

THE IMPACT OF EXCESSIVE SCREEN TIME ON THE DEVELOPMENT OF CRITICAL THINKING IN MATHEMATICS EDUCATION STUDENTS IN INDONESIA

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Abstract

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Digital screens are an important part of higher education, but their use is not properly managed, but their use can disrupt the cognitive conditions needed for critical thinking. This integrative literature review examines the impact of excessive screen time on the development of critical thinking in mathematics education students in Indonesia. A total of 32 scientific and authoritative sources, most of which were published in 2015-2026, were synthesized with a focus on screen duration, problematic smartphone use, media multitasking, attention, self-regulation, academic performance, and critical thinking learning. Evidence suggests that screen exposure is not intrinsically harmful; greater risks are related to non-academic multitasking, compulsive device checking habits, device isolation, late night use, and replacement of deep learning or sleep time. Meta-analysis and experimental findings show a small academic negative association as well as a plausible mechanism through attention neglect, reduced available working memory capacity, and fragmented learning. The use of digital for problem-solving and information evaluation can support learning. Evidence from Indonesia confirms the existence of relevant issues related to smartphone use and critical thinking challenges, although direct causal research in mathematics education is still limited. Further research needs to combine objective device usage logs with validated math-specific critical thinking measures.

INTRODUCTION

Digital technology has become an integral part of learning in higher education. Smartphones, laptops, tablets, learning management systems, social media, video platforms, mathematics software, and generative information devices allow students to obtain learning resources, communicate, visualize mathematical objects, and complete academic assignments quickly. In Indonesia, internet access has reached a scale that makes digital participation a prevalent part of student life. The Indonesian Internet

Service Providers Association reported 221.56 million internet users with a national penetration rate of 79.5% by 2024, and Generation Z is the largest age group of users (Indonesian Internet Service Providers Association [APJII], 2024). Therefore, for mathematics education students, digital devices can function both as learning infrastructure and as a source of constant distractions.

The main problem is not just that students stare at screens for hours. Screen time is heterogeneous exposure. An hour spent making a GeoGebra representation, comparing evidence, or reading research articles cognitively differs from an hour spent scrolling through entertainment content, repeatedly checking notifications, or moving simultaneously between lectures and unrelated messages. Contemporary evidence further distinguishes the total duration of intended use, context, compulsive nature, and multitasking. Amez and Baert (2020), in a review of college-level research, found the dominance of negative associations between smartphone use and academic performance, but emphasized the large heterogeneity and limitations of many studies in supporting causal claims. Troll et al. (2021) also show that the way students manage smartphone use, including the habit of procrastinating work and device placement, can be more informative than just the number of minutes of use recorded.

This distinction is important for critical thinking. Critical thinking in higher education involves interpretation, analysis, evaluation, inferences, explanations, and self-regulation that are carried out in a directed manner, rather than simply the rapid reproduction of information. Meta-analytical evidence suggests that critical thinking skills can develop during college and through intentionally designed learning interventions, especially when learning makes the reasoning process explicit and incorporates authentic problems, dialogue, and mentoring (Abrami et al., 2015; Huber & Kuncel, 2016). Mathematics education increases these demands because students must justify procedures, identify assumptions, compare strategies, evaluate representations, detect invalid reasoning, and connect symbolic outcomes with conceptual meaning. Aizikovitsh-Udi and Cheng (2015) argue that mathematics learning can develop a disposition and critical thinking skills when learners are asked to explain, question, and evaluate, rather than just calculate.

Evidence from Indonesia also shows that critical thinking skills cannot be considered to develop automatically in mathematics students. Susilo et al. (2019), who studied 40 mathematics students in Central Java, found that overall critical thinking performance was in the medium category and performance on strategy indicators was relatively low, especially on tasks involving area area and integral certainty. A more recent systematic review of mathematics education research concludes that problem-based learning and other active approaches hold promise for improving critical thinking skills, while emphasizing the role of learning design and the meaningful integration of information and communication technologies (Nafiah et al., 2024). These findings make the quality of students' digital habits important educationally: the same devices that provide mathematical resources can support or hinder the sustained reasoning needed in critical thinking.

