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Needs analysis of digital learning media using microlearning and visual signaling SPLDV

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ABSTRACT
Autonomous learning on Two-Variable Linear Equation Systems (Sistem Persamaan Linear Dua Variabel/SPLDV) is still hampered by conceptual difficulties. At the same time, available digital media have not been designed based on students' empirical needs. This study aims to identify students' needs for microlearning-based digital learning media with visual signaling on the SLSDV material, as part of the Analyze stage in the research and development (RnD) framework. This study used a descriptive quantitative-qualitative approach, involving 32 eighth-grade students selected through purposive sampling and two mathematics teachers from a junior high school in Malang Regency. The study collected data through a needs questionnaire and semi-structured interviews. The results showed that most students (87.5%) found it easier to understand the material when it was presented step by step per sub-topic, 75% were helped by visuals such as pictures and diagrams, and 56.3% still had difficulty distinguishing SPLDV solution methods. Students also strongly preferred short videos (2-5 minutes) and reflective pauses after each section. These findings indicate a clear need for learning media that breaks material into micro-units and includes visual markers. This need aligns with recent meta-analytic evidence on cognitive load management and signaling principles in multimedia learning. Thus, this analysis provides a strong empirical foundation for the design phase of developing more effective SPLDV learning media.

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ABSTRACT
Pembelajaran mandiri pada materi Sistem Persamaan Linear Dua Variabel (SPLDV) masih terkendala oleh kesulitan konseptual, sementara media digital yang tersedia belum banyak dirancang berdasarkan kebutuhan empiris siswa. Penelitian ini bertujuan untuk mengidentifikasi kebutuhan siswa terhadap media pembelajaran digital berbasis microlearning yang disertai visual signaling pada materi SPLDV, sebagai bagian dari tahap Analyze dalam kerangka penelitian dan pengembangan (RnD). Penelitian ini menggunakan pendekatan deskriptif kuantitatif-kualitatif, melibatkan 32 siswa kelas VIII yang dipilih melalui purposive sampling serta dua guru matematika dari sebuah SMP di Kabupaten Malang. Data dikumpulkan melalui angket kebutuhan dan wawancara semi-terstruktur. Hasil menunjukkan bahwa sebagian besar siswa (87,5%) lebih mudah memahami materi bila disajikan secara bertahap per sub-topik, 75% terbantu oleh visual seperti gambar dan diagram, dan 56,3% masih kesulitan membedakan metode penyelesaian SPLDV. Siswa juga menunjukkan preferensi tinggi terhadap video singkat (berdurasi 2-5 menit) serta jeda reflektif setelah setiap bagian materi. Temuan ini menunjukkan kebutuhan nyata akan media pembelajaran yang membagi materi ke dalam unit-unit mikro dan menyertakan penanda visual. Kebutuhan ini sejalan dengan bukti meta-analitik terkini mengenai pengelolaan beban kognitif dan prinsip signaling dalam pembelajaran multimedia. Dengan demikian, hasil analisis ini memberikan landasan empiris yang kuat bagi tahap design dalam pengembangan media pembelajaran SPLDV yang lebih efektif.

Keywords: *media pembelajaran digital; microlearning; SPLDV; visual signaling*

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INTRODUCTION

The Two-Variable Linear Equation System (Sistem Persamaan Linear Dua Variabel/SPLDV) is a mathematics material for grade VIII of junior high school that requires students to understand the relationships between variables simultaneously, translate contextual situations into mathematical models, and choose the right solution strategy among graphing, substitution, elimination, and combination methods (Nuraeniah et al., 2022). Researchers have consistently reported difficulties at these stages in both Indonesian and international contexts, with even prospective mathematics teachers showing weak conceptual understanding when solving systems of linear equations. The difficulty is cross-level rather than confined to junior high school maturity (Dewi, 2021). Two design strategies have shown promise in addressing these difficulties.

