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Microlearning in K–12 Education: A Systematic Review of Cognitive Outcomes, Metacognitive Assessment, and Self-Regulated Learning

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Abstract: Microlearning organizes instruction into brief, focused units, but evidence in K–12 education remains uneven, particularly for metacognitive outcomes. This systematic review synthesizes how microlearning has been implemented and what cognitive, metacognitive, and self-regulated learning (SRL) outcomes have been reported among K–12 students. Searches used 73 documented queries across web-mediated scholarly discovery linked to publisher or DOI records, ERIC, DOAJ, GARUDA, national journals, and citation chaining for publications from 2021 to 2026. Eleven empirical studies met the inclusion criteria. We conducted a narrative synthesis and appraised methodological quality using the 2018 Mixed Methods Appraisal Tool. The studies varied in format, design, measures, and reporting. Eight reported findings supportive of cognitive outcomes, while one reported mixed findings, one was descriptive, and one was uncertain; only two studies used comparison groups, whereas six used one-group pretest–posttest designs. One study measured SRL using a questionnaire, and none directly assessed metacognitive knowledge or regulation. The findings suggest potential support for cognitive outcomes but do not establish general effectiveness across K–12 settings. Evidence of metacognitive improvement remains insufficient. Stronger comparative designs and direct, process-sensitive measures are needed.

Keywords: Cognitive Outcomes; Microlearning; K–12 Education; Metacognition; Self-Regulated Learning.

Introduction

Digital learning has broadened how K–12 instructional materials are delivered and revisited, increasing the need to align content and pacing with students' learning needs and opportunities for self-regulation (Toomla et al., 2026; Zhidkikh et al., 2023; Haliem et al., 2026; Xu et al., 2023). Microlearning organizes instruction into small, focused units; school-based examples include short science units and modular combinations of text, video, infographics, and quizzes (Marlina et al., 2026; Munawarah, 2025). However, evidence in primary and secondary education remains less extensive than in higher education and professional training, and studies differ in definitions, formats, durations, and measured outcomes. Its potential should therefore be interpreted in light of each study's design and context (Silva et al., 2025; Alias & Razak, 2023; Monib et al., 2025).

For this review, microlearning is an instructional approach that organizes brief, focused, structured units around specific learning objectives; this operational definition is used because the literature has no single standardized definition (Cronin & Durham, 2024; Sankaranarayanan et al., 2023; Haryanti et al., 2023). Microcontent refers to a focused content segment, while microvideos and microlectures are delivery formats. A micromodule is treated here as a compact learning unit linking an objective, concise content, examples, practice, feedback, and reflection; several units may be organized as an e-module (Monib et al., 2025; Susilana et al., 2022; Tang et al., 2022; Thillainadesan et al., 2022). Units may use text, audio, video, quizzes, or combinations of media. Brief duration alone does not determine learning depth, and no universal duration can be prescribed because time depends on content complexity, prior knowledge, age, and media (Cavanagh & Kiersch, 2023; Sozmen, 2022).

Theoretically, dividing content into smaller segments can help students manage the limited capacity of working memory. Cognitive Load Theory explains that digital learning can increase cognitive load when it

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presents too much information, uses complex navigation, or combines media inappropriately. Therefore, brief content should still be carefully selected to emphasize essential information and organized with a clear structure (Skulmowski & Xu, 2022). The segmentation principle in multimedia learning suggests that complex content may be easier to understand when presented in stages and controlled by the learner. However, these benefits depend on the type of content and students' characteristics (Cavanagh & Kiersch, 2023; Çeken & Taşkın, 2022). Thus, microlearning does not automatically make learning easier. Content that is merely divided into small segments without clear conceptual connections may make it more difficult for students to understand and connect information.

The cognitive outcomes examined in this review include academic achievement, learning outcomes, conceptual understanding, knowledge retention, working memory, literacy, problem-solving, and critical thinking. Recent K–12 studies have examined achievement and learning satisfaction (Tang et al., 2022), conceptual understanding and retention (Hamdani et al., 2026), and critical thinking (Arimbawa et al., 2025). Conceptual understanding is not viewed solely as the ability to recall definitions. It also includes students' ability to understand meaning, connect different forms of representation, explain relationships among concepts, apply concepts in specific situations, and distinguish examples from non-examples. A recent secondary-school study assessed basic concepts, conceptual application, and scientific reasoning as indicators of conceptual understanding (Hamdani et al., 2026). Presenting content in small units may help students focus on particular conceptual relationships, retrieve previously learned knowledge, and receive feedback before moving on to the next segment. Research on microlearning and multimedia segmentation suggests potential benefits for managing cognitive load, comprehension, and retention; primary-school evidence also supports retrieval practice with accuracy feedback as a learning strategy (Susilana et al., 2022; Liu, 2024; Franzoi et al., 2025). However, these benefits should be demonstrated using instruments that directly measure indicators of conceptual understanding. Assessment should include applying knowledge in unfamiliar situations and retaining understanding over time, rather than relying solely on students' satisfaction or perceptions of learning (Hamdani et al., 2026; Tang et al., 2022).

Metacognition differs from cognitive ability because it concerns students' ability to understand and regulate their own thinking. It includes knowledge about how to learn and the ability to plan, monitor, and evaluate thinking while completing a task. Metacognition can be measured in various ways, such as the accuracy of students' judgments about whether their answers are correct, think-aloud activities while they complete tasks, records of answer revisions, judgments of learning, or their ability to identify errors. Questionnaires alone may not accurately represent the metacognitive processes that actually occur during learning. Neuroeducation research explains that metacognitive knowledge and the ability to regulate thinking are related, but each requires appropriate measurement methods (Fleur et al., 2021). In addition, a meta-analysis of adolescent students found that the relationship between metacognition and mathematical ability may vary depending on the measurement method. Assessments conducted while students are working on a task may provide different information from self-report measures (Muncer et al., 2022).

Self-regulated learning (SRL) is generally conceptualized as a multidimensional, goal-directed process. It involves regulating cognition—including metacognitive processes such as planning, monitoring, and evaluation—as well as motivation and affect, behavior, and learning resources and context. These may include managing time and effort, structuring the study environment, learning with peers, and seeking help (de Ruig et al., 2023; Luo & Zhou, 2024; Mitalia & Prihatin, 2021). Measures used with secondary-school students likewise treat metacognitive, motivational, and behavioral processes as related but distinct aspects of SRL. Examples include metacognitive judgment and monitoring, emotional control, planning, and evaluation (Ramadhani et al., 2024; Salsabila & Hapsari, 2026). Accordingly, motivation, learning satisfaction, and independent learning should not, by themselves, be interpreted as metacognitive skills. They may represent other dimensions or outcomes associated with SRL; metacognitive skills should be assessed using measures that directly examine learners' knowledge and regulation of their thinking. Reflective prompts in digital learning can help students plan, monitor, and evaluate their learning, but their effectiveness may vary depending on the appropriateness of the prompts, how well they are adapted to students' needs, and the quality of the feedback provided (Guo, 2022). Research on video-based learning that supports SRL also indicates that motivation and learning-resource management often receive less attention than content delivery (Cohen et al., 2026). The distinction between SRL and metacognition must therefore be clear, so that improvements in conceptual understanding through microlearning are not automatically taken as evidence that students' metacognitive skills have improved.