Research on smartphones and learning provides several plausible mechanisms. Experimental research suggests that irrelevant messages and device multitasking in the classroom can reduce the quality of note-taking, comprehension, and subsequent exam performance (Kuznekoff et al., 2015; Glass & Kang, 2019). In fact, the mere existence of a smartphone that is of personal significance can reduce the working memory capacity available under certain conditions (Ward et al., 2017). Cognitive research also links more

intense media multitasking to the occurrence of attention deficit and memory failure, although meta-analysis findings and cross-age research suggest that the effects are heterogeneous and should not be understood as a universal cognitive deficit (Madore et al., 2020; Matthews et al., 2022; Parry & le Roux, 2021). Therefore, the relevant question is not whether screens are absolutely harmful, but rather what kind of usage patterns interfere with or even facilitate critical reasoning.

This article discusses specific research gaps, namely the limited direct evidence on excessive screen time and the development of critical thinking in undergraduate students in mathematics education in Indonesia. Most of the available research examines academic performance, problematic smartphone use, distraction, attention, memory, or critical thinking separately. This review integrates these pathways to build a careful and specific interpretation of mathematics education. The aim is to clarify what can be categorized as excessive screen time in a university context, synthesize evidence on the mechanisms that link screen use behavior to processes relevant to critical thinking, identify conditions when digital media can support rather than weaken critical thinking, and formulate implications for further learning and research in mathematics education programs in Indonesia.

LITERATURE REVIEW

Screen Time, Problematic Usage, and Digital Distractions

Screen time generally refers to the time spent viewing or interacting with a screen-based device, but this concept becomes analytically weak if all activities are treated as equal. Recent evidence at the college level supports a more differentiated approach. Zeng et al. (2026), in a systematic review and meta-analysis of 72 studies involving 71,633 college students, reported that longer screen exposure was associated with a number of adverse health impacts as well as lower academic performance in the study group that examined the results. However, the dose-response threshold was not uniform for all outcomes, and the study did not justify the use of a one-time universal time limit to determine academic or cognitive impact. Therefore, in this review the term excessive screen time is used functionally: screen use is considered excessive when its duration, time of use, content, or compulsive patterns repeatedly replace sleep time or deep academic activity, cause uncontrolled task transfer, or produce measurable impairments of learning and self-regulation.

Problematic smartphone use is related to screen time, but the two are not identical. The term describes a loss of control, attention alienation or dominance, dependence-like behavior, or functional impairment, rather than just the duration of use. Paterna et al. (2024) synthesized 29 studies and reported a small negative association between problematic smartphone use and academic achievement. Sunday et al. (2021), through 44 studies involving 147,943 college students, also found a small negative association between smartphone addiction and learning, with stronger negative impacts when phones were used while studying. Hsieh (2025), who analyzed 45 studies and 84,268 college students, reported an overall small negative association between smartphone use frequency and academic performance and identified multitasking in the classroom as one of the most detrimental patterns. These results were consistent in the direction of the relationship, but also showed that the magnitude of the effect was relatively small and influenced by measurements, behaviors, and context.

Research in Indonesia is beginning to provide culturally relevant measuring tools for problematic mobile device use behaviors. Muthmainnah et al. (2025) validated the

Indonesian version of the Nomophobia Questionnaire in students aged 18-24 years and found good psychometric traits in different gender groups, problematic smartphone use rates, and different durations of daily social media use. This study does not prove that Indonesian students experience critical thinking disorders; rather, the study shows that problematic relationships with smartphones can be reliably measured in the Indonesian student population. This kind of instrument can be combined with objective device usage logs and critical thinking assessments in future mathematics education research.

Critical Thinking in Mathematics Education

Critical thinking is a generalized high-level thinking skill as well as a domain-sensitive practice. In mathematics, effective critical thinking requires field knowledge because evaluating arguments, assessing whether a representation is valid, or identifying hidden assumptions depends on conceptual understanding. At the same time, common habits such as asking for evidence, considering alternatives, monitoring the reasoning process, and delaying judgment when information is inadequate can be applied to a wide range of mathematical topics. Tiruneh et al. (2018) show that a learning environment explicitly designed for critical thinking can support general reasoning as well as field-specific reasoning when learning activities make the thinking process visible and provide opportunities for guided practice.

Mathematics education provides very suitable conditions for the development of critical thinking because a problem can be solved in a variety of ways and mathematical claims demand justification. Aizikovitsh-Udi and Cheng (2015) describe the development from dispositions such as openness and perseverance to abilities such as analysis and evaluation. In the Indonesian context, Susilo et al. (2019) show that mathematics students can perform some clarification and inference tasks better than strategic reasoning, which suggests that procedural mastery does not guarantee complete critical thinking skills. Nafiah et al. (2024) review mathematics education research and highlight problem-based learning as an often effective approach, thus reinforcing the importance of learning designs that require students to formulate, test, and defend ideas.