Material segmentation remains a core strategy for managing cognitive load in contemporary instructional design, and visual signaling consistently improves learning outcomes in complex multimedia material, with a moderate effect across 29 experimental studies and 2,726 participants (Alpizar et al., 2020; Paas & van Merriënboer, 2020). These findings are reinforced by a meta-analysis of Richard Mayer's multimedia learning research corpus, which confirmed signaling as one of the design principles with the most consistent supporting evidence, including for STEM-based materials (Cromley & Chen, 2025). Microlearning strategies that present material in small units show similar effectiveness; a systematic review of microlearning in basic education found consistent gains in motivation, performance, and retention (Astiwardhani & Sobandi, 2024).

A systematic review of 136 journal articles found that researchers have empirically tested signaling across a variety of learning environments, including video-based math materials. However, it remains limited in virtual and augmented reality contexts (Çeken & Taşkın, 2022). Together, these findings support combining microlearning and signaling as a design solution for abstract mathematics material such as SPLDV. Although these two lines of research have conceptualized difficulties in SPLDV and the effectiveness of microlearning/signaling separately, few studies explicitly explore junior high school students' needs for combining both as a basis for media design. Prior research applying the ADDIE model to mathematics education shows both the model's popularity in this domain and a recurring gap in how thoroughly researchers treat the Analyze stage.

Research on ADDIE-based mathematics learning media generally introduces the needs analysis stage briefly, without detailing independent learning habits, specific conceptual difficulties, or students' preferences for microlearning-signaling formats (Spatioti et al., 2022). Developed articulate storyline-based mathematics media for eighth-grade students. However, they moved directly from the ADDIE framework to instrument design without detailing the Analyze stage, mirroring the development of statistics learning media, where Analyze received little elaboration relative to the validity and practicality testing that followed (Masrifah et al., 2023).

However, the Analyze stage is crucial to ensuring that design decisions rest on empirical data rather than developer assumptions. Based on this gap, this study aims to describe junior high school students' needs for microlearning-based digital learning media and visual

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signaling in SPLDV materials to inform the Design stage of future development research. The results of this needs analysis are expected to provide a solid empirical foundation for developing media that is not only technologically engaging but also aligned with how students cognitively process complex mathematical material.

LITERATURE REVIEW

This literature review links four domains: students' conceptual difficulties in SPLDV as the empirical problem. Cognitive Load Theory (CLT) as the framework explaining its cognitive roots; microlearning and visual signaling as design strategies that may address it, and needs analysis within the ADDIE framework as the methodological approach that ensures media design rests on empirical data rather than developer assumptions.

Students' Conceptual Difficulties in SPLDV Materials: A Cognitive Perspective

SPLDV asks Grade VIII students to hold several competencies at once: reading relationships between variables, translating context into a mathematical model, and choosing among graphing, substitution, elimination, and combination methods. Students struggled with story problems and felt uncomfortable modeling them mathematically (Utami et al., 2023). Among 15 students, the weakest indicator was concluding graphs (roughly a quarter), followed by analyzing SPLDV solutions (54%) (Nuraeniah et al., 2022).

More recent data reinforce this, with average comprehension on SPLDV story problems reaching only 48% and "*omitted conclusion*" errors dominating at 49.4%, suggesting students' shortfalls lie not only in calculation but in integrating information into a coherent mental representation (Rizal et al., 2021). The problem is not confined to junior high school: in a qualitative study of three prospective teachers, some relied on memorized procedures rather than conceptual understanding (Rizal et al., 2021). This suggests the difficulty persists across levels, rooted in the limits of working memory, which can hold only a handful of elements at a time (Paas & van Merriënboer, 2020). CLT provides a framework for explaining why this load overwhelms novice learners (Sweller et al., 2019).

Cognitive Load Theory: A Theoretical Framework for Understanding the Difficulties of Learning Mathematics

Cognitive Load Theory (CLT) rests on the premise that working memory is severely limited, holding roughly five to nine elements for no more than 20 seconds before consolidation into a schema, in contrast to the relatively unlimited capacity of long-term memory (Paas & van Merriënboer, 2020). SPLDV simultaneously demands verbal, symbolic, and procedural processing (Utami et al., 2023). CLT distinguishes three types of load: intrinsic load from the material's inherent complexity, as when SPLDV requires grasping variable relationships, translating context, and selecting a method all at once; extraneous load from suboptimal design, as when SPLDV instruction separates story problems, formulas, and worked solutions into disconnected sections; and germane load, the capacity devoted to schema formation.