Supporting literature shows that microlearning has been implemented in various learning contexts. However, the use of these sources must take into account the populations and outcomes they examine. Studies

involving university students can provide information about instructional design principles or the development of learning media, but they cannot be treated as empirical evidence about K–12 students (Mariyani et al., 2026; Susilana et al., 2022; Utama et al., 2024). A needs analysis involving high school students may provide insight into students' readiness for and preferences regarding microlearning, but it should not be included as a core study if it does not measure learning outcomes (Rizky et al., 2023). In addition, previous systematic reviews and meta-analyses can serve as sources for comparison and for understanding the development of research, but not as primary study data (Prasittichok & Smithsarakarn, 2024; Silva et al., 2025). Separating these sources is important to ensure that the number of core studies accurately represents research evidence concerning K–12 students and is not inflated by differences in population, research design, or strength of evidence.

Previous reviews have examined microlearning across broad educational settings, pedagogical approaches, and learning outcomes (Alias & Razak, 2023; Monib et al., 2025; Silva et al., 2025). However, findings from university students, needs analyses, material analyses, and media-validation studies cannot be treated as direct empirical evidence about K–12 student outcomes (Mariyani et al., 2026; Susilana et al., 2022; Utama et al., 2024; Dewanti et al., 2023; Nitiasih et al., 2023; Rizky et al., 2023).

This review contributes a focused synthesis of empirical K–12 studies that separates cognitive outcomes from SRL and metacognitive assessment, distinguishes controlled effects from single-group changes, associations, product testing, and descriptive findings, and appraises methodological quality using MMAT 2018. This scope makes it possible to describe both the potential of microlearning and the limits of the evidence, especially the lack of direct metacognitive measurement. The implications are framed for K–12 practice and research, with junior-high micromodules treated as one possible application.

This review synthesizes the implementation of microlearning and reported cognitive, metacognitive, and self-regulated learning (SRL) outcomes among K–12 students in studies published from 2021 to 2026. It also appraises the methodological quality of the included studies using MMAT 2018 and derives implications for K–12 instructional design and evaluation, including the possible application of these implications to junior-high micromodules. The review is guided by four research questions:

1. What are the key research and implementation characteristics of K–12 microlearning?
2. What cognitive outcomes are reported for K–12 microlearning?
3. How are metacognitive skills and SRL measured and reported in K–12 microlearning studies, and what gaps remain?
4. What theoretical, pedagogical, and methodological implications can be drawn from current K–12 microlearning evidence for future instructional design and evaluation?

Method

Review Design, Protocol, and Reporting Guidelines

This study used a systematic literature review with a narrative synthesis approach. Article selection and reporting were conducted in accordance with the PRISMA 2020 guidelines, which can be applied to reviews of educational research, whether or not they include a meta-analysis (Page et al., 2021). Reporting of information sources and search strategies followed PRISMA-S, including documentation of article sources, keywords or search queries, search limits, the number of results, search dates, and the process for identifying and removing duplicate records (Rethlefsen et al., 2021).

PICOS Criteria

Eligibility criteria were established using PICOS to define the population, intervention, comparator, outcomes, and study design clearly and consistently. The operational definitions used are presented in Table 1. Review articles, studies conducted at the higher education level, needs analyses that did not measure learning outcomes, and media-development studies that did not measure student outcomes were excluded from the primary empirical studies. However, these sources could still be used as supporting references when relevant to the discussion.

Information Sources and Search Strategy

The final article search was conducted on 20 August 2026, with publication years limited to 2021–2026. The search process was documented in LOG_PENCARIAN and comprised 73 queries. Searches were conducted primarily through web-based scholarly sources linking to publisher webpages or DOIs, as well as through ERIC, DOAJ, GARUDA, national journals, and chained reference searches. The keywords included intervention terms such as "microlearning", "micro-lecture", "microvideo", "nano-learning", "microcontent", "micromodule", and "microlearning-based e-module"; population terms such as "K–12", elementary, primary, junior high, middle school, secondary, high school, and vocational; and outcome terms such as achievement, conceptual understanding, retention, working memory, literacy, problem solving, critical thinking, metacognition, and self-regulated learning. Each query was adapted to the search rules of the respective source,

including the use of site-specific limits. Only articles with legally accessible full texts were considered for inclusion in the review. An overview of the search pathways and query patterns is presented in Table 2, while the complete queries are stored in a workbook to enable the searches to be replicated.

Table 1. Search Strategy and Sources/Pathways for Identifying Records

Search pathway/source recorded in the log	Number of queries	Query pattern	Limits	Audit interpretation
Scholarly discovery → official publisher/DOI	43	Intervention terms × K–12 terms × outcome terms; directed to official article/DOI pages.	2021–2026; journal articles; legally accessible full text.	A web-mediated discovery pathway, not a single bibliographic database.
DOI/journal verification + citation chaining	12	Titles/DOIs; reference lists and related articles.	Metadata and indexing match.	Used to supplement and verify the search.
ERIC	3	site:eric.ed.gov + microlearning/microlecture + school.	2021–2026.	Accessed using the site-specific limit recorded in the log.
Official national journals	3	Indonesian/English terms + journal OJS pages.	SINTA 1–3.	Verified on the article and SINTA webpages.
DOAJ	2	site:doaj.org + topic/population terms.	Open access.	Accessed using the site-specific limit recorded in the log.
GARUDA	2	site:garuda.kemdikbud.go.id + microlearning.	2021–2026.	A national aggregator pathway.
One-off search pathways	8	OpenAlex/publishers; Crossref/publishers; Springer; MDPI; Frontiers; PMC; SAGE/Wiley/T&F; "Scopus discovery".	As specified in the queries.	The label "Scopus discovery".

Screening, Deduplication, and Full-Text Assessment

All search results were first merged, and duplicates were removed by matching DOIs and normalized titles. Differences in capitalization, spacing, and punctuation were disregarded. Articles without DOIs were checked manually to ensure that variations in title wording were not treated as separate articles. Of the 301 initial records, 119 duplicates were removed, leaving 182 unique records. Title and abstract screening then excluded 132 records that did not meet the criteria for population, intervention, outcomes, document type, publication period, or journal reputation. The remaining 50 articles proceeded to a more detailed assessment.

At the next stage, the full texts or official journal webpages were assessed against the PICOS criteria. Of the 50 candidate articles, 27 were excluded from the main corpus, while 12 sources were retained as supporting references because they were review articles, higher education studies, needs analyses, material analyses, or development studies that did not measure the primary student outcomes. Thus, 39 articles were not included in the core empirical database, while 11 studies met all the criteria. This distinction ensured that sources outside the main corpus were not considered without value. The PRISMA screening stages and counts are presented in Table 3 and Figure 1.

Table 3. PRISMA 2020 Screening Stages After Reconciliation

Stage	n	Calculation	Notes
Records identified	301	—	Raw results from 73 queries; may include duplicate records.
Duplicates removed	119	301 − 119	Deduplication based on DOI and title.
Unique records screened	182	= 182	Title and abstract screening.
Records excluded at title/abstract screening	132	182 − 132	Did not meet the population, intervention, outcome, year, document type, or indexing criteria.
Candidates assessed in detail	50	= 50	Full texts or official journal webpages and metadata were checked.
Excluded from the core corpus	27	—	Recorded in ARTIKEL_DIEKSKLUSI.
Supporting references	12	—	Retained as theoretical or comparative sources, not as core empirical studies.
Total not included in the core corpus	39	27 + 12	Separates excluded articles from supporting sources.
Core empirical studies	11	50 − 39	Synthesis corpus.

