings..

RESULTS AND DISCUSSION

Result

This research was conducted at SD Negeri 1 Maron and SD Negeri Kebongunung, Purworejo Regency. SD Negeri 1 Maron was designated as the control class with conventional learning, while SD Negeri Kebongunung was designated as the experimental class using the interactive digital learning media SIMAS (Interactive Sites for Water Cycle Material). The main objective of this research was to test the validity, practicality, and effectiveness of SIMAS media in improving the learning independence of fifth grade elementary school students on the water cycle material.

Product validation was conducted by four experts: a material expert, a content expert (educational psychology), an instructional media expert, and an educational technology expert. The validation results showed that the SIMAS media met the criteria for very valid in all assessment aspects.

Table 1. SIMAS Media Validity Test

No.	Expert Type	Rated aspect	Validity Percentage	Category	Interpretation of Results
1	Subject Matter Expert	The suitability of the content and structure of the material with the Independent Curriculum and support for student learning independence.	93.75%	Very Valid	The material is in accordance with the curriculum, contextual, and supports the development of independent learning.
2	Content Expert (Educational Psychology)**	Suitability of media to the cognitive and psychological development stages of elementary school children.	97.86%	Very Valid	The media is in line with the characteristics of elementary school students and is able to foster responsibility and self-control.

3	Media Expert	Display design, interactivity, and ease of navigation.	97.92%	Very Valid	Attractive, interactive display, easy to use without intensive assistance.
4	Technology Expert	Accessibility, stability, security, and compatibility of web-based media.	95.83%	Very Valid	The media is stable, fast to access, and safe to use on various devices.
	Average		96.35%	Very Valid	SIMAS media is suitable for use without major revisions.

Table 1 shows that the SIMAS media obtained an average validity score of 96.35%, indicating a very valid category across all expert evaluations. The material expert confirmed strong curriculum alignment and conceptual accuracy, while the educational psychology expert validated its suitability for students' cognitive and socio-emotional development. The media and technology experts rated the interface design, interactivity, accessibility, and technical stability at very high levels. Collectively, these results demonstrate that SIMAS fulfills content, pedagogical, and technological feasibility standards, and is therefore appropriate for classroom implementation without major revisions.

Table 2. SIMAS Media Practicality Test

No	Component	Teacher	Headmaster	Supervisor	Average Score	Category
1	Ease of access and use	4	4	4	4	Very Practical
2	Clear usage guide	4	4	4	4	Very Practical
3	Efficiency of time of use	4	4	4	4	Very Practical
4	Support for student learning independence	4	4	4	4	Very Practical
5	Compliance with school facilities	3.5	3.5	3.5	3.5	Very Practical
6	Technology security	3.5	3.5	3.5	3.5	Very Practical
Total score		23	23	23	23	Very Practical
Maximum score		24	24	24	24	-
Validity percentage		95.83%	95.83%	95.83%	95.83%	Very Valid
Practicality criteria		Very practical and worth using with revisions				

As shown in Table 2, SIMAS achieved an overall practicality score of 95.83%, indicating a very practical classification. Consistent high ratings across teachers, principals, and supervisors reflect that the media is intuitive, accessible, and easily integrated into regular instructional time without imposing additional workload on educators. The strong score for "support for student learning independence" suggests that SIMAS effectively facilitates autonomous navigation and self-paced learning—key SRL behaviours—because students can interact with content without continuous teacher intervention. The positive ratings for technological security and compatibility imply that the platform adheres to basic CTML usability principles by providing stable access, clear navigation, and coherence. Minor improvements suggested by practitioners, such as simplifying login and fixing navigation buttons, were implemented, reinforcing the platform's readiness for classroom deployment.

Table 3. N-Gain Scores of Learning Independence in Experimental and Control Groups

No	Aspect	Experiment		Difference	Control		Difference
		Before	After		Before	After	
1	Independence from others	0.25	0.88	0.63	0.25	0.70	0.50
2	Confidence	0.23	0.90	0.67	0.23	0.43	0.60
3	Discipline	0.43	0.88	0.45	0.43	0.38	0.45
4	Responsibility	0.23	0.95	0.72	0.23	0.53	0.70
5	Initiative	0.18	0.90	0.72	0.18	0.30	0.37
6	Self-control	0.18	0.73	0.55	0.18	0.28	0.17
Average		0.25	0.87	0.62	0.25	0.43	-
Criteria		BB	BSB	-	BB	MB	-
N-Gain		0.83		-	0.24		-
N-Gain Criterion		Tall		-	Low		-

Table 3 demonstrates a clear difference in learning independence gains between the experimental and control groups. The average N-Gain for the experimental class reached 0.83 (high category), indicating substantial improvement across all six SRL indicators, while the control class achieved only 0.24 (low category). This pattern suggests that SIMAS not only improved students' conceptual understanding but also enhanced SRL behaviours such as initiative, responsibility, and self-monitoring. The high post-intervention scores in the experimental group reflect effective engagement with SIMAS features—self-paced exploration, interactive tasks, and embedded self-assessment—while the control group's limited gains imply that conventional learning provided fewer opportunities for autonomy. These results confirm the effectiveness of

SIMAS in supporting the development of self-regulated learning in elementary science instruction.