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Because intrinsic and extraneous loads are additive, effective design minimizes extraneous load. Hence, capacity remains for germane processing, the basis for the two strategies this study pursues: microlearning, which reduces intrinsic load by breaking material into small units, and visual signaling, which reduces extraneous load by directing attention to essential information, together preventing students from being overwhelmed by volume or losing track of what matters (Ariadi et al., 2024). Most research applying these strategies has been conducted in traditional settings rather than complex digital environments, a gap this study addresses (Astiwardhani & Sobandi, 2024).

Microlearning: Material Segmentation as a Cognitive Load Management Strategy

Microlearning delivers content in short, focused units, typically 3 to 15 minutes long, each centered on a single learning objective and framed for the digital age as small, digestible chunks that strengthen understanding, retention, and motivation (Banister et al., 2020). It serves as a segmentation strategy that addresses working memory limits by breaking complex material into gradually processable pieces: one unit for understanding variables, the next for modeling, and the next for solution methods, allowing students to master each concept before advancing. A meta-meta-analysis of 29 reviews spanning nearly 1,200 studies identified segmentation as one of the most robust, consistent design principles for learning, with stronger effects for complex material and settings, including video-based mathematics instruction (Ciptagustia et al., 2026). The characteristic most relevant to SPLDV is microlearning's ability to deliver staged content that matches students' attention spans: short, video-based microlearning measurably increases engagement, with preferred durations of 2-5 minutes, and is significantly more effective than conventional instruction across domains. Segmentation alone, however, is not sufficient, since dividing material into small units still leaves students needing support to identify what matters most within each one, a role visual signaling plays as a complementary strategy (Alpizar et al., 2020).

Visual Signaling: Directing Attention to Reduce Extraneous Load. The principle of

The signaling (or cueing) principle refers to visual markers, such as highlights, arrows, or color, that direct learners' attention to essential information within complex material (Alpizar et al., 2020). In CLT, it reduces extraneous load by removing the need for learners to independently identify which elements matter most, which is particularly relevant to SPLDV's combined verbal, symbolic, and procedural presentations. A meta-analysis of 29 experimental studies found that signaling consistently improved outcomes, with stronger effects on transfer and inferential outcomes than on factual recall (Çeken & Taşkın, 2022).

This disproportionately benefits low-prior-knowledge learners, who lack the schemas to identify important information unaided. This distinction matters for SPLDV, where junior high school students typically encounter linear equation systems for the first time. In mathematics learning, signaling can mark critical steps, such as a subtraction operation in the elimination method, or color-code coefficients, variables, and constants to clarify an equation's structure, consistent with Indonesian findings that visual representation supports mathematical understanding more broadly. However, research combining signaling with microlearning

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specifically for SPLDV remains scarce, a gap this study addresses (Kurniawati & Juandi, 2023).

Needs Analysis in the ADDIE Framework: Empirical Foundations for Media Design

Needs analysis is the first stage of the ADDIE framework, ensuring later design decisions rest on empirical data rather than developer assumptions (Rosyanto et al., 2025). For mathematics-learning media specifically, a thorough needs analysis identifies students' conceptual difficulties in the targeted material, maps their independent-learning habits, and determines format preferences suited to their cognitive characteristics, without this, media design risks missing the root causes of learning difficulties (Rizal et al., 2021). Most ADDIE-based mathematics-media research, however, treats needs analysis briefly as an introductory step, without detailing students' learning profiles, specific conceptual difficulties, or their preferences for microlearning-signaling formats, even though the depth of needs analysis strongly determines the quality of subsequent design decisions. A design principle's effect depends on context: learner characteristics, material type, and intended outcome (Tu et al., 2021).

METHODS

This study occupies the Analyze stage of a research and development (R&D) process structured around the ADDIE model, prioritized as the sole focus because the later phases, Design, Development, Implementation, and Evaluation, depend on the empirical needs data this stage produces. A quantitative descriptive design, supported by qualitative data, describes students' needs for microlearning-based, visually signaled SPLDV media while capturing the reasoning behind reported preferences and difficulties; because the study had not yet developed the media, it did not test product effectiveness.

