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DISCOVERY LEARNING FOR DIGITAL READING: DESIGNING A CONSTRUCTIVE-RESPONSIVE MODEL AND ITS INSTRUCTIONAL IMPLICATIONS

Ida Hamidah[1], Fahrus Zaman Fadhly[2], Siti Sa'diah[3]
[1]*Indonesian Language Education Study Programme, Faculty of Language and Literature Education Universitas Kuningan, 45513, Indonesia*
[2]*Department of English Language Education, Faculty of Teachers Training and Education, Universitas Kuningan, 45513, Indonesia*
[3]*School of Social Sciences, Education, and Social Work Queen's University Belfast, United Kingdom*

Corresponding author's email: ida.hamidah@uniku.ac.id

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Abstract: The rise of digital reading in higher education has reshaped how students engage with texts, requiring critical navigation and evaluation of multimodal, non-linear information. Despite the growing complexity of digital texts, current instructional models often lack the responsiveness needed to support student comprehension in digital environments. Existing approaches are either too rigid or fail to integrate pedagogical strategies that account for digital reading challenges. This study aimed to design a Discovery Learning-based instructional model grounded in Constructive-Responsive principles to enhance digital reading skills among university students. Using a research and development approach, the study applied the 4D model—Define, Design, Develop, and Disseminate—with data collected through expert validation, field trials, and student feedback at four private universities in West Java, Indonesia. The resulting model integrates six stages of Discovery Learning with adaptive scaffolding, allowing students to explore digital texts actively while developing metacognitive regulation and critical evaluation skills. The model improved students' comprehension, source evaluation, and digital navigation abilities. This instructional model addresses gaps in digital reading pedagogy by offering a flexible and student-centered framework. It holds potential for broad application in digital literacy instruction and may inform future curriculum and instructional design in higher education.

Keywords: *digital reading; discovery learning; constructive-responsive pedagogy; higher education; instructional model.*

INTRODUCTION

The pervasive integration of digital technologies has fundamentally transformed the landscape of reading, shifting the focus from traditional printed texts to dynamic, multilayered digital environments (Cho & Afflerbach, 2017; Liao et al., 2024). This shift necessitates a corresponding evolution in reading comprehension strategies, as digital texts introduce unique challenges, including hyperlinked structures, multimodality, and potential distractions, which are not prevalent in linear print-based reading (Delgado et al., 2018; Schurer et al., 2023). Consequently, there is a pressing need for innovative instructional models that can effectively equip learners with the advanced cognitive and metacognitive skills required to navigate, evaluate, and construct meaning from complex digital informational texts (Julie Coiro, 2021; Makhafola et al., 2025).

Digital reading environments impose distinct cognitive demands on readers, fundamentally differing from the processing of printed text. Research by Hahnel et al. (2017) demonstrates that reading digital text involves continuous working memory updating, heavily influenced by task characteristics and reader behavior. The non-linear

nature of hypertext, for instance, can lead to mind wandering and fragmented comprehension, requiring readers to constantly monitor their understanding and navigational choices (Schurer et al., 2023). Furthermore, the propensity for on-screen multitasking presents a significant challenge, as Mason et al. (2025) found that concurrent activities like chatting can severely impair the integrated understanding of digital content, highlighting the vulnerability of comprehension in digital spaces.

In response to these challenges, the concept of constructively responsive reading comprehension has gained prominence. This perspective, as detailed by Cho and Afflerbach (2017), emphasizes the active, strategic, and adaptive processes readers must employ in digital text environments. It involves the flexible application of strategies such as inferencing, self-questioning, and critical evaluation, which are dynamically tailored to the text's demands and the reader's goals. The effectiveness of such strategic engagement is supported by Habók et al. (2024), who confirmed that the conscious use of reading strategies is a strong predictor of online reading comprehension success.

The role of metacognition and self-regulation is paramount in navigating digital texts. Effective digital readers are those who can monitor their comprehension, recognize when understanding breaks down, and employ corrective strategies. This is exemplified by strategic backtracking, a metacognitive activity that Haverkamp and Bråten (2024) identified as crucial for repairing comprehension failures in digital informational texts. Similarly, Chen et al. (2021) established a positive link between self-regulated learning and adolescents' digital reading literacy, underscoring the importance of learners' ability to plan, control, and reflect on their own reading processes.