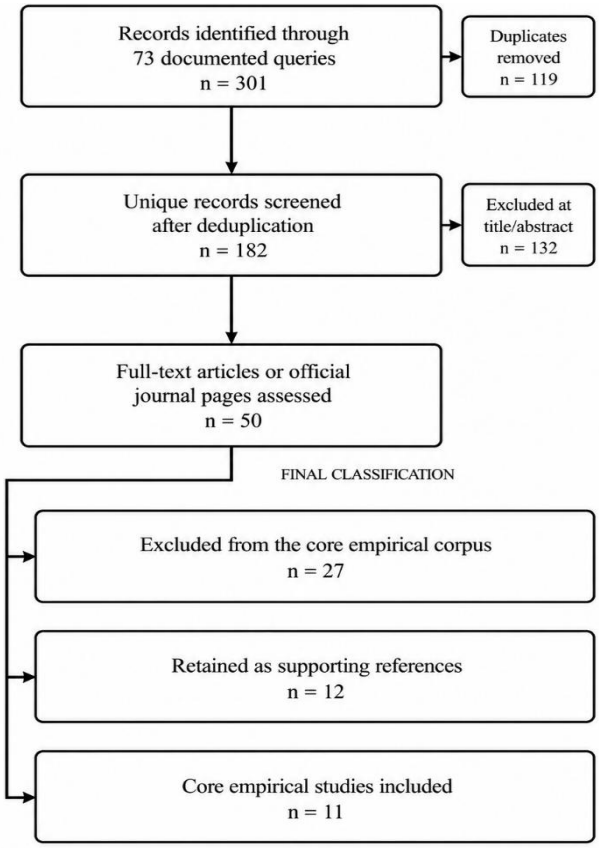


Figure 1. PRISMA 2020 flow diagram based on the reconciliation of the workbook.

Data Extraction

Data extracted from each article included study identification details, year of publication, country, students' educational level and grade, subject area, sample size, types of media and platforms, instructional duration, intervention length, number of sessions, delivery method, learning conditions, study design, comparison group, instruments, measured outcomes, statistical data, interpretation of findings, study limitations, and journal indexing status.

MMAT 2018 Quality Appraisal

The methodological quality of each study was appraised using the 2018 version of the MMAT after the studies had been grouped by research design (Hong et al., 2018). All studies were first assessed using two screening questions. The appraisal was then tailored to each study type: Category 3 for non-randomized quantitative studies, Category 4 for descriptive or analytical quantitative studies, and Category 1 for qualitative studies. For development studies using a pretest–posttest design, the appraisal focused on quantitative outcomes relevant to the RQs rather than solely on product feasibility. Each criterion was rated as "Yes," "No," or "Cannot tell" (TT), with a rationale based on the information reported in the article. In accordance with the MMAT guidance, the appraisal findings were not combined into a single score or percentage, as each aspect of methodological quality needs to be considered separately.

Data Synthesis, Ethics, and Transparency

A narrative synthesis was used because the reviewed studies varied considerably in research design, educational level, subject area, media type, intervention length, instruments, outcome definitions, and statistical reporting. Accordingly, findings from controlled studies were distinguished from score changes in single-group studies, associations identified through surveys, results of limited testing in development studies, and qualitative findings. No meta-analysis was conducted because effect size data were not sufficiently comparable across studies, and some articles did not report the required statistics. This SLR did not involve new participants; therefore, it did not require ethical approval of the kind required for primary research. The search and data extraction processes were documented in a workbook to support traceability and auditing. Journal indexing status and article links were also verified against the records available as of August 20, 2026.

Result and Discussion

Search and Selection Results

The PRISMA flow is based on deduplicated records. Of the 301 records identified through 73 queries, 119 duplicates were removed, leaving 182 unique records for title-and-abstract screening; 132 were excluded, and 50 proceeded to full-text or official journal-page assessment. Of these 50, 27 were excluded from the core corpus, 12 were retained as supporting references, and 11 met the criteria for inclusion as core empirical studies. The LOG_PENCARIAN separately contains 120 entries marked "relevant" and 46 marked "passed verification." As described in the search log, these entries may recur across queries and are not unique-record totals; they were not used to calculate the PRISMA counts. The 12 supporting references are not part of the 11-study empirical corpus.No eligible core studies published in 2021 were identified. The included studies were published between 2022 and 2026: two in 2022, three in 2024, three in 2025, and three in 2026. Of the 11 articles analyzed, three were published in journals whose Scopus status had been verified, four in SINTA 2 journals, and four in SINTA 3 journals. No articles came from SINTA 1 journals. The DOI for each article was also checked against the article title, author names, publication year, and journal name on the journal's official website.

Study Characteristics

Ten studies were conducted in Indonesia and one in Saudi Arabia. Based on the methods sections, the studies covered two at the elementary school level, three at the junior high school level, three at the senior high school level, and three at the vocational high school level. Hamdani et al. (2026) was classified as a junior high school study because the methods section identified the participants as eighth-grade junior high school students, although the title and abstract referred to senior secondary education. Alwazzan (2026) was classified as a senior high school study because most of the text referred to high school, despite one inconsistency in the conclusion.

Mathematics was the most frequently studied subject, appearing in four studies, while each of the other seven subject areas appeared once. By primary analytical design, the 11 studies comprised two quasi-experimental studies with comparison groups, six one-group pretest–posttest studies, one PLS-SEM survey, one qualitative case study, and one development study with an unclear comparison design. Product-development status is a separate, overlapping characteristic and should not be added to these analytical-design counts. Overall, eight studies reported pretest and posttest results.

The number of participants that could be confirmed ranged from 20 to 233. Several studies had inconsistencies or limitations in reporting sample sizes: Hamdani et al. (2026), Tang et al. (2022), Utami et al. (2024), Silvester et al. (2025), and Marsofiyati et al. (2024). Details of the study characteristics and participant numbers are presented in Table 4.

Table 4. Characteristics of the 11 Core Empirical Studies

Study	Country; educational level	Subject/outcome	Design	Analytical n	Media	Indexing
Hamdani et al. (2026)	Indonesia; Grade VIII junior high school	Science; concepts, retention, SRL	Quasi-experimental, with a control group	32 (16/16); methods section reports 64	Digital science module	SINTA 2
Tang et al. (2022)	Indonesia; Grade VII junior high school	Mathematics; achievement	Quasi-experimental, three groups	95; the text also reports 108/89	Microlecture	Scopus
Jiang et al. (2022)	Indonesia; Grades VII–IX junior high school	Mathematics; perceived achievement	PLS-SEM survey	233	Microlecture	Scopus
Alwazzan (2026)	Saudi Arabia; girls' senior high school	Digital cognition; working memory	One-group pretest–posttest	35	Adaptive nano-learning	Scopus
Kurniawan et al. (2024)	Indonesia; Grades IV–V elementary school	Language; literacy	ADDIE, one-group pretest–posttest	60	Short videos	SINTA 2
Utami et al. (2024)	Indonesia; Grade X senior high school	Mathematics; problem-solving	ADDIE, one-group pretest–posttest	32; field test reports 30	Digital micromodule	SINTA 2
Marsofiyati et al. (2024)	Indonesia; vocational high school	Correspondence; skills/retention	Dick & Carey; outcomes not described in detail	Not reported	Video/digital media	SINTA 2
Arimbawa et al. (2025)	Indonesia; Grade X vocational high school	Mathematics; critical thinking	Four-D, one-group pretest–posttest	36	SIMPLE E-Module	SINTA 3
Wira et al. (2026)	Indonesia; Grade XI vocational high school	Programming; learning outcomes	ADDIE, one-group pretest–posttest	30	Moodle + project	SINTA 3
Silvester et al. (2025)	Indonesia; elementary school, four schools	Cross-curricular; digital literacy	Qualitative case study	Not reported	Short videos	SINTA 3
Anjarwati & Dewi (2025)	Indonesia; Grade X senior high school	Economics; learning outcomes	ADDIE, one-group pretest–posttest	20	Instagram	SINTA 3

RQ1 Findings: Forms and Implementation of Microlearning

The interventions varied considerably in format. Four studies used short videos or microlectures, and three used digital modules or e-modules organized into small units. The remaining studies used adaptive audio-visual nano-learning, project-based e-learning, Instagram, and digital correspondence media. Platforms included YouTube, WhatsApp, Moodle, Instagram, Exelearning/SIMPLE E-Module, Google Classroom, Canva, CapCut, and KineMaster. However, reporting on the intervention technology was inconsistent, as some studies described their analytical tools in greater detail than their learning platforms.