The junior high school had three grade VIII classes. The researcher first interviewed two mathematics teachers to confirm all three classes had completed the SPLDV unit and to understand students' general characteristics. Each class teacher then announced the study and invited voluntary participation. 32 students agreed and completed the questionnaire, a process consistent with purposive sampling, in which participants are selected for their fit with study-relevant criteria rather than randomly assigned. Restricting participation to students who had already studied SPLDV ensured responses reflected authentic, firsthand difficulties. The same two teachers were interviewed as a supporting data source for triangulation, verifying and enriching the questionnaire findings.

The primary instrument was a needs questionnaire that adapted theoretical constructs from the literature review, cognitive load theory, the segmenting effect, and the signaling principle, into measurable, SPLDV-specific items rather than adopting an existing instrument wholesale. Its five categories were likewise adapted from the ADDIE Analyze-stage dimensions: (A) independent-study habits; (B) metacognitive strategies; (C) conceptual difficulties in SPLDV material; (D) media-format preferences; and (E) self-efficacy, using a five-point Likert scale to quantify attitudes and perceptions. Semi-structured interview guidelines, adapted from the same constructs, complemented the questionnaire to probe the reasoning behind students' responses. Semi-structured interview guidelines, adapted from

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the same theoretical constructs, complemented the questionnaire to probe the reasoning behind students' reported preferences and difficulties.

Data collection proceeded in three stages: 1) The questionnaire was administered to all 32 students in the classroom; 2) Semi-structured interviews followed with students showing extreme scores on conceptual-difficulty or media-preference items; and 3) The two teachers were interviewed last for an educator's perspective. All interviews were audio-recorded and transcribed. Quantitative data were analyzed descriptively through frequency and percentage, presented in tables, since the study aimed to describe distributions rather than test relationships between variables; qualitative data were analyzed thematically following a six-phase procedure: familiarization, coding, theming, review, naming, and reporting—chosen to weave student and teacher perspectives into one coherent narrative that deepened interpretation of the quantitative results.

RESULTS AND DISCUSSION

This section presents the findings of the needs analysis conducted at the Analyze stage within the ADDIE framework, drawn from a needs questionnaire completed by 32 eighth-grade students and semi-structured interviews with two mathematics teachers at a junior high school in Malang Regency. Findings are organized into five categories: (A) independent learning habits; (B) metacognitive strategies; (C) conceptual difficulties in SPLDV material; (D) media-format preferences; and (E) self-efficacy. Theoretical interpretation and comparison with prior research follow in the Discussion section below.

Students' Independent Learning Habits (Category A)

Table 1 shows that digital-device access is nearly universal (90%), self-study sessions cluster in the 30-60-minute range (56.3%), and students prefer visual, independent formats such as videos (40.6%) over social or discussion-based ones (0%).

Table 1. Students' Independent Learning Habits (Category A, n=32)

No.	Questions	Answer Options	f	%
1	A1. Frequency of Mathematics learning outside school hours	Never/Rarely/Sometimes/Often/ Very Often	0 / 3 / 12 / 13 / 4	0% / 9,4% / 37,5% / 40,6% / 12,5%
2	A2. Duration of independent study per session	<30 minutes / 30-60 minutes / 1-2 hours / >2 hours / Never	6 / 18 / 8 / 0 / 0	18,8% / 56,3% / 25% / 0% / 0%
3	A3. Favorite self-study methods	Reading books / Practice questions / Videos-YouTube / Online discussions	11 / 8 / 13 / 0	34,4% / 25% / 40,6% / 0%
4	A4. Availability of digital devices at home	Always available / Sometimes unusable / Sometimes available / Not available	29 / 3 / 0 / 0	90% / 9,4% / 0% / 0%

Source: Research 2026

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Digital-device access is thus nearly universal among respondents, while self-study sessions cluster in the 30-60-minute range and lean heavily toward visual, independent formats over social or discussion-based ones.

Metacognitive Strategies in Learning (Category B)

Table 2 shows a gap between students' awareness-based habits, such as repeating unclear material (75%) and note-taking (78.2%), and their regulation-based habits, such as pausing when material is difficult (only 6.3% always do) and checking comprehension after a topic (53.2%), which are comparatively less consistent.