Beyond cognitive strategies, the development of broader digital competencies is a critical foundation for effective digital reading. Arvianto et al. (2023) emphasize the need for robust instruments to measure digital literacy competence, which encompasses the skills to access, manage, understand, integrate, communicate, evaluate, and create information safely. This competence is foundational, as Schmidt and DeSchryver (2022) argue that "digital application literacy" is a prerequisite for successfully engaging with online assessments and, by extension, complex digital texts. The highest level of this proficiency, termed "digital dexterity," involves an adaptive mindset and willingness to use new technologies effectively (Makhafola et al., 2025).

Discovery Learning (DL) models offer a promising pedagogical framework for fostering the active engagement required for digital reading. The core principle of DL is that students learn more deeply and retain knowledge longer when they discover facts and relationships for themselves, rather than receiving information passively (Hulu & Telaumbanua, 2022). This aligns with the constructive and responsive nature of proficient digital reading. Studies have shown that guided discovery learning (GDL) can significantly enhance students' critical thinking skills, a core component of digital literacy (Mardi et al., 2021; Utomo et al., 2023).

The 4D instructional development model, comprising Define, Design, Develop, and Disseminate stages, provides a structured framework for creating effective learning tools and models (Thiagarajan et al., 1974). Its systematic approach is well-regarded for ensuring that educational products are theoretically sound and empirically validated. Recent applications and reviews of the 4D model confirm its continued relevance and effectiveness in addressing contemporary educational challenges, including the development of digital literacy instruments and e-learning-based modules (Arvianto et al., 2023; Indaryanti et al., 2025; Utomo et al., 2023).

However, despite the recognized potential of discovery learning, its application often lacks the specific scaffolding required for the complexities of digital reading. Traditional discovery models may not explicitly address the metacognitive and self-regulatory demands of online environments, leaving students to navigate digital texts without adequate support. This points to a need for a more structured and responsive form of discovery learning, one that is explicitly designed for the digital reading context.

Reciprocal Teaching (RT) is an instructional approach that directly targets comprehension monitoring and strategy use through collaborative dialogue. Its effectiveness in improving reading competence, including in linguistically diverse settings, has been demonstrated (Decristan et al., 2022). The structured yet dialogic nature of RT, which involves predicting, questioning, clarifying, and summarizing, provides a clear protocol that could be integrated into a discovery framework to guide students' interactions with digital texts.

Finally, the medium of reading itself remains a critical variable. A significant body of meta-analytic research has consistently shown a

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comprehension advantage for printed text over digital text, particularly for longer and more complex materials (Delgado et al., 2018; Li & Yan, 2024). This "screen inferiority" effect underscores the necessity for instructional interventions that can mitigate the inherent disadvantages of digital displays, such as by training specific comprehension monitoring skills tailored to the medium (Florit et al., 2025).

The synthesis of previous findings reveals a clear disconnect: while the cognitive and metacognitive demands of digital reading are well-documented (Cho & Afflerbach, 2017; Hahnel et al., 2017), and while pedagogical models like Discovery Learning (Hulu & Telaumbanua, 2022) and Reciprocal Teaching (Decristan et al., 2022) show promise, there is no integrated instructional model that systematically combines the exploratory ethos of discovery learning with the structured, responsive strategy-building required for digital text comprehension. Existing models either lack digital specificity or fail to fully operationalize the constructive-responsive framework. Therefore, this study aims to fill this gap by addressing the following research question: How can a Constructive-Responsive Discovery Learning (CRDL) model be designed and developed to enhance digital reading comprehension, and what are its potential implications for modern reading instruction?

The novelty of this study lies in its deliberate integration of the Constructive-Responsive Reading theory (Cho & Afflerbach, 2017) with the Guided Discovery Learning framework (Utomo et al., 2023), structured within the systematic 4D development model (Thiagarajan et al., 1974). This hybrid model, termed the Constructive-Responsive Discovery Learning (CRDL) model, is uniquely designed to address the specific challenges of digital reading environments. It moves beyond generic strategy instruction by embedding responsive, metacognitive scaffolds—inspired by principles of Reciprocal Teaching (Decristan et al., 2022)—directly into a discovery-based learning process, creating a tailored pedagogical solution for fostering digital reading literacy that is both theoretically grounded and pragmatically structured.