Cognitive Pathways: Attention, Working Memory, and Deep Processing

The most plausible relationship between excessive screen use behavior and critical thinking is attention fragmentation. Critical analysis of a mathematical argument requires students to maintain goals, store intermediate results in working memory, inhibit irrelevant responses, and compare various alternatives over time. Device alerts and phone checking habits add competing stimuli. Ward et al. (2017) found in two experiments that the mere existence of a proprietary smartphone can reduce the working memory capacity and liquid intelligence performance available, even when participants are not actively using the device. These results should not be generalized to every learning situation, but illustrate how attention control can be overwhelmed even before a real distraction occurs.

The evidence on multitasking in the classroom is more direct. Sana et al. (2013) found that multitasking using a laptop during lectures decreased comprehension in both students who multitasked and their peers. Kuznekoff et al. (2015) found that irrelevant mobile messages interfered with taking notes and learning, while messages related to lectures were less detrimental, thus confirming the importance of the type of content. Glass and Kang (2019) found that the division of attention due to the use of internet-connected devices during class decreased exam performance. Martin et al. (2025), through a synthesis of 26 studies on digital distractions, identified consequences such as skipping learning materials, shallow text processing, increased browsing and scanning

activities, and multitasking. These results are not the same as a direct decline in critical thinking, but can decrease the quality of information encoding and the continuous attention that is the basis of complex reasoning.

Memory research provides another link. Madore et al. (2020) report that attention neglect predicts memory failure and more intense media multitasking is associated with a greater tendency to lose attention and forget. Uncapher and Wagner (2018) reviewed the growing literature on media multitasking and emphasized the relationship between attention and memory, while warning of methodological inconsistencies and causal ambiguity. Parry and le Roux (2021) then conducted a meta-analysis of cognitive control findings and found a small, heterogeneous relationship, rather than a simple disorder that applies to all conditions. Matthews et al. (2022) even found evidence that technological multitasking in everyday life can go hand in hand with better performance on some measure of multitasking flexibility. Overall, these studies reject technological determinism: the problem is not that screens necessarily impair cognition, but rather that frequent interruptions can make the continuous modes of cognition needed for difficult mathematical reasoning less frequent.

Self-Regulation, Procrastination, and Time Shifts

The second pathway involves self-regulation. College students rarely use smartphones simply because the device becomes a distraction from the outside; they also use it to regulate boredom, emotions, social relationships, and assignment avoidance. Troll et al. (2021) found that self-control as an individual trait is related to distractions and problematic smartphone use, as well as that procrastination and phone placement habits help explain the relationship between self-control and academic performance. Hawi and Samaha (2016) reported a negative association between the risk of smartphone addiction and academic performance, while Samaha and Hawi (2016) linked the risk of smartphone addiction to stress and poorer academic outcomes. Previous research by Lepp et al. (2014) also found that higher cell phone use was associated with lower GPAs and higher anxiety in college students.

For math education students, time shifts can have greater consequences because mastery of concepts requires repeated engagement with non-simple problems. Students who spend the same total amount of study time but break it down into many short intervals may get less in-depth practice than students who study in uninterrupted blocks of time. Felisoni and Godoi (2018), using direct measurements of smartphone use, found a negative association between mobile device use and academic performance, with classroom use being a particularly important factor. Kates et al. (2018) also reported a negative summary relationship between mobile phone use and academic outcomes in their meta-analysis. The consistency of these findings supports concerns about excessive or irregular use, but it still leaves questions about the direction of the relationship: lower-achieving students may also use phones more often, while stress or unmeasured motivation may affect both behaviors.

Sleep, Time of Use, and Indirect Effects

Screen exposure can also affect conditions that support critical thinking indirectly through sleep and fatigue. Zeng et al. (2026) found a relationship between greater screen exposure and poorer sleep quality in college students. Sleep deprivation can lower alertness and executive function, so late-night screen use that delays bedtime can have an impact even though academic use during the day is productive. This distinction again supports the functional definition of excessive screen time. Fixed limits based solely on

the number of hours are less informative than the question of whether the device is used during lectures, interferes with problem-solving, lasts up to the time it should be used for sleep, or repeatedly hinders students from completing tasks that require high cognitive ability.