Discussion

The findings indicate that SIMAS produced a substantial improvement in students' learning independence. The gain score in the experimental class reached a high category, whereas the control class remained in the low category. This contrast demonstrates that key features of SIMAS—such as autonomous navigation, segmented content, and embedded self-evaluation tasks—effectively support self-paced learning in line with CTML principles, including segmentation, coherence, and integrated verbal–visual processing. The consistent improvement across all SRL indicators further suggests that students not only enhanced their conceptual understanding but also developed stronger self-control, initiative, and responsibility in managing their learning. Interview results corroborate these outcomes, revealing that the interactive design of SIMAS made students more active and confident, a pattern not observed in the control group. Overall, these findings indicate that interactive multimedia environments can enhance SRL by giving learners the flexibility to regulate the pace, sequence, and strategies of their learning autonomously.

The effectiveness of SIMAS in enhancing students' learning independence can be theoretically explained through the mechanisms proposed in the Cognitive Theory of Multimedia Learning. Learning becomes more meaningful when verbal and visual information are integrated coherently, allowing learners to manage their cognitive load more efficiently (Mayer, 2020). The interactive features of SIMAS such as segmented explanations, animations, and embedded formative assessments align with these principles and enable students to process information at their own pace, which is reflected in the consistently high gains across SRL indicators. Well designed multimedia can strengthen conceptual understanding by increasing attention and sustaining engagement (Setiyowati & Widhyahrini, 2022 ; Putri, et al. 2020) . From an SRL perspective, the autonomy embedded in SIMAS supports Zimmerman's (2019) key processes of forethought, performance monitoring, and self-reflection. Students can independently choose learning paths, complete self-check quizzes, and revisit materials behaviours that mirror the independence and initiative documented in digital learning studies (Salvara & Zumrotun, 2024 ; Supartayasa & Wibawa, 2022). The interactive tasks also resonate with Vygotskian socio-cultural principles explained by Woolfolk (2021), where digital tools function as cognitive partners that expand students' zone of proximal development. Overall, these theoretical linkages suggest that SIMAS does not merely present content digitally but operationalises core SRL and CTML principles, thereby explaining why significant improvements were observed compared to conventional instruction.

Although the findings demonstrate the strong potential of SIMAS in promoting students' self-regulated learning, several limitations must be acknowledged. First, the study involved a relatively small and region-specific sample, which may limit the generalisability of the results to broader elementary school populations. Second, the quasi-experimental design did not fully control for all external variables—such as students' digital familiarity or home learning environments—which may have influenced the outcomes. Third, the effectiveness of SIMAS was assessed over a short intervention period, so its long-term impact on sustained SRL behaviours could not be evaluated. Fourth, the qualitative component relied primarily on interviews and observations without extended triangulation or member checking, which may constrain the depth of interpretive validity. Lastly, the study focused on SRL and conceptual understanding but did not investigate other potentially relevant learning outcomes, such as digital literacy or collaborative skills. Future research should employ larger samples, longitudinal designs, and more robust qualitative validation procedures to strengthen the evidence base for SIMAS and explore its broader pedagogical implications.

Future studies may extend the development of SIMAS by incorporating adaptive learning pathways and real-time analytics to better monitor students' SRL progression. Research with larger and more diverse samples across different regions is needed to enhance the generalisability of the findings. Longitudinal designs are also recommended to examine the sustainability of SRL improvements over longer periods and to explore whether SIMAS influences students' learning habits beyond the science domain. Additionally, integrating collaborative learning features—such as peer feedback, discussion forums, or group-based challenges—may provide insights into how digital platforms can support both individual and social dimensions of learning. Further research should also compare SIMAS with other digital learning models using more advanced statistical analyses, such as multilevel modelling, to understand the nuanced factors that contribute to SRL development in digital environments. Finally, future studies could evaluate the impact of SIMAS on broader competencies, including digital literacy, problem-solving, and motivation, to inform its refinement as a comprehensive tool for elementary digital learning.

CONCLUSION

This study concludes that the SIMAS web-based learning media is valid, practical, and effective in strengthening students' self-regulated learning in water-cycle instruction. The findings extend SRL and CTML theory by showing that segmented multimedia content, interactive tasks, and embedded self-assessment can enhance students' forethought, performance control, and reflective processes. Practically, SIMAS offers teachers an accessible digital tool that supports autonomous learning and aligns with the Independent Curriculum. However, the study is limited by its short

implementation period and restricted sample. Future research should examine long-term effects, test SIMAS across varied school contexts, and compare its performance with other digital platforms or LMS-based learning environments.

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