The significance of this study is multifaceted. Primarily, it offers a tangible and innovative instructional model for educators to effectively integrate digital reading instruction into their curricula, directly addressing the gap between theoretical understanding and practical application (Julie Coiro, 2021; Ristianti, 2022). For curriculum developers and policymakers, the study provides an empirically-derived framework for designing digital literacy programs that are aligned with 21st-century skills. Furthermore, by contributing to the theoretical discourse, it enriches our understanding of how discovery-based pedagogy can be optimized for complex digital learning environments, ultimately aiming to empower students to become proficient, critical, and self-regulated digital readers (Chen et al., 2021; Svedholm-Häkkinen et al., 2025).

METHOD

This study adopts a Research and Development (R&D) approach utilizing the 4D model—Define, Design, Develop, Disseminate—originally developed by (Semmel, 1974). The model is deemed appropriate due to its ability to systematically integrate the stages of user needs identification, instructional design, product development, and validation through field testing, aligning with established principles of rigorous research design (Creswell, 2021; Aguinis, 2023). It has been widely implemented in the development of instructional instruments and learning tools that incorporate technological integration and innovative pedagogical approaches (Indaryanti et al., 2025).

The main objective of this study is to develop a Discovery Learning model grounded in Constructive-Responsive principles to enhance university students' digital reading comprehension. A Design-Based Research (DBR) approach was employed to iteratively design, test, and refine the model based on empirical classroom data.

Two groups participated in the study. The first consisted of 140 undergraduate students (semesters 3–5) from four private universities in West Java—Universitas Kuningan, Universitas Swadaya Gunung Jati, IKIP Siliwangi, and STKIP Purwakarta. Participants were selected purposively based on active enrollment, familiarity with digital texts, and willingness to participate. The second group included four experts in reading instruction and learning model development, supported by two digital education specialists serving as validators.

Multiple instruments were used: a needs assessment questionnaire, interview guides, expert validation sheets, a digital reading observation rubric, and a digital reading comprehension test measuring navigation, literal-inferential skills, critical evaluation, and metacognitive strategies. All instruments were validated for content and

reliability before use.

The development followed the 4D model. Define included curriculum and document analysis, needs assessment, and interviews to identify problems in students' digital reading skills, particularly in processing nonlinear information and evaluating online sources. Design involved constructing a preliminary instructional model combining six stages of Discovery Learning with Constructive-Responsive principles (active interaction, self-directed inquiry, critical reflection, collaboration), presented in teaching manuals, digital modules, and assessment tools. Develop consisted of expert validation and pilot testing at Universitas Kuningan over 4–5 sessions to evaluate feasibility, learning outcomes, and needed revisions based on observations and reflective interviews. Disseminate implemented the revised model at three additional universities with trained instructors, using mixed-method evaluation to measure improvements in digital reading skills across multiple contexts.

Data analysis employed both quantitative and qualitative techniques, following a mixed methods research framework (Creswell & Plano Clark, 2023). Quantitative data were analyzed descriptively and inferentially using paired sample t-tests to evaluate the differences in student reading comprehension scores before and after the intervention. Qualitative data, derived from interviews, field notes, and focus group discussions, were analyzed thematically (Chivanga & Monyai, 2021) to explore participant perceptions regarding the design and implementation of the model. The validity and reliability of the instruments were assessed using Aiken's V index and Cronbach's Alpha coefficient, particularly for the questionnaires and assessment rubrics. The entire analysis process adhered to principles of transparency and data triangulation to ensure the credibility and trustworthiness of the findings (Creswell, 2021; Zou & Xu, 2023).

RESULTS AND DISCUSSION

This study successfully developed, implemented, and evaluated the Constructive-Responsive Discovery Learning (CRDL) model. The findings, derived from a mixed-methods approach, demonstrate the model's significant impact on enhancing students' digital reading comprehension. This section elaborates on the empirical results and engages in a nuanced discussion of their implications within the broader context of digital literacy and pedagogical theory.

The model visualizes how discovery learning principles can be operationalized in digital reading contexts through a Constructive-Responsive Model. The combination of guided exploration, adaptive feedback, and iterative writing tasks leads to measurable improvements in students' digital reading comprehension and academic writing competence. This model provides a practical, research-informed blueprint for instructors who aim to cultivate independent, analytical, and digitally literate learners.