Table 2. Students' Metacognitive Strategies in Learning (Category B, n=32)

No.	Questions	Never	Rare	Sometimes	Frequent	Always
1	B1. Repeating the part that is not understood	3,1%	0%	21,9%	43,8%	31,3%
2	B2. Make notes of key points	0%	15,6%	6,3%	31,3%	46,9%
3	B3. Check your understanding after a topic	3,1%	18,8%	25%	34,4%	18,8%
4	B4. Continue learning without a break even if it is difficult	15,6%	15,6%	34,4%	28,1%	6,3%

Source: Research 2026

This pattern points to a gap between students' awareness-based habits (repeating, note-taking) and their regulation-based habits (pausing, checking comprehension), which are comparatively less consistent.

Conceptual Difficulties in SPLDV Material (Category C)

Table 3 shows that students find staged, visual presentation easiest (C2, 87.5%; C5, 75%), while they struggle most to distinguish solution methods (C6, 56.3%) and link equations to real-world context (C3, 50.1%).

Table 3. Students' Perception of SPLDV Conceptual Difficulties (Category C, n=32)

No.	Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1	C1. Overwhelmed by understanding formulas, tables, and explanations together	9,4%	15,6%	46,9%	21,9%	6,3%
2	C2. It is easier to understand the material when presented in stages	0%	3,1%	9,4%	28,1%	59,4%
3	C3. Confused about connecting mathematical equations and story problems	3,1%	18,8%	28,1%	43,8%	6,3%

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No.	Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
4	C4. Does not capture key points due to fast/dense serving	3,1%	25%	34,4%	15,6%	21,9%
5	C5.Pictorial/diagrammatic explanations are easier to understand	0%	6,3%	34,4%	40,6%	34,4%
6	C6. Difficult to distinguish the substitution/elimination/combination method	3,1%	28,1%	12,5%	37,5%	18,8%

Source: Research 2026

Students thus report the greatest ease with staged, visual presentation of material. In contrast, they have the greatest difficulty distinguishing between solution methods and linking equations to their real-world context, the two areas where scores clustered most toward "disagree" or "neutral" responses.

Microlearning and Visual Signaling Format Preferences (Category D)

Table 4 shows preferences clustering around presentation format: material in small sections (D1, 87.5%), reflective pauses (D2, 78.2%), and short 2-5-minute videos (D4, 71.9%), while QR codes for supplementary content (D3) draw a more mixed response, with over a third of students neutral.

Table 4. Students' Preferences for Learning Media Formats (Category D, n=32)

No.	Statement	Very Much Dislike	Dislike	Neutral	Like	Very Like
1	D1. Material is presented in small sections per sub-topic	0%	6,3%	6,3%	46,9%	40,6%
2	D2. Pauses and reflective questions after each section	0%	3,1%	18,8%	43,8%	34,4%
3	D3. QR code to additional videos/exercises	0%	3,1%	34,4%	46,9%	15,6%
4	D4. Short video (2- 5 minutes) with step-by-step	0%	0%	28,1%	50%	21,9%

Source: Research 2026

Overall, preferences cluster most strongly around presentation format (segmentation, short video, reflective pause). At the same time, the access mechanism for supplementary content (QR codes) draws a more mixed response, with over a third of students neither favoring nor opposing it.

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Self-Efficacy in Learning Mathematics (Category E)

Table 5 shows confidence concentrated in visually and conceptually guided tasks (E1, E2, both 78.2%), alongside a sharp drop in confidence for independent problem-solving (E3, 43.7%).

Table 5. Students' Self-Efficacy in Learning Mathematics (Category E, n=32)

No	Item	Very Unsure	Not Sure	Neutral	Confident	Very Confident
1	E1. Confident in understanding concepts when explained visually/real-life examples	0%	3,1%	18,8%	34,4%	43,8%
2	E2. Confident in working on problems based on concept understanding	0%	3,1%	18,8%	34,4%	43,8%
3	E3. Confident in being able to overcome learning difficulties independently	0%	21,9%	34,4%	28,1%	15,6%
4	E4. Anxious to work on problems based on deep concept understanding	0%	3,1%	65%	18,8%	12,5%

Source: Research 2026

Across Category E, confidence is concentrated in visually or conceptually guided tasks, with comparatively lower confidence in unaided, independent problem-solving (E3, 43.7%), a gap that stands out against the otherwise consistent 78.2% confidence reported for E1 and E2.