Reported unit durations also varied: 9 minutes and 7 seconds in Tang et al. (2022), approximately 1.5 minutes in Alwazzan (2026), 10–15 minutes in Arimbawa et al. (2025), 1–5 minutes in Silvester et al. (2025), and 1–7 minutes in Marsofiyati et al. (2024), although information on sessions and sample size in the latter study was unclear. The other six studies did not report unit durations consistently; therefore, a single ideal duration that applies across contexts cannot yet be established.

Delivery strategies included in-class use, pre-class learning, flipped classrooms, self-directed learning, discussions, interactive exercises, quizzes, feedback, programming projects, and social media. Tang et al. (2022) found that microlectures delivered both during and before class resulted in higher posttest scores than the control condition, although the two microlecture approaches did not differ significantly from each other. Silvester et al. (2025) emphasized the importance of flexibility, including offline video playback when access to devices and the internet was limited.

The overall intervention periods also differed, ranging from three sessions over three weeks in Tang et al. (2022), to at least one semester in Jiang et al. (2022), to three sessions comprising six to eight class periods in Anjarwati and Dewi (2025). Alwazzan (2026) reported several stages of activities but did not specify the effective learning duration. Most development studies also did not fully report the number of sessions, exposure dose, or time spent using the intervention. A summary is presented in Table 5.

RQ2 Findings: Cognitive Outcomes

All core studies reported cognitive outcomes or indicators related to cognitive abilities, but the strength of the evidence varied. Two studies used comparison groups. Hamdani et al. (2026) reported higher conceptual understanding in the microlearning-based science module group ($M = 81.38$; $SD = 6.41$) than in the conventional group ($M = 72.06$; $SD = 6.87$), $t = 3.21$, $p = 0.003$, $d = 0.80$. Retention was also higher (78.94 compared with 69.13), although the timing of the delayed test was not described in detail. Tang et al. (2022) likewise found that the two microlecture groups had higher mean posttest scores than the control group: 85.00 and 86.66, compared with 74.18, with $F = 7.03$ and $p < 0.05$. However, the two microlecture delivery methods did not differ significantly ($p = 0.536$). These findings support the potential benefits of microlearning compared with the control conditions, but do not show that one delivery method was superior.

Six one-group pretest–posttest studies reported positive changes following the interventions. Alwazzan (2026) reported an improvement in working memory quality from $M = 46.94$ to $M = 63.46$, $t(34) = 6.854$, $p < 0.001$, $d = 1.15$. Kurniawan et al. (2024) found a 34.35% increase in language literacy, while Utami et al. (2024) reported an increase in problem-solving ability from $M = 6.17$ to $M = 24.28$, $t(31) = -7.121$, $p < 0.001$. Arimbawa et al. (2025) recorded an increase in critical-thinking scores from 51 to 81, with an N-gain of 0.62. Wira et al. (2026) reported an increase in learning outcomes from 64.80 to 81.83, with an N-gain of 0.52, while Anjarwati and Dewi (2025) found an increase in economics scores from 54 to 94, $p < 0.001$, with an N-gain of 0.80. Although these results were positive, the absence of comparison groups in these studies limits causal conclusions.

Jiang et al. (2022) conducted a PLS-SEM survey of 233 students and found that the model explained 76.9% of the variance in learning achievement and 77.3% of the variance in satisfaction. However, because the data were collected through questionnaires and not all relationships were significant, the findings are classified as mixed associations rather than direct evidence of microlecture effects. In a qualitative study, Silvester et al. (2025) found that students appeared more focused, were able to restate the main messages, and were more critical in distinguishing educational videos from entertainment. However, the study did not use standardized tests or pre–post measurements. Marsofiyati et al. (2024) reported an approximately 25% improvement in correspondence skills and 80% retention after one week. However, the findings remain uncertain because information on the sample, statistics, and comparison conditions was insufficient.

Overall, eight studies showed a positive trend: two controlled studies and six one-group pretest–posttest studies. One study reported mixed findings, one was qualitatively descriptive, and one had uncertain findings. No study reported entirely non-significant results, although Tang et al. (2022) and Jiang et al. (2022) reported some non-significant outcomes. The categories of findings and their interpretive limitations are retained in Table 6 to avoid overstating causal claims.

Tabel 6. Synthesis of cognitive outcomes and strength of inference

Study	Outcome/ instrument	Results	Category	Underlying design	Inference limitations
Hamdani	25-item concept test; retention	81.38 vs. 72.06; t = 3.21; p = .003; d = .80; retention: 78.94 vs. 69.13	Positive/supportive	Controlled	Non-randomized; conflicting sample size; delayed testing insufficiently detailed
Tang	20-item multiple-choice mathematics test	Posttest: 74.18, 85.00, and 86.66; F = 7.03; both microlecture groups differed significantly from the control; no significant difference between variants (p = .536)	Positive, with a non-significant sub-outcome	Controlled	Sample size and intervention duration inconsistently reported
Jiang	TAM–ECM/achievement questionnaire	R^2 for achievement = .769; several paths were non-significant	Mixed	Survey/SEM	Shows associations; achievement was self-reported
Alwazzan	Working Memory Quality Scale	46.94 → 63.46; t(34) = 6.854; p < .001; d = 1.15	Positive/supportive	One-group	No control group; homogeneous sample
Kurniawan	Language literacy test	Mean increase of 34.35%	Positive/supportive	One-group development study	Limited statistical detail
Utami	Problem-solving test	6.17 → 24.28; t(31) = −7.121; p < .001	Positive/supportive	One-group development study	Conflicting sample size; no control group
Marsofiyati	Correspondence skills/retention	25% improvement; 80% retention after one week	Uncertain	Development study, insufficiently detailed	Sample size, comparison group, and analysis inadequately reported
Arimbawa	Critical-thinking test	51 → 81; N-gain = .62	Positive/supportive	One-group development study	No inferential analysis or control group
Wira	Five programming essay questions	64.80 → 81.83; N-gain = .52	Positive/supportive	One-group development study	Limited reporting on test validity and intervention fidelity
Silvester	Interviews, observations, and documents	Focus, meaning-making, discussion, and digital literacy were described	Descriptive/qualitative	Case study	Does not measure score changes or effects
Anjarwati	Economics test	54 → 94; p < .001; N-gain = .80	Positive/supportive	One-group development study	n = 20; no control group

RQ3 Findings: Metacognition and Self-Regulated Learning

Only Hamdani et al. (2026) explicitly measured self-regulated learning (SRL), using a 24-item Likert questionnaire covering planning, monitoring, cognitive strategies, motivation regulation, and self-reflection. The mean SRL score in the microlearning group was 82.25, higher than the comparison group's score of 71.81. However, inferential analyses of SRL were not reported in as much detail as those for conceptual understanding, and no process data were provided. Therefore, this finding indicates a difference in self-reported scores rather than direct evidence of changes in metacognitive skills.

None of the core studies directly measured metacognitive knowledge or regulation. Although the SRL construct used by Hamdani et al. (2026) includes metacognitive elements, it also covers motivation and general learning strategies. Thus, only one study measured SRL, one combined cognitive and SRL outcomes, and none directly measured metacognitive skills. This gap is also related to the methods of measurement. Self-report questionnaires primarily reflect perceptions of learning habits, whereas direct measurement needs to capture monitoring and control processes as tasks are performed. Metacognition should therefore be assessed by combining measures of knowledge, control, and process data (Fleur et al., 2021; Muncer et al., 2022), for example, through confidence judgments, time spent on each unit, content revisits,

answer revisions, reflective notes, or think-aloud protocols. A summary is presented in Table 7.