Potential Benefits and Importance of Intended Use

A balanced review should also consider the benefits of using digital media. Wilmer et al. (2017) stated that smartphones are flexible tools and can expand cognitive abilities when used wisely, although they also reviewed evidence about possible risks to attention and memory. Mathematics students routinely use screens to access dynamic visualizations, statistical software, computer algebra systems, learning videos, digital libraries, collaborative documents, and online discussions. In such situations, screen use can expand, rather than replace, cognitive processes. The most important variable is whether technology shifts low-level work to devices while still retaining students' responsibilities to interpret, justify, and evaluate.

Direct research on social media and critical thinking illustrates this duality. Cheng et al. (2024) found that social media use can be positively associated with critical thinking skills, while dependence on social media is negatively related, suggesting that access and dependence should not be equated. Galindo-Dominguez et al. (2025) found that social media functions involving information retrieval, content creation, and problem-solving are associated with higher learning competencies for learning and critical thinking, although social media function itself is a weak predictor compared to learning competence to learn. Sarafranz et al. (2026) did not find a simple direct relationship between social media addiction and critical thinking in young adults; instead, executive dysfunction mediates the relationship. These studies support a model in which self-regulation and executive control determine whether digital participation is cognitively productive or disruptive.

RESEARCH METHODS

This study uses an integrative literature review design. The integrative review was chosen because the main questions of the study include educational psychology, cognitive science, higher education, media use, and mathematics education, while direct research on screen time and critical thinking in undergraduate mathematics education students in Indonesia is still limited. Therefore, this review aims to synthesize interrelated mechanisms and limiting conditions, not to estimate a single causal effect or claim a level of completeness like the PRISMA systematic review.

Targeted searches were conducted on publications relevant to five concept groups: screen time and students; problematic smartphone use or smartphone use and academic performance; media multitasking, attention, working memory, and memory; social media and critical thinking; and critical thinking in mathematics education, including research in Indonesia. Priority is given to peer-reviewed journal articles from 2015-2026, the latest systematic meta-analyses and reviews, and empirical research with a sample of students. A small amount of research prior to 2015 was retained because it was experimental research or higher education research that was fundamental and directly relevant to multitasking devices and academic outcomes. The Indonesian context was complemented by national official reports on internet use and evidence from peer-reviewed Indonesian mathematics education research.

Sources are included when discussing at least one of the following: (a) screen duration or screen-related behavior in students; (b) problematic smartphone use or

multitasking media as well as academic results, attention, memory, or self-regulation; (c) social media use and critical thinking; (d) interventions or learning environments that develop critical thinking; or (e) critical thinking in mathematics students in Indonesia. Sources are excluded if they are in the form of non-academic opinions, duplicate reports, focus exclusively on populations that are too far removed from the context of college learning without applicable cognitive mechanisms, or contain claims that cannot be traced to scientific sources or identifiable official sources.

A total of 32 sources were retained for the final synthesis. The evidence was narratively encoded into six themes: definition and measurement of excessive screen time; attention mechanisms and working memory; media multitasking and deep processing; self-regulation and time shifts; sleep and usage time; and the use of digital intended as a moderator factor. The findings were then interpreted in relation to mathematics education tasks such as proof, gradual problem-solving, representation, argument evaluation, and strategy comparison. Since most of the available evidence was correlational or derived from samples outside Indonesia, conclusions were expressed in terms of reasonable risks, relationships, and learning implications, rather than as direct causal effects on mathematics education students in Indonesia.

RESULTS AND DISCUSSION

General Patterns of Evidence

From the literature reviewed, there are three recurring conclusions. First, screen duration is generally a less precise predictor of problematic use, multitasking, and context of use. Second, the most consistent negative relationship is related to academic performance and the learning process, rather than to directly measured critical thinking. Third, research that directly measures critical thinking shows a conditional pattern: digital and social media use can support critical thinking when students actively evaluate information, create content, solve problems, and organize their learning process, while dependency and executive dysfunction are associated with poorer functioning in aspects relevant to critical thinking. Table 1 summarizes the representative evidence on which these conclusions are based.