Discussion

This needs analysis reveals three key patterns consistent across all five categories: the need for material segmentation, visual markers, and structured reflective pauses. These patterns are not simply students' aesthetic preferences but reflect how their cognitive processes handle complex SPLDV material. The sub-sections below interpret these patterns against relevant theory and prior research, highlighting where the present findings converge with, extend, or diverge from existing evidence.

Segmentation of Material as a Cognitive Need, Not an Aesthetic Preference

87.5% of students said staged material was easier to follow (C2). An equal proportion preferred small per-sub-topic sections (D1), giving direct empirical weight to segmentation as a design principle for SPLDV media, consistent with segmented instructional videos producing significantly lower cognitive load than non-segmented formats (Zheng et al., 2022). These results add evidence at a specific intersection of grade level and format: students preferred short 2-5-minute segments (D4, 71.9%). These segments are considerably shorter than the units and worked well for secondary-school mathematics

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lectures, suggesting that optimal segment length depends on a topic's cognitive demands rather than remaining fixed. SPLDV requires students to coordinate variable relationships and engage in contextual modeling (Sweller et al., 2019). Method selection may simultaneously narrow the attention window they can sustain, compared with more linear content. This is reinforced by students' preferred self-study length of 30-60 minutes (A2, 56.3%), which maps naturally onto a sequence of several 2-5-minute units. Segmentation for SPLDV media is therefore not a stylistic choice but a direct response to a measurable mismatch between students' attention capacity and the demands of unsegmented instruction (Pratiwi & Fajri, 2025; Utami et al., 2023).

Visual Markers as a Bridge between Visual Preferences and Cognitive Demands

Three-quarters of students said pictorial or diagrammatic explanations were easier than text alone (C5), and 78.2% felt confident understanding concepts explained visually (E1), evidence that visual signaling functions as more than a stylistic preference, consistent with its moderate, well-supported effect on learning, particularly for STEM material. A meta-analysis found a consistent, moderate effect for signaling ($d = 0.38$) (Alpizar et al., 2020). This matters even at the level of individual symbols: spatially clustering algebraic terms by order of operations significantly improves problem-solving performance, suggesting that the notation's perceptual structure, not just surrounding explanation, shapes how students parse a problem (Harrison et al., 2020). Eye-tracking research, however, offers a counterpoint, finding only limited gains in reasoning or accuracy among students who already concentrated well unaided.

SPLDV students here report a different struggle: not sustaining attention, but distinguishing solution methods (C6, 56.3%) and connecting equations to real-world referents (C3, 50.1%), difficulties closer to a process-articulation gap than to inattention (Kaitera & Harmoinen, 2022). Visual signaling in SPLDV media therefore likely needs to do more than direct gaze, combining text-picture clarification with structural cues at multiple levels, color-coding across solution methods, and spatial grouping within the equations themselves. A further gap reinforces this need: self-efficacy was high for visual tasks (E1, 78.2%) but markedly lower for independent problem-solving (E3, 43.7%), which the expertise reversal principle explains signaling disproportionately benefits novice learners who lack the schemas to locate essential information unaided (Çeken & Taşkın, 2022), fitting students encountering SPLDV for the first time and suggesting why null results observed among more experienced problem-solvers elsewhere may not generalize here (Magnone & Yezierski, 2024).

Structured Reflective Pause as an External Facilitation for Cognitive Regulation

A paradox emerges in the data: 68.8% of students said they sometimes or often keep working without a break even when material feels difficult (B4), yet 78.2% preferred reflective pauses once these were explicitly offered as a feature (D2), not a preference gap, since students clearly value pausing, but a self-regulation gap, in which they do not reliably act on that value unprompted. We found a related pattern in emergency remote education during COVID-19, where unmanaged cognitive load correlated with lower self-perceived learning outcomes because learners had to manage load on their own rather than through

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instructional design. The present data extend this to a much younger, face-to-face-adjacent population, suggesting a broader limitation in how adolescent learners manage cognitive load without explicit structure, one a well-designed SPLDV medium can directly address. Practically, this means building reflective pauses into each unit's structure rather than leaving them up to learners to remember (Tzafilkou et al., 2022). A short comprehension check at a fixed point removes the need for students to initiate the pause themselves, a necessary correction given how consistently students here undervalued their own tendency to skip breaks (B4) relative to how much they wanted them once offered (D2) (de Bruin et al., 2025).