RQ4 Findings: Implications for K–12 Microlearning Design and Evaluation

The corpus suggests that a micromodule should be understood as a structured learning unit comprising a specific objective, concise content, an example or representation, retrieval practice, feedback, and reflection. Unit duration need not be standardized; it should be adjusted to the complexity of the material and refined through pilot testing. The verified range of approximately 1.5–15 minutes indicates that the time required may differ between abstract concepts and procedural content.

To support conceptual understanding, several micromodules should be connected through concept maps, transfer questions, and examples and counterexamples so that segmentation does not fragment the structure of knowledge. Metacognitive skills can be practiced through a plan–monitor–evaluate cycle: setting a target, estimating one's understanding, completing a task, evaluating confidence, receiving feedback, and deciding whether to review or move on. Digital prompts can support this mechanism in general (Guo, 2022), but this SLR has not established a causal effect of micromodules on metacognition in K–12 education.

Future K–12 evaluations should, where feasible, include a comparison group, pretests and posttests for distinct outcomes, implementation-fidelity data, intervention duration and session counts, and a retention test. Conceptual understanding should be measured with content-based indicators, while metacognition should be assessed directly through knowledge and regulation measures, including planning, monitoring, and evaluation. Questionnaires can be complemented by process data or calibration tasks. Junior-high micromodules offer one application for testing these design principles; the current SLR does not establish a causal effect of micromodules on metacognition. Figure 2 is therefore a proposed framework for future testing, not a causal relationship established by this review.

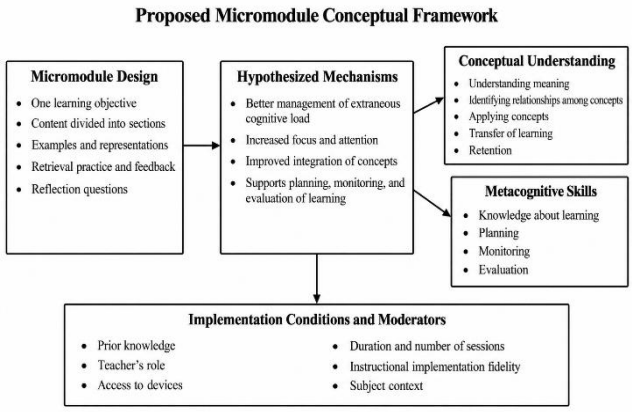


Figure 2. Proposed conceptual framework linking micromodules, conceptual understanding, and metacognitive skills

Methodological Quality Appraisal

Table 8 presents the 2018 MMAT appraisal results for each study by criterion. Nearly all studies had appropriate research questions and data, with the exception of Marsofiyati et al. (2024). The most common weaknesses in non-randomized studies were limited or unrepresentative sample sizes, lack of control for confounding variables, and insufficiently clear reporting of intervention implementation. Differences in sample sizes reported across sections of the articles also led to a "No" rating for the outcome completeness criterion in Hamdani et al. (2026), Tang et al. (2022), and Utami et al. (2024).

Jiang et al. (2022) reported reliability and PLS-SEM analyses, but the study was conducted at only one school, the response rate was unclear, and learning achievement was self-reported. Silvester et al. (2025), meanwhile, used an appropriate case study design and employed interviews, observations, document analysis, and triangulation. However, claims of "effectiveness" and "improvement" were considered stronger than the available evidence because they were not supported by direct measurements of students' outcomes. The MMAT findings were not combined into a single overall score because the pattern of strengths and weaknesses in each study was considered more informative than a single percentage.

Table. 8. MMAT 2018 Appraisal by Study and Criterion

Study	Category	S1	S2	C1	C2	C3	C4	C5	Main rationale
Hamdani	3	Yes	Yes	No	Yes	No	No	TT	Purposive sampling/one setting; n = 64 vs. 32; confounder control and fidelity unclear.
Tang	3	Yes	Yes	No	Yes	No	TT	TT	Intact classes; n = 108/89/95; baseline data available, but confounder control and fidelity were limited.
Jiang	4	Yes	Yes	TT	No	TT	TT	Yes	One school; achievement was self-reported; response rate unclear; PLS-SEM adequate.

Study	Category	S1	S2	C1	C2	C3	C4	C5	Main rationale
Alwazzan	3	Yes	Yes	No	Yes	Yes	No	TT	n = 35 female participants; reliable scale; no control group; fidelity not described in detail.
Kurniawan	3	Yes	Yes	No	TT	TT	No	TT	Product testing in two schools; limited details on the instrument, attrition, and fidelity.
Utami	3	Yes	Yes	No	TT	No	No	TT	One setting; limited validation; n = 30 vs. 32; no control group.
Marsofiyati	3	Yes	TT	TT	TT	TT	No	TT	Sample, measurement, analysis, and comparison group insufficiently reported.
Arimbawa	3	Yes	Yes	No	TT	Yes	No	TT	n = 36; limited evidence of test validity and fidelity; no control group.
Wira	3	Yes	Yes	No	TT	Yes	No	TT	n = 30; five essay questions without detailed validity evidence; no control group.
Silvester	1	Yes	Yes	Yes	Yes	Yes	TT	Yes	Triangulation was adequate; claims of improvement/effectiveness exceed the descriptive data.
Anjarwati	3	Yes	Yes	No	TT	Yes	No	TT	n = 20; limited information on the instrument and fidelity; no control group.

Note. Yes = meets the criterion; No = does not meet the criterion; TT = cannot be determined. S1 = clear research questions; S2 = data adequate to address the research questions. Category 3 (non-randomized): C1 sample representativeness; C2 measurement appropriateness; C3 outcome completeness; C4 confounder control; C5 intervention implemented as intended. Category 4 (descriptive): C1 sampling strategy; C2 sample representativeness; C3 measurement appropriateness; C4 risk of nonresponse; C5 statistical analysis. Category 1 (qualitative): C1 appropriateness of the approach; C2 data collection methods; C3 derivation of findings; C4 support for the interpretation; C5 coherence. No total score was calculated.

Synthesis of Findings for RQ1–RQ4

Table 9 summarizes the four research questions. RQ1 shows that microlearning formats and research designs varied, while duration was often incompletely reported. RQ2 indicates potential improvements in cognitive outcomes, but only two studies used comparison groups. RQ3 shows that only one study measured SRL and none directly assessed metacognitive skills. RQ4 therefore identifies cautious, context-specific implications for K–12 instructional design and evaluation, including linked micro-units, practice, feedback, and direct outcome measurement.

Table 9. Summary of Findings, Evidence Base, and Implications for RQ1–RQ4

RQ	Brief answer	Evidence base	Implications
RQ1	Media and strategies varied; 2 elementary, 3 junior high, 3 senior high, and 3 vocational high school studies; mathematics was dominant; duration was often unreported.	11 studies: 2 controlled, 6 one-group, 1 survey, 1 qualitative, and 1 development study with insufficient detail.	Report unit granularity, platform, duration, number of sessions, online/offline conditions, and implementation fidelity.
RQ2	Cognitive benefits appear possible, but the strength of the evidence varies.	8 supportive; 1 mixed; 1 descriptive; 1 uncertain.	Distinguish controlled effects, one-group changes, associations, and descriptive findings.
RQ3	SRL was measured once; no study directly measured metacognition.	1 SRL questionnaire; 0 direct measures.	Combine questionnaires with calibration measures, logs, reflections, or think-aloud protocols.
RQ4	Current evidence supports cautious, context-specific implications for K–12 design; direct evidence of metacognitive gains is absent.	Theoretical mechanisms and design/measurement gaps.	Use linked micro-units, practice, feedback, and reflection; test with stronger comparison designs, transfer and retention measures, fidelity data, and direct metacognitive/SRL measures. Junior-high micromodules are one possible application.