Table 1. Representative Evidence of Screen-Related Behaviors and Processes Relevant to Critical Thinking

Source	Key evidence	Interpretive relevance
Kates et al. (2018)	Meta-analysis; mobile phone use showed a small negative association with academic outcomes ($r = -0.16$).	It supports the existence of worry, but the effect is small and non-specific on critical thinking.
Ward et al. (2017)	Two experiments found that the available cognitive capacity was lower when participants' smartphones stood out more attentively.	Competition in working memory can interfere with gradual reasoning.
Madore et al. (2020)	Attention neglect predicts forgetting; heavier media multitasking is associated with greater memory neglect and failure.	Demonstrate the mechanism of fragmented attention to weaker retention.
Paterna et al. (2024)	A meta-analysis of 29 studies found a small negative association between problematic smartphone use and academic achievement.	Problematic usage is more informative than screen duration alone.

Source	Key evidence	Interpretive relevance
Hsieh (2025)	A meta-analysis of 45 studies found a small negative association; multitasking in the classroom was among the most detrimental behaviors.	Context and behavior moderate screen-related risks.
Cheng et al. (2024)	The use of social media is positively related to critical thinking, while dependence on social media is negatively related.	Digital media can be productive or disruptive depending on the regulation of its use.
Galindo-Dominguez et al. (2025)	Use for information, creation, and problem-solving is related to critical thinking, but learning to learn competency is a stronger predictor.	Self-regulation and learning strategies are the main moderators.
Susilo et al. (2019)	Mathematics students in Indonesia showed moderate overall critical thinking levels and low strategy performance on calculus-related tasks.	Showing the need for the development of critical thinking specific to mathematics in Indonesia.
Zeng et al. (2026)	A review of 72 student studies linked longer screen exposure to poorer academic performance and sleep outcomes.	Supports functional concerns related to time shifts and late-night use.

Attention Fragmentation as a Threat to Mathematical Reasoning

Mathematical critical thinking relies on the continuity of the thought process. A proof may require students to maintain definitions, assumptions, intermediate deductions, and final claims in an integrated mental model. Statistical problems may require students to compare multiple representations while monitoring whether the chosen procedure corresponds to the data-generating situation. Repeated shifts to messages or entertainment content incur reorientation costs: students must reconstruct the state of the problem after each interruption. Therefore, the literature on classroom multitasking, device isolation, and attention spanking has immediate relevance even though it does not specifically mention critical thinking measurements (Glass & Kang, 2019; Madore et al., 2020; Ward et al., 2017).

The educational implication is not that every phone should be permanently banned. Kuznekoff et al. (2015) found a meaningful distinction between messages that are relevant and irrelevant to lectures, while Martin et al. (2025) document the sources of distraction that come from technology as well as the learning process. A math lecturer who asks students to use a dynamic graphing tool for five minutes then shuts down the device before a proof-of-concept discussion is creating a different attention environment from the classroom that leaves the device continuously available for a move to an unrelated activity. The key is deliberate segmentation: technology is activated for obvious cognitive purposes and disabled when continuous reasoning becomes the object of learning.

Self-Regulation and the Difference between Duration and Control

The evidence also suggests that so-called "excessive" use should not be determined through a single numerical threshold. Hsieh (2025), Paterna et al. (2024), and Sunday et al. (2021) each reported a small overall negative association, but the magnitude differed by construct and behavior. Troll et al. (2021) showed that device placement habits and procrastination may be better predictors of the duration of objective use alone. Thus, two college students who both have four hours of screen exposure per day may face different risks: one student may spend most of his or her time on scheduled academic assignments, while another student checks devices uncontrollably and intermittently,

breaking up study time and procrastinating assignments. Functional definitions capture this difference better than uniform time limits.

For mathematics education programs, self-regulation needs to be treated as part of professional formation. Prospective teachers must not only be able to solve mathematical problems, but also set an example of a disciplined investigation process to their students in the future. They need to be able to recognize when online answers do not have adequate support, when computational tools produce outputs that need to be verified, and when quick searches replace, not support, conceptual reasoning. Thus, the problem of screen time is also a problem of media literacy: students need to learn to take advantage of digital conveniences without relinquishing epistemic responsibility.