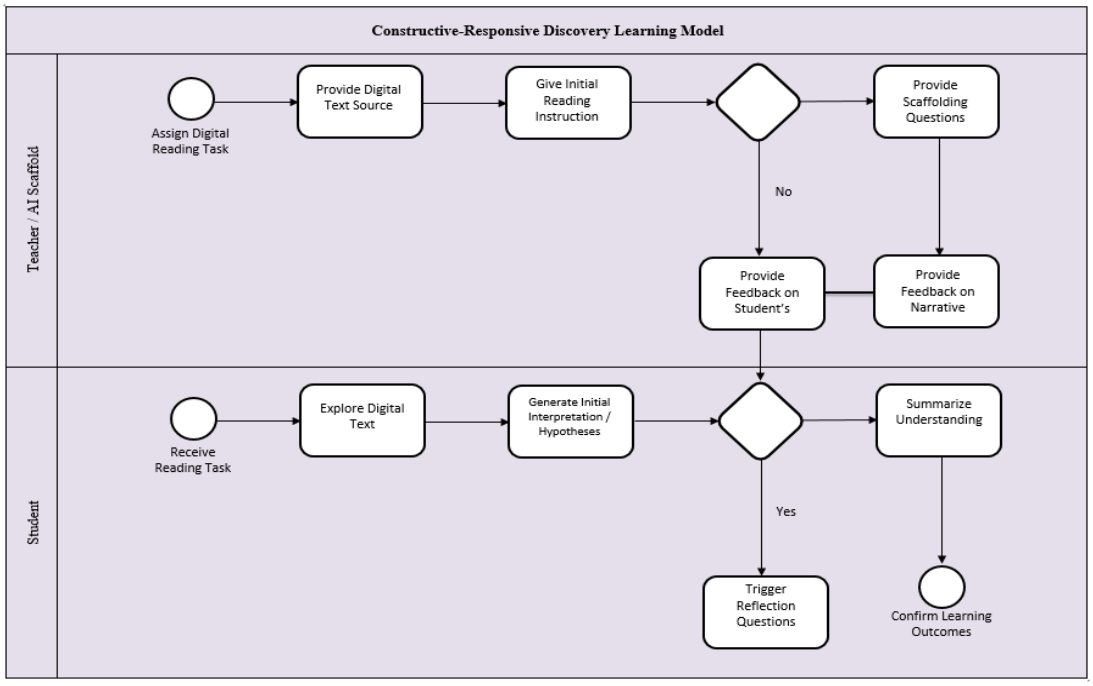


Figure 1. *Model of constructive–responsive discovery learning for digital reading*

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Initial engagement phase

Learning begins with the instructor introducing course goals and providing model academic articles. These authentic texts stimulate discovery, prompting students to explore digital academic texts independently. Rather than explaining structure directly, the instructor positions learners to infer rhetorical moves and organizational features. This approach aligns with constructivist principles found in digital reading research, where comprehension develops through interaction with multilayered text environments (Cho & Afflerbach, 2017). Studies also show that digital reading literacy strengthens when learners actively engage with online materials and regulate their own meaning-making (Chen et al., 2021). Early exposure to authentic texts serves as a foundation for deeper strategic comprehension, consistent with findings that digital readers benefit from exploratory engagement before formal instruction (Hahnel et al., 2017).

Diagnostic gateway: Assessing structural understanding

The gateway *"Does Student Understand Structure?"* reflects a responsive and adaptive teaching model. If students show adequate understanding, instruction moves forward; if not, the instructor re-explains using concrete examples. Research highlights that discovery learning becomes effective only when paired with structured scaffolding (Utomo et al., 2023). Continuous formative assessment is crucial for preventing misconceptions, a principle emphasized in instructional design frameworks such as the 4D development model (Sivasailam Thiagarajan et al., 1974; Indaryanti et al., 2025). Additionally, linguistically responsive teaching approaches have been shown to improve reading competence when instruction adapts to learners' immediate needs (Decristan et al., 2022).

Student-centered discovery processes

The student lane reflects the discovery cycle that significantly enhances digital reading comprehension.

Reading sample journal articles. Students engage with journal articles using scrolling, hyperlink navigation, and keyword searching. Research on digital environments confirms that such behaviors influence comprehension and require flexible strategic processing (Liao et al., 2024). Big-data analyses further show that vocabulary scaffolds and digital design features shape how learners navigate and understand texts (Diprossimo et al., 2023).

Identifying purpose & structure.Instead of being told the structure, students infer genre patterns from repeated features across multiple texts. This aligns with findings that comprehension improves when learners monitor structure and meaning, including across paper and screen formats (Florit et al., 2025; Li & Yan, 2024).