Theoretical Implications: Integration of Microlearning and Signaling in the CLT Framework

These findings extend theoretical understanding of segmentation and signaling by surfacing a context- and material-type-dependent boundary condition. Research found engagement in a higher-education computer-games course peaked around 6-9-minute segments, nearly double the 2-5-minute preference SPLDV students reported here, suggesting the two principles are not fixed design constants transferable uniformly across learner age or task complexity, but sensitive to a topic's cognitive demands and to learners' developmental stage (McKee & Ntokos, 2022). For SPLDV, where students must coordinate variable relationships, contextual translation, and method selection simultaneously, shorter units paired with structural visual markers may be necessary to keep intrinsic load manageable in a way that longer-format microlearning, adequate for less demanding or more mature populations, would not require (Husnah et al., 2025; Prasittichok & Smithsarakarn, 2024). This carries a direct methodological implication: designers cannot adopt segmentation and signaling parameters wholesale from studies at different educational levels, since the depth of the Analyze stage determines whether design decisions rest on evidence relevant to the actual population or on parameters borrowed from unrelated contexts (Spatioti et al., 2022). The present needs analysis therefore functions not merely as a data-gathering exercise but as the mechanism by which students empirically derive context-appropriate parameters for SPLDV media rather than assume them.

Practical Implications: Design Decisions for the Design Stage

Students' comparatively lower and more ambivalent preference for QR codes (D3, 62.5% like strongly like, with 34.4% neutral) is consistent with the observation that digital-content success depends less on a technology's availability than on how well its access mechanism fits learners' habitual study approach (Ariadi et al., 2024). A review of QR-code integration in classrooms found that successful implementation depends heavily on students' prior familiarity with scanning and on reliable device access conditions that cannot be assumed uniformly across a junior-high classroom, and a scanning step that interrupts a student's flow may not match how learners prefer to move through material (Leshchenko et al., 2022). This aligns with findings from developing a smartphone-supported learning application: designing an access mechanism students would use consistently required in-depth analysis of learners' context and habits, not merely their content needs (Rizal et al., 2021).

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SPLDV media should therefore avoid relying on QR codes as the sole gateway to supplementary content, integrating such material directly into the primary instructional flow so working-memory capacity is directed toward SPLDV content rather than navigating access barriers. This study has two main limitations. First, it covers only the Analyze stage of the ADDIE framework, a deliberate choice shaped by time constraints that did not allow for the additional data collection, product development, and iterative testing later phases require; the aim was in-depth needs mapping as a foundation for future development. Second, participants were limited to 32 students from a single school in Malang City, sufficient for descriptive and thematic analysis, but intended to provide an empirical basis for this specific context rather than broader generalization.

CONCLUSION

Analysis of responses from 32 grade VIII students and interviews with two mathematics teachers points to three recurring needs: short, segmented micro-units rather than continuous blocks, reflecting the mismatch between students' working-memory capacity and the material's demand for simultaneous processing of variables, models, and solution methods; visual markers that help distinguish solution methods, connect equations to real-world context, and identify essential information, a response to specific conceptual difficulties rather than a stylistic preference; and reflective pauses built into the material's structure, since students do not reliably create such pauses on their own even when they recognize their value. Together, these needs establish, empirically rather than by developer assumption, the design parameters: segment duration, the placement of visual markers, and structured reflective pauses that should guide the Design stage of SPLDV media development within the ADDIE framework. Further research is recommended to develop SPLDV media informed by this needs analysis and test its effectiveness on conceptual understanding and retention, extend data collection to schools with more varied characteristics to examine how far these needs generalize, and investigate whether the same parameters hold for other mathematics topics with different cognitive demands.

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