Discussion

Evidence Patterns and Limits of Inference

The synthesis shows that microlearning in K–12 education is often tested as a digital product in a single class. Consequently, the available evidence more often concerns media feasibility, participant responses, and local score changes than between-group comparisons. The strongest evidence comes from two controlled studies: a microlearning-based science module was associated with higher conceptual understanding and retention, while mathematics microlectures produced better posttest results than expository instruction

(Hamdani et al., 2026; Tang et al., 2022). However, both studies were quasi-experimental, reported inconsistent sample sizes, and did not fully control for confounding factors.

Six one-group studies also reported positive changes, but these results cannot yet be considered evidence of causation because they may have been influenced by regular instruction, test familiarity, maturation, participant selection, or the novelty effect. N-gain values also cannot be compared directly across studies because of differences in scales, subject matter, intervals, and instrument quality. Alwazzan (2026) reported a large effect size, but the study still involved only one group. Therefore, improvements in language literacy, problem-solving, critical thinking, programming, and economics are better viewed as a basis for further testing than as evidence of universal effectiveness.

Jiang et al. (2022) and Silvester et al. (2025) provide additional insight into perceptions and implementation contexts, but their findings cannot be interpreted in the same way as experimental results. Marsofiyati et al. (2024) also illustrates that reported improvements, without sufficient information on sample size, comparison groups, and analysis, are not enough to establish the certainty of the findings. The strength of each finding should therefore be interpreted in light of its study design, so that all positive results are not treated as having the same level of evidence.

Segmentation, Multimedia, and Cognitive Load

The media formats suggest that segmentation is a plausible mechanism, although it has rarely been tested directly. Reported unit durations ranged from approximately 1.5 minutes, to videos lasting 1–9 minutes, to activities lasting 10–15 minutes. According to cognitive load theory, segmentation can help reduce extraneous cognitive load when content is divided according to its conceptual structure, irrelevant information is removed, and learners have opportunities to understand important relationships (Skulmowski & Xu, 2022). Multimedia principles also emphasize signaling, coherence, contiguity between text and visuals, and pacing control, rather than short duration alone (Cavanagh & Kiersch, 2023; Çeken & Taşkın, 2022).

However, overly fragmented material may lead learners to remember isolated pieces without understanding the relationships between concepts. Micromodules should therefore include links between sessions, such as advance organizers, concept maps, cumulative questions, and transfer exercises. Repetition should also involve retrieval and elaboration rather than simply replaying content. Evidence from primary education indicates that microlearning can support flexibility and engagement, but evidence on long-term outcomes remains limited (Silva et al., 2025). Access, learner characteristics, and teacher readiness should also be considered (Sozmen, 2022).

The reported durations are insufficient to conclude that shorter units are better. A 1.5-minute unit may not suit science or mathematics concepts that require reasoning, while a 10–15-minute unit may function as a micromodule if it has a clear objective and can be completed independently. Alignment with content and learning objectives is more important than a fixed time limit. Future K–12 studies should report both planned duration and actual time spent, because learners may repeat a unit, pause to reflect, or return to earlier material.

Conceptual Understanding, Retention, and Transfer

Cognitive outcomes varied across the studies, ranging from working memory to academic achievement. Conceptual understanding was most clearly assessed in the science module, while other studies examined it through mathematical problem-solving and descriptions of science concepts. Hamdani et al. (2026) was the study most closely aligned with the thesis focus because it measured conceptual understanding, retention, and SRL concurrently. However, inconsistencies in educational level, sample size, and intervention details limit the potential for direct replication. Tang et al. (2022) used a three-group design that allowed microlectures to be compared with a control condition and different delivery methods to be examined, although no significant differences were found between the microlecture variants.

Retention was explicitly measured in only a few studies, and the timing of delayed tests was often unclear. Micromodule evaluation should therefore include three aspects: immediate understanding, transfer to new problems or representations, and retention after a specified interval. Assessment instruments should also differ from practice questions so that transfer does not merely reflect repetition. Constructed-response questions, explanations of answers, or concept maps may be used as supplementary measures, with clear reporting of scoring rubrics and scoring reliability.

Metacognition Is Not Synonymous with SRL, Motivation, or Satisfaction

The absence of direct measures of metacognition is an important finding. One study on SRL provides an initial perspective, but its questionnaire cannot show whether learners are able to monitor their understanding and select strategies more effectively. This distinction matters because metacognition is one component of SRL, while SRL also includes motivation, behavior, time management, and the learning

environment. Therefore, increases in motivation, satisfaction, or focus, as well as positive responses to videos, cannot automatically be interpreted as improvements in metacognitive skills (Fleur et al., 2021; Muncer et al., 2022).

Micromodules can include reflective prompts before, during, and after each unit—for example, prompts about prior knowledge, confidence, remaining questions, and next steps. Metacognitive prompts in computer-based learning may support SRL and learning outcomes when they are specific, adaptive, and accompanied by feedback (Guo, 2022), although their frequency should be tested to avoid increasing learning burden. Future evaluations should combine questionnaires with process data, such as calibration accuracy, decisions to revisit a unit, answer revisions, study time, written reflections, or think-aloud protocols with a subset of participants. These measures can help identify the regulation processes that occur during learning (Cohen et al., 2026). Junior-high studies may be one setting for applying this approach.

Comparison with Previous Reviews

Previous reviews describe variation in microlearning formats and contexts and report that evidence in basic education is less extensive than evidence in higher education or professional training (Alias & Razak, 2023; Monib et al., 2025; Silva et al., 2025). A meta-analysis of microlearning for EFL speaking found an effect, but its population and outcome differ from the K–12 cognitive, metacognitive, and SRL outcomes considered here (Prasittichok & Smithsarakarn, 2024). These syntheses provide useful context, but their findings should not be transferred directly to the outcomes examined in this review.

The present review adds a focused map of 11 empirical K–12 studies, separates core outcome evidence from supporting literature, and distinguishes controlled findings from one-group score changes, survey associations, development testing, and qualitative descriptions. It also examines whether metacognition was measured directly, rather than treating SRL questionnaires or learner perceptions as equivalent evidence. This narrower scope explains the smaller core corpus and makes the methodological limits of the evidence more visible.

Pedagogical and Methodological Implications for K–12 Learning

Across K–12 settings, micromodules are best treated as components of a learning sequence rather than replacements for the broader learning process. Short units can activate prior knowledge, explain one concept, provide a worked example, support retrieval practice, address misconceptions, or prompt reflection. Offline access may be important where devices or internet access are limited, as reported by Silvester et al. (2025). Platform choices should account for accessibility, feedback, and the learning activities required. The appropriate design will vary by age, subject, and learning objective; junior-high instruction is one context in which these principles can be evaluated.

Across K–12 research, evaluation should move beyond product feasibility to examine learning outcomes, mechanisms, target groups, and intervention duration. Where feasible, comparison designs should document baseline conditions, teacher characteristics, instructional time, and additional exposure. Analyses may use ANCOVA or multilevel models where appropriate. Reports should distinguish participants recruited, allocated, completing the intervention, and included in analyses, and should document implementation fidelity, including unit delivery, actual duration, repetitions, prompt completion, and possible contamination between groups.