Critical Thinking Doesn't Increase Just Because of Exposure

Direct research on critical thinking provides an important correction to the overly simplistic narrative of screen time. Cheng et al. (2024) show that social media use and reliance on social media may have an inverse relationship with critical thinking. Galindo-Dominguez et al. (2025) found that social media's function of acquiring information, creating content, and solving problems is related to stronger learning competencies for learning as well as critical thinking, but that social media function itself is a weak predictor. Sarafranz et al. (2026) further show that executive dysfunction may mediate the relationship between social media addiction and critical thinking. These results imply that screens do not determine the cognitive level of an activity. The same platform can be used for passive consumption, comparing evidence, providing collaborative explanations, or building arguments.

This principle is very important in mathematics. Digital devices can free working memory from repetitive calculations, display patterns through visualization, and allow for rapid testing of guesses. However, if students accept the results of a calculator or software without questioning the reasons for their validity, technology can reduce the amount of reasoning that is actually done. Therefore, productive digital tasks require an accountability structure: students need to make predictions before doing calculations, explain after doing the visualization, compare at least two methods if appropriate, and provide reasons for whether the results produced by the tool make mathematical sense. This kind of design is in line with the explicit critical thinking learning recommended by Abrami et al. (2015) and the math-focused findings summarized by Nafiah et al. (2024).

Indonesia's Context and the Direct Evidence Gap

The Indonesian context reinforces the importance of this topic without resolving causal questions. High internet penetration means that students learn in an environment with continuous connectivity as a normal condition (APJII, 2024). Muthmainnah et al. (2025) show that nomophobia constructs and problematic smartphone use can be reliably measured in Indonesian students. At the same time, Susilo et al. (2019) show that there is still room to improve the critical thinking strategies of mathematics students. What is still not available is a study that simultaneously measures digital behavior and mathematics-specific critical thinking in the same sample of Indonesian students over time.

Thus, the claim that excessive screen time directly causes the weakening of the critical thinking skills of mathematics education students in Indonesia would go beyond the currently available evidence. A stronger conclusion supported by evidence is that some common screen use behaviors can interfere with attention, memory, sleep, and self-regulation, all of which are important conditions for sustained critical reasoning. This risk pathway is theoretically coherent and empirically supported, but still requires direct

testing on the target population. This distinction is important for scientific accuracy and to avoid moral panic towards technology.

Practical Implications for Mathematics Education Programs

The literature supports a series of interventions that are proportionate and focus on behavior, rather than blanket prohibition. First, lecturers can establish device-free deep work intervals for proofing activities, complex problem-solving, and individual reasoning, while allowing the use of devices in computing or visualization activities where the purpose is clearly defined. Second, students can use focus mode, group notifications at specific times, and put phones out of range when working on demanding tasks; Ward et al. (2017) and Troll et al. (2021) provide a basis for reduced isolation and habitual access. Third, lectures can explicitly teach metacognitive monitoring by asking students to record when and why they switch assignments and compare their perceptions to objective log screen time.

Fourth, assignments should demand epistemic products that cannot be solved simply by copying digital answers, such as annotated completion paths, error analysis, comparison of competing strategies, written justification, and reflection on assumptions. Fifth, educators need to protect sleep-related routines by avoiding unnecessary late-night communication norms and teaching students to distinguish urgent academic communication from demands to be always available. Sixth, study programs need to integrate media and information literacy with mathematical pedagogy so that students learn to evaluate online explanations, verify computational outputs, and distinguish authoritative mathematical evidence from algorithmic popularity or visibility.

These recommendations are deliberately made more specific than just a recommendation to "reduce screen time". Reductions in general may be beneficial for some students, but learning success depends on reducing the forms of use that are most likely to break down the thought process as well as increasing forms of digital use that demand explanation and evaluation. Table 2 presents a practical framework that links screen-related risks to the consequences of math learning and proportionate responses.

Further Research Direction

Further research in Indonesia should go beyond cross-cutting self-report designs. A robust design can involve mathematics education students from several universities and combine objective smartphone screen time logs with activity categories, validated measures of problematic or nomophobia use, sleep indicators, and math-specific critical thinking tasks. Repeated measurements over a semester will help distinguish relatively stable individual differences from changes related to lectures and digital habits. Where ethically possible, random or quasi-experimental interventions can compare reduced notifications, phone placement, or structured deviceless problem-solving periods with usual practices.

Critical thinking outcomes should be domain-sensitive. Instead of relying solely on a general self-report scale, researchers can use tasks that ask students to analyze erroneous solutions, evaluate proofs, compare multiple representations, justify statistical conclusions, and choose strategies under conditions of incomplete information. This will align the outcome measurement with the cognitive work that is actually expected of a prospective math teacher. Researchers also need to separate total screen time from academic screen time, use for entertainment, social media use, classroom multitasking, and late-night use. This separation is important because the literature reviewed repeatedly shows that the purpose and regulation of use moderates the relationships found.