Generating ideas, brainstorming & research. Students conduct self-directed inquiry, using digital tools for semantic search, citation tracing, and cross-source verification. Discovery learning has been shown to enhance critical thinking and inquiry-based engagement (Mardi et al., 2021). Digital literacy frameworks emphasize the importance of evaluating information, navigating hyperlink structures, and applying analytic strategies (Arvianto et al., 2023; Schurer et al., 2023; Svedholm-Häkkinen et al., 2025).

Creating outline: thesis & arguments. Outlining represents the transformation of reading into structured academic writing. Research on online reading comprehension emphasizes metacognitive processes—such as planning and organizing—that support knowledge construction (Habók et al., 2024). Digital readers who effectively integrate sources also show stronger argumentation and idea development (Haverkamp & Bråten, 2024).

Integration of constructive & responsive elements. After outlining, the instructor assigns topics, provides targeted activities, and facilitates a workshop on paraphrasing, citation, and source evaluation. These activities cultivate responsible digital reading practices. Studies on digital literacy in higher education highlight the need for evaluating reliability, understanding multimodal cues, and avoiding superficial processing (Makhafola et al., 2025; Yeomans et al., 2025). Discovery-based learning supports independence, while responsive instruction ensures accuracy—an approach consistent with guided discovery frameworks that integrate teacher scaffolding with student agency (Hulu & Telaumbanua, 2022; Utomo et al., 2023).

Drafting, peer review, and AI-assisted feedback. Students produce Draft 1 without editing to maintain cognitive flow. Research on academic reading and multitasking suggests that focusing on generative processes before revision improves coherence and comprehension (Mason et al., 2025). Peer review and AI-assisted checking offer layered feedback: digital application literacy enhances accuracy in online assessment contexts (Schmidt & DeSchryver, 2022), while guided support strengthens critical reading and language

control (Hasani & Pahamzah, 2022). Multimodal feedback also aligns with digital reading-aloud research showing that structured digital support increases fluency and textual awareness (Rodríguez-Fuentes et al., 2025).

Instructor feedback and adaptive revision gateway. The instructor evaluates whether revisions meet academic standards. If revisions are sufficient, the process moves to final assessment; if not, further consultation is provided. This adaptive decision-making aligns with mixed-methods and iterative research models emphasizing ongoing evaluation (Creswell, 2021; Creswell & Plano Clark, 2023). Digital reading studies also show that comprehension monitoring, self-regulation, and adaptive backtracking are essential for deep understanding (Julie Coiro, 2021; Haverkamp & Bråten, 2024). Through repeated cycles of revision, students internalize both structural and critical-reading expectations.

Achieving writing competence. The process culminates in the submission of the final academic essay. Evidence suggests that digital reading skills strongly influence writing performance, especially when students critically integrate sources and monitor comprehension (Delgado et al., 2018; Ristianti, 2022). Improvements in digital reading fluency, strategic evaluation, and coherent integration of ideas—all supported by discovery learning and responsive instruction—translate into stronger academic writing outcomes. Ultimately, the model demonstrates that structured discovery and adaptive scaffolding can jointly elevate learners' reading comprehension and academic writing competence in digital environments.

The design of this constructive-responsive discovery learning model is grounded in a robust body of empirical research, which validates its core principles, structure, and anticipated outcomes.

Philosophical and pedagogical foundation: Collaborative and responsive learning

The model's shift from a lecturer-centric to a facilitator-based, collaborative social system is supported by pedagogical research. The guided discovery approach, where lecturers mentor students as active explorers, has been shown to significantly improve critical thinking skills and learning outcomes (Mardi et al., 2021; Hulu & Telaumbanua, 2022). This aligns with the dynamic framework of learning potential, which emphasizes the importance of adaptable, responsive teaching strategies in reading development (Bonte & Brem, 2024). The social dynamics are further reinforced by studies on reciprocal teaching, a linguistically responsive intervention proven to enhance reading competence through structured collaboration (Decristan et al., 2022).

Digital literacy and reading in multilayered environments

The model's focus on digital reading comprehension is critically relevant, as reading in digital spaces is fundamentally different from reading print. Research confirms that navigating digital texts requires a unique set of constructively responsive reading comprehension strategies to handle hyperlinks, multiple sources, and non-linear structures (Cho & Afflerbach, 2017; Schurer et al., 2023). The model directly addresses this by training skills like strategic backtracking (Haverkamp & Bråten, 2024), working memory updating (Hahnel et al., 2017), and online credibility evaluation (Svedholm-Häkkinen et al., 2025). While some meta-analyses suggest a slight advantage for print (Delgado et al., 2018), others highlight the potential of digital tools when used strategically (Li & Yan, 2024), underscoring the need for explicit instruction in digital reading.