Conclusion

Across the 11 empirical studies, microlearning was implemented through varied formats and was associated with generally favourable cognitive findings. However, only two studies used comparison groups; six relied on one-group pretest–posttest designs, and the remaining evidence came from a survey, a qualitative study, or incomplete reporting. The findings therefore suggest potential support for cognitive outcomes but do not establish effectiveness across K–12 settings. Evidence for metacognition and SRL remains limited: one study used a self-report SRL questionnaire, and none directly assessed metacognitive knowledge or regulation.

The conclusions are limited by the small and heterogeneous corpus, the concentration of studies in Indonesia (10 of 11), inconsistent reporting and methodological limitations, and a search strategy based on web-mediated scholarly discovery, selected sources, and citation chaining that may not capture every eligible study. Future research should use stronger comparative designs, report intervention duration and fidelity, assess transfer and retention, and measure metacognitive and SRL processes directly. The review offers cautious design considerations for K–12 teaching; their effectiveness should be tested in the relevant learner groups and contexts.

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and R. All authors have read and agreed to the published version of the manuscript.

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References

Alias, N. F., & Razak, R. A. (2023). Exploring the pedagogical aspects of microlearning in educational settings: A systematic literature review. *Malaysian Journal of Learning and Instruction, 20*(2), 267–294. https://doi.org/10.32890/mjli2023.20.2.3

Alwazzan, M. S. (2026). Adaptive nano-learning improves working memory quality in high school students. *Frontiers in Education, 11*, Article 1812472. https://doi.org/10.3389/feduc.2026.1812472

Anjarwati, M. A., & Dewi, R. M. (2025). Development of economy microlearning media assisted by Instagram to improve student learning outcomes. *Jurnal Pendidikan Ilmu Sosial, 35*(1), 151–164. https://doi.org/10.23917/jpis.v35i1.10139

Arimbawa, G. P. A., Parwati, N. N., Agustini, K., Suartama, I. K., & Sudarma, I. K. (2025). The effectiveness of microlearning-based e-modules in improving critical thinking abilities of vocational high school students. *JKTP: Jurnal Kajian Teknologi Pendidikan, 8*(3), 235–247. https://doi.org/10.17977/um038v8i32025p235-247

Cavanagh, T. M., & Kiersch, C. (2023). Using commonly-available technologies to create online multimedia lessons through the application of the cognitive theory of multimedia learning. *Educational Technology Research and Development, 71*(3), 1033–1053. https://doi.org/10.1007/s11423-022-10181-1

Çeken, B., & Taşkın, N. (2022). Multimedia learning principles in different learning environments: A systematic review. *Smart Learning Environments, 9*, Article 19. https://doi.org/10.1186/s40561-022-00200-2

Cohen, A., Ezra, O., Michaeli, E., Cohen, G., Gabbay, H., & Bronshtein, A. (2026). Beyond content delivery: A systematic review of video-based SRL interventions and gaps in explicit motivational and resource-management instruction. *Journal of Intelligence, 14*(2), Article 33. https://doi.org/10.3390/jintelligence14020033

Cronin, J., & Durham, M. L. (2024). Microlearning: A concept analysis. *CIN: Computers, Informatics, Nursing, 42*(6), 413–420. https://doi.org/10.1097/CIN.0000000000001122

de Ruig, N. J., de Jong, P. F., & Zee, M. (2023). Stimulating elementary school students' self-regulated learning through high-quality interactions and relationships: A narrative review. *Educational Psychology Review, 35*, Article 71. https://doi.org/10.1007/s10648-023-09795-5

Dewanti, R., Sukmatanti, R., & Iskandar, I. (2023). An analysis of senior high school English learning materials: Microlearning perspectives. *Indonesian EFL Journal, 9*(2), 151–160. https://doi.org/10.25134/ieflj.v9i2.8806

Fleur, D. S., Bredeweg, B., & van den Bos, W. (2021). Metacognition: Ideas and insights from neuro- and educational sciences. *npj Science of Learning, 6*, Article 13. https://doi.org/10.1038/s41539-021-00089-5

Franzoi, L., Cembrani, V., Mulatti, C., & Treccani, B. (2025). Retrieval practice enhances learning in real primary school settings, whether distributed or not. *Frontiers in Psychology, 16*, Article 1632206. https://doi.org/10.3389/fpsyg.2025.1632206

Guo, L. (2022). Using metacognitive prompts to enhance self-regulated learning and learning outcomes: A meta-analysis of experimental studies in computer-based learning environments. *Journal of Computer Assisted Learning, 38*(3), 811–832. https://doi.org/10.1111/jcal.12650

Haliem, T. D., Murti, R. C., Wibowo, S. E., & Suryani, L. (2026). Teachers' perspectives on implementing microlearning in numeracy literacy in elementary schools. *Jurnal Prima Edukasia, 14*(1), 125–136. https://doi.org/10.21831/jpe.v14i1.86071 Jurnal Prima Edukasia

Hamdani, H., Marlina, R., Nurussaniah, Lathifah, S. S., & Zb, A. (2026). Effects of microlearning based science modules on conceptual understanding and self regulated learning: A quasi experimental study in senior secondary schools. *International Journal of Education and Teaching Zone, 5*(1), 254–269. https://doi.org/10.57092/ijetz.v5i1.774

Haryanti, S., Rahmi, E., Safitri, P. T., Hanafi, I., & Susanto, T. T. D. (2023). Microlearning dalam pembelajaran fisika: Literature review. *Navigation Physics: Journal of Physics Education, 5*(1), 44–51. https://doi.org/10.30998/npjpe.v5i1.1862

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information, 34*(4), 285–291. https://doi.org/10.3233/EFI-180221

Jiang, P., Wijaya, T. T., Mailizar, M., Zulfah, Z., & Astuti, A. (2022). How micro-lectures improve learning satisfaction and achievement: A combination of ECM and extension of TAM models. *Mathematics, 10*(19), Article 3430. https://doi.org/10.3390/math10193430

Kurniawan, N., Sugiarto, M. A., & Cahyono, A. E. (2024). Microlearning media for language literacy: A learning innovation for elementary school students. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran, 10*(4), 1517–1527. https://doi.org/10.33394/jk.v10i4.12961

Liu, D. (2024). The effects of segmentation on cognitive load, vocabulary learning and retention, and reading comprehension in a multimedia learning environment. *BMC Psychology, 12*, Article 4. https://doi.org/10.1186/s40359-023-01489-5

Luo, R.-Z., & Zhou, Y.-L. (2024). The effectiveness of self-regulated learning strategies in higher education blended learning: A five years systematic review. *Journal of Computer Assisted Learning, 40*(6), 3005–3029. https://doi.org/10.1111/jcal.13052

Mariyani, A., Munfariqoh, A., Rahma, N. I., & Daing, C. A. (2026). MEME-based Assemblr Edu microlearning enhance student's cognitive ability. *JED (Jurnal Etika Demokrasi), 11*(2). https://doi.org/10.26618/4s0wa093

Marlina, R., Hamdani, H., & Pamungkas, R. (2026). Development of microlearning media science concepts in senior high school: Emphasis on technology literacy. *Jurnal Inovasi Teknologi Pendidikan, 13*(1), 117–131. https://doi.org/10.21831/jitp.v13i1.94536

Marpaung, C. F. S., Priatna, N., & Suhendra. (2024). Development of a microlearning-based e-module to improve seventh-grade students' understanding of triangle and quadrilateral. *Jurnal Pendidikan MIPA, 25*(3), 1244–1258. https://doi.org/10.23960/jpmipa/v25i3.pp1244-1258

Marsofiyati, Eryanto, H., Faslah, R., Swaramarinda, D. R., Yuliawan, R., Rasto, R., Muhidin, S. A., Latief, M. J., & Santoso, J. T. B. (2024). Transforming correspondence learning through microlearning-based media for vocational high school students. *JTP – Jurnal Teknologi Pendidikan, 26*(3), 1024–1036. https://doi.org/10.21009/jtp.v26i3.50206