Finally, future research should test mechanisms, not just correlations. Executive function, learning competence to learn, self-control, attention span, sleep quality, and procrastination are plausible mediators and supported by this review (Galindo-Dominguez et al., 2025; Madore et al., 2020; Sarafraz et al., 2026; Troll et al., 2021; Zeng et al., 2026). Showing whether these variables statistically or experimentally explain changes in math-specific critical thinking would provide a more actionable basis for college policy than simply a separate relationship between the number of hours of daily use and test scores.

Table 2. Functional Screen Time Management Framework for Mathematics Education

Screen-related risks	Possible consequences of learning	Proportionate educational response
Fast notifications and task moves	Incomplete representation of the problem; repeated reconstruction of the state of proof or solution.	Use focus modes and device-less deep work blocks when proofing, modeling, and troubleshooting complex issues.
Phone isolation within range	Working memory resources can be used to resist the urge to check the device.	Place the phone out of direct range when performing high-load reasoning; reuse the device for obvious academic purposes.
Use of entertainment or social media while studying	Time shifts, procrastination, superficial processing.	Schedule entertainment time; use app limits and conduct an objective review of weekly screen time.
Use of late-night screens	Sleep disturbances and decreased alertness the next day.	Set communication limits and a routine to reduce device usage before bed.
Passive acceptance of digital answers	Reduced justification, error detection, and epistemic responsibility.	Require prediction, written reasoning, source evaluation, and verification of the results produced by the tool.
The use of mathematical technology aimed at	Can support collaborative visualization, experimentation, and explanation.	Use dynamic devices strategically, then ask students to explain why the results are mathematically valid.

CONCLUSION

This integrative review shows that excessive screen time can reasonably inhibit the development and expression of critical thinking in mathematics education students when screen use behaviors distort attention, increase nonacademic multitasking, replace deep study or sleep time, and become difficult to control. Meta-analyses in college students generally show a small negative relationship between problematic or frequent smartphone use and academic outcomes (Hsieh, 2025; Paterna et al., 2024; Sunday et al., 2021), while experimental and cognitive research provide explanations for mechanisms such as divided attention, reduced working memory capacity, attention neglect, and disruption of the learning process (Glass & Kang, 2019; Madore et al., 2020; Ward et al., 2017). The mechanism is educationally relevant because mathematical critical thinking requires continuous maintenance of goals, conceptual integration, alternative evaluation, and justification.

At the same time, the available evidence does not support the claim that screen exposure is intrinsically harmful or that a single universal daily hour threshold can define excessive use for all students. Digital devices can support critical thinking when used intentionally for information evaluation, mathematical visualization, content creation, collaborative explanation, and problem-solving. Research on social media use and critical thinking shows that dependence, executive function, learning competence to learn, and purpose of use can be more informative than exposure alone (Cheng et al., 2024; Galindo-Dominguez et al., 2025; Sarafraz et al., 2026). Therefore, excessive screen time should

be functionally defined as a pattern of duration, time of use, or compulsive traits that repeatedly interfere with learning, sleep, or self-regulation.

For mathematics education programs in Indonesia, the practical implication is to manage digital attention, not reject digital technology. Lecturers can combine the use of structured technology with device-free intervals for deep reasoning, designing tasks that demand justification rather than simply retrieving answers, teaching students to verify digital outputs, and encouraging objective monitoring of screen use habits. These strategies are consistent with evidence that critical thinking develops through explicit reasoning exercises, authentic problems, dialogue, and guided reflection (Abrami et al., 2015; Tiruneh et al., 2018).

A major limitation of this review is that there is still a lack of direct research that simultaneously measures screen use behavior and mathematics-specific critical thinking among undergraduate students in Indonesia. Most of the evidence comes from academic performance or cognitive processes as well as populations outside Indonesia, so the application of causal relationships to the Indonesian context should be done with caution. Future multi-location longitudinal and experimental research should incorporate objective device usage logs, usage context categories, sleep measures and self-regulation, and validated math-specific critical thinking tasks. Such evidence will enable universities to move away from general concerns about screen time to more precise and evidence-based digital learning practices.

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