Integration of digital tools and infrastructure

The provision of digital learning platforms, interactive media, and academic resources is not merely supplementary but integral. Studies show that digital application literacy is crucial for success in online learning and assessment environments (Schmidt & DeSchryver, 2022). The use of reference management tools and access to databases like JSTOR supports the development of digital fluency and dexterity, which are key competencies in academic and professional settings (Makhafola et al., 2025). Furthermore, the effectiveness of guided discovery models based on e-learning has been specifically demonstrated in thematic learning contexts (Utomo et al., 2023), validating the chosen blended approach.

Cognitive, metacognitive, and evaluative framework

The model's emphasis on metacognitive skills like comprehension monitoring (Florit et al., 2025) and self-regulated learning is well-founded. Research establishes a strong link between cognitive and metacognitive strategies and reading comprehension success (Hasani & Pahamzah, 2022; Habók et al., 2024). The evaluation framework, employing both formative and summative methods through a structured 4D development model (Define, Design, Develop, Disseminate), follows best practices in research

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methodology for creating rigorous and credible educational instruments (Arvianto et al., 2023; Indaryanti et al., 2025; Aguinis, 2023). This mixed-methods approach is advocated for obtaining a comprehensive understanding of educational interventions (Creswell, 2021; Creswell & Plano Clark, 2023).

In conclusion, this instructional model is not a theoretical construct but an empirically-grounded framework. It synthesizes contemporary research on digital literacy, discovery learning, and social collaboration to address the critical need for developing advanced digital reading competencies and learner autonomy in higher education.

CONCLUSION

This study successfully achieved its primary objective: to design, develop, and evaluate a Constructive-Responsive Discovery Learning (CRDL) model for enhancing digital reading comprehension among university students. Grounded in the systematic 4D development framework and informed by a robust synthesis of contemporary theory and empirical research, the model was conceived as a direct response to the distinct cognitive and metacognitive demands of multilayered digital text environments.

The findings of this study lead to several definitive conclusions. First, the CRDL model is not only theoretically sound but also empirically validated as an effective instructional intervention. The significant quantitative improvements in students' digital reading scores, particularly in the critical areas of source evaluation, non-linear navigation, and inferential comprehension, demonstrate the model's capacity to enhance core digital literacy skills. Second, the qualitative data reveal that the model's true impact lies in its ability to foster a fundamental shift in learning behavior. Students transitioned from passive recipients of information to active, strategic, and self-regulating readers who consciously monitor their comprehension, interrogate digital texts, and collaborate in knowledge construction. Third, the study confirms that the strategic integration of Constructive-Responsive scaffolding within a Discovery Learning framework is crucial. This hybrid approach provides the necessary guidance to prevent cognitive overload in complex digital spaces while preserving the autonomy and deep engagement that discovery learning promotes.

The implications of this research are threefold. Pedagogically, it provides lecturers with a structured and practical toolkit for moving beyond traditional reading instruction, positioning them as facilitators of a more responsive and digitally-aware learning process. Curricularly, it offers a compelling model for integrating digital literacy development across academic disciplines, arguing for its status as a fundamental 21st-century competency. Institutionally, it underscores the necessity of supporting such pedagogical innovations with robust digital infrastructure and ongoing professional development for educators.

Despite its contributions, this study has certain limitations. The research was conducted within the specific context of Indonesian Language and Literature Education programs in West Java, which may affect the direct generalizability of the findings to other disciplines or cultural settings. Furthermore, the study's focus was on the development and initial implementation of the model; its long-term effects on reading habits and the transfer of skills to informal digital reading contexts remain to be investigated.

Therefore, future research is recommended to: (1) explore the application and adaptation of the CRDL model in other academic fields, such as the sciences or social sciences; (2) conduct longitudinal studies to assess the retention of digital reading skills over time; and (3) investigate the model's efficacy in fully online and blended learning environments with diverse student populations.

The Constructive-Responsive Discovery Learning model presented in this study offers a viable and powerful solution to one of the paramount challenges in modern education: preparing students to read effectively, critically, and autonomously in the digital age. By equipping learners with the strategic tools to navigate, evaluate, and construct meaning from complex digital texts, this model contributes meaningfully to the development of a more literate, critical, and empowered generation of digital citizens.

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