McNeill, L., & Fitch, D. (2023). Microlearning through the lens of Gagné's nine events of instruction: A qualitative study. *TechTrends, 67*(3), 521–533. https://doi.org/10.1007/s11528-022-00805-x

Mitalia, S., & Prihatin, T. (2021). Revealing the students' self-regulated learning levels during the COVID-19 outbreak: A single case study in Jakarta. *Indonesian Journal of Curriculum and Educational Technology Studies, 9*(2), 111–121. https://doi.org/10.15294/ijcets.v9i2.54034

Monib, W. K., Qazi, A., & Apong, R. A. (2025). Microlearning beyond boundaries: A systematic review and a novel framework for improving learning outcomes. *Heliyon, 11*(2), Article e41413. https://doi.org/10.1016/j.heliyon.2024.e41413

Munawarah, N. (2025). Pengembangan microlearning berbasis *station rotation* untuk pembelajaran Informatika di SMP. *Jurnal Didaktika Pendidikan Dasar, 9*(3), 999–1014. https://doi.org/10.26811/didaktika.v9i3.1980 Kemendikdasmen

Muncer, G., Higham, P. A., Gosling, C. J., Cortese, S., Wood-Downie, H., & Hadwin, J. A. (2022). A meta-analysis investigating the association between metacognition and math performance in adolescence. *Educational Psychology Review, 34*(1), 301–334. https://doi.org/10.1007/s10648-021-09620-x

Nitiasih, P. K., Santosa, M. H., Suarcaya, P., & Ratnaya, G. (2023). Micro learning media for teaching English at junior high school students. *Journal of Education Technology, 7*(4), 629–635. https://doi.org/10.23887/jet.v7i4.69627

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Prasittichok, P., & Smithsarakarn, P. N. (2024). The effects of microlearning on EFL students' English speaking: A systematic review and meta-analysis. *International Journal of Learning, Teaching and Educational Research, 23*(4), 525–546. https://doi.org/10.26803/ijlter.23.4.27

Ramadhani, R., Syahputra, E., & Simamora, E. (2024). The construct validity of self-regulated learning questionnaire for senior high school students: A Rasch model analysis. *International Journal of Evaluation and Research in Education, 13*(3), 2032–2038. https://doi.org/10.11591/ijere.v13i3.26816

Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., Koffel, J. B., & PRISMA-S Group. (2021). PRISMA-S: An extension to the PRISMA statement for reporting literature searches in systematic reviews. *Systematic Reviews, 10*, Article 39. https://doi.org/10.1186/s13643-020-01542-z

Rizky, M. F., Nurhikmah, H., & Febriati, F. (2023). Exploring the potential of microlearning for TOEFL iBT preparation among high school students. *Journal of Educational Science and Technology, 9*(3), 220–234. https://doi.org/10.26858/est.v9i3.51107

Salsabila, S., & Hapsari, A. (2026). Indonesian EFL secondary school students' self-regulated writing strategies. *JEES (Journal of English Educators Society), 11*(1), 52–59. https://doi.org/10.21070/jees.v11i1.1896

Sankaranarayanan, R., Leung, J., Abramenka-Lachheb, V., Seo, G., & Lachheb, A. (2023). Microlearning in diverse contexts: A bibliometric analysis. *TechTrends, 67*(2), 260–276. https://doi.org/10.1007/s11528-022-00794-x

Silva, E. S., da Costa, W. P., de Lima, J. C., & Ferreira, J. C. (2025). Contribution of microlearning in basic education: A systematic review. *Education Sciences, 15*(3), Article 302. https://doi.org/10.3390/educsci15030302

Silvester, S., Saputro, T. V. D., Purnasari, P. D., Sadewo, Y. D., & Kusnanto, K. (2025). Design of short-video-based microlearning for enhancing elementary students' digital literacy. *Jurnal Penelitian Ilmu Pendidikan, 18*(1), 49–58. https://doi.org/10.21831/jpip.v18i1.91011

Skulmowski, A., & Xu, K. M. (2022). Understanding cognitive load in digital and online learning: A new perspective on extraneous cognitive load. *Educational Psychology Review, 34*, 171–196. https://doi.org/10.1007/s10648-021-09624-7

Sozmen, E. Y. (2022). Perspective on pros and cons of microlearning in health education. *Essays in Biochemistry, 66*(1), 39–44. https://doi.org/10.1042/EBC20210047

Sudira, P., Inderanata, R. N., Widodo, S., Wagiran, W., & Aryani, S. T. (2026). Mobile microlearning with repeated short video access: Effects on vocational skill retention. *Jurnal Pendidikan Vokasi, 15*(3), 299–308. https://doi.org/10.21831/jpv.v15i3.95712

Susilana, R., Dewi, L., Rullyana, G., Hadiapurwa, A., & Khaerunnisa, N. (2022). Can microlearning strategy assist students' online learning? *Jurnal Cakrawala Pendidikan, 41*(2), 437–451. https://doi.org/10.21831/cp.v41i2.43387

Tang, J., Wijaya, T. T., Weinhandl, R., Houghton, T., Lavicza, Z., & Habibi, A. (2022). Effects of micro-lectures on junior high school students' achievements and learning satisfaction in mathematics lessons. *Mathematics, 10*(16), Article 2973. https://doi.org/10.3390/math10162973

Thillainadesan, J., Le Couteur, D. G., Haq, I., & Wilkinson, T. J. (2022). When I say … microlearning. *Medical Education, 56*(8), 791–792. https://doi.org/10.1111/medu.14848

Toomla, K., Hooshyar, D., Kikas, E., Malva, L., Malleus-Kotšegarov, E., & Aus, K. (2026). Tracing and supporting self-regulated learning in K-12 digital learning: A systematic review of the last three decades (1990–2024). *Educational Research Review, 51*, Article 100782. https://doi.org/10.1016/j.edurev.2026.100782 sciencedirect.com

Utama, C., Mashfufah, A., & Thohir, M. (2024). Digital pedagogy in primary education: Developing SIPEJAR microlearning to cultivate critical thinking skills. *Jurnal Eduscience, 11*(3), 747–762. https://doi.org/10.36987/jes.v11i3.6598

Utami, W. B., Setyosari, P., Sa'dijah, C., & Praherdhiono, H. (2024). Development of microlearning modules based on Candi Singasari as a culturally responsive teaching to enhance problem-solving ability. *JTP – Jurnal Teknologi Pendidikan, 26*(3), 971–984. https://doi.org/10.21009/jtp.v26i3.50120

Wira, I. B. G., Sudatha, I. G. W., Warpala, I. W. S., Parwati, N. N., & Suartama, I. K. (2026). Project-based e-learning development with a microlearning approach to improve programming learning outcomes of vocational high school students. *JKTP: Jurnal Kajian Teknologi Pendidikan, 9*(1), 10–21. https://doi.org/10.17977/um038v9i12026p010-021

Xu, Z., Zhao, Y., Liew, J., Zhou, X., & Kogut, A. (2023). Synthesizing research evidence on self-regulated learning and academic achievement in online and blended learning environments: A scoping review. *Educational Research Review, 39*, Article 100510. https://doi.org/10.1016/j.edurev.2023.100510 sciencedirect.com

Zhidkikh, D., Saarela, M., & Kärkkäinen, T. (2023). Measuring self-regulated learning in a junior high school mathematics classroom: Combining aptitude and event measures in digital learning materials. *Journal of Computer Assisted Learning, 39*(6), 1834–1851. https://doi.org/10.1111/jcal.12842