# Doctoral Learners' Perceptions of Metacognitive Prompts and Cognitive Load in Multimedia Learning: Mixed Methods Study

Authors:

Tom Brown, Samantha Lawson Davis, Timothy Mosunich, Sara Ortiz, Ricky Ratcliff,

Tyler Stike, Jaisri Thoppay, Percy Wong

## Abstract

While metacognitive prompts (MCPs) are intended to support learning and self-regulation, their impact on cognitive load (CL) in multimedia learning environments is mixed. Well-designed prompts can ease mental effort in some situations, but poorly timed ones can disrupt engagement and increase mental effort. This study examines how doctoral students, who regularly face high cognitive demands, perceive MCPs and their influence on cognitive load within multimedia learning environments. The purposes of this study were to 1) examine doctoral students' perceptions of the use and effectiveness of MCPs in multimedia learning environments and to integrate quantitative and qualitative findings to understand how MCPs influence perceived cognitive load and support learning performance; 2) statistically examine the relationship between perceived MCP use/effectiveness and experienced cognitive load; and 3) understand how individual differences, content complexity, and media influence the effectiveness of reflection and the impact of MCPs on learners' mental effort and emotional regulation. This mixed-methods study combines quantitative survey data and qualitative open-ended responses to help inform the design and use of MCPs to better support doctoral students' focus and learning while minimizing cognitive load.


## Perspective

This study is grounded in Cognitive Load Theory (CLT; Sweller et al., 2019) and Metacognitive Theory (Flavell, 1976; Zimmerman, 2008). CLT posits that instructional design influences learners' cognitive processing by affecting three distinct types of loads: intrinsic, extraneous, and germane. Intrinsic load reflects the inherent complexity of the material, extraneous load arises from poorly designed instruction, and germane load supports schema

construction and meaningful learning. Effective instructional interventions seek to reduce extraneous load while promoting germane load.

Metacognitive Theory emphasizes the role of learners' awareness and control of their own cognitive processes. Metacognition includes planning, monitoring, and evaluating one's own learning strategies. Metacognitive prompts (MCP) are instructional elements designed to encourage such reflection. Zimmerman (2008) and Eggers et al. (2024) support the potential of metacognitive prompts to promote deeper engagement, self-regulation, and ultimately improved learning outcomes.

In multimedia learning contexts, integrating metacognitive prompts may serve dual roles: enhancing self-regulation and increasing germane cognitive load. However, if poorly timed or overly frequent, they may contribute to extraneous cognitive load. The current study explores this delicate balance, aiming to understand whether the perceived benefits of metacognitive prompts outweigh any additional mental effort they may impose.

This study uses a mixed-methods approach to assess the impact of metacognitive prompts on cognitive load (CL). The qualitative data uses participant feedback to complement the quantitative findings, offering a deeper understanding of how metacognitive strategies are perceived and implemented by learners.

## Methods

This study adopted a mixed methods concurrent design to investigate doctoral students' perceptions of metacognitive prompts (MCP) and cognitive load (CL) within online multimedia learning environments, and to what extent metacognitive prompts improve cognitive load management and performance in their doctoral coursework.

Participants (n=27) were recruited from a university doctoral program. Data were collected using a survey containing validated Likert-scale questions on MCP and author-developed Likert-scale and open-ended questions on CL. Quantitative data were analyzed using descriptive statistics and Spearman rank correlation to examine the relationship between MCP and CL. Qualitative data from open-ended responses were analyzed using thematic analysis to identify patterns in participants' experiences with MCP and their impact on cognitive load management. The study context was online multimedia learning modules within participants' doctoral coursework.

## Data Source

For this study, 27 doctoral student participants completed surveys assessing two constructs: "Metacognitive Prompts" (MCP) regarding awareness/use of metacognitive strategies, and "Cognitive Load" (CL) concerning the perceived impact of these prompts. A 5-point Likert scale (where 1=Strongly Disagree, 5=Strongly Agree) was used. There were thirteen 5-point Likert scale questions on MCP, and nine 5-point Likert scale questions on CL. Additionally, there were two open ended questions regarding CL.

The MCP questions came from a validated instrument from the University of Florida College of Education. The Cronbach's α for the MCP questions was 0.90, which demonstrates excellent internal consistency. The CL questions were created by the authors of the survey. The Cronbach's α for the CL questions was 0.70, which is acceptable internal consistency. Additionally, one of the CL questions was phrased negatively, the responses to this question were reverse-coded. The Cronbach's α was calculated on the recoded data. OBJ

## Results

### Quantitative Results

Quantitative descriptive analyses (n=27) indicated doctoral students reported high awareness and frequent use of metacognitive strategies prompted by MCP ($M = 4.01$, $SD = 0.27$; Cronbach's $\alpha = .90$), coupled with moderate perceived cognitive load associated with these prompts ($M = 3.70$, $SD = 0.29$; Cronbach's $\alpha = .70$). A Spearman rank correlation analysis found a statistically significant, moderately strong positive relationship between MCP and perceived cognitive load ($r = .57$, $p < .001$), suggesting higher metacognitive engagement prompted by MCP correlates with increased cognitive load.

**Qualitative Results**

Qualitative thematic analysis of participants' open-ended responses revealed considerable variability in their experiences (Cohen's Kappa = 1.00; Percent Agreement > 83%), underscoring the robustness of these findings. Participants consistently described a dual nature of MCP effects:

- **Positive** experiences included using prompts as a cognitive aid to "organize thoughts" or as an emotional relief, described by participants as "brain breaks."
- **Negative** experiences involved MCP perceived as "mentally exhausting," "distracting," or disruptive, particularly when prompt design was poorly matched with learner preferences or content complexity.

Prompt effectiveness was notably influenced by:

- Prompt type (guidance vs. reflective questions)
- Contextual factors (content complexity, learner autonomy)
- Delivery modality, with video prompts consistently preferred over text.

**Integrated Findings**

Integrating qualitative and quantitative results illuminates a nuanced picture: while doctoral students clearly value MCP as tools for enhancing metacognitive awareness and

regulation, these prompts are inherently cognitively demanding. The qualitative insights reveal the critical distinction between productive germane cognitive load—facilitating deeper processing and meaningful learning—and extraneous cognitive load, stemming from prompts that are poorly timed, contextually inappropriate, or modality-mismatched. The moderately strong correlation ($r = .57$) quantitatively substantiates this duality, indicating that enhanced metacognitive engagement is intrinsically linked to increased cognitive load, which is contextually determined.

**Summary of Key Findings**

- Participants have high MCP awareness/use.
- MCPs moderately increase cognitive load perceptions.
- Statistically significant positive correlation between MCP engagement and cognitive load.
- Dual nature of MCP: both beneficial (germane load) and burdensome (extraneous load), dependent on context and design.

## Conclusion

This study contributes empirical evidence illuminating the complex interplay between metacognitive prompts and cognitive load within advanced multimedia learning contexts. Critically, it underscores that effective metacognitive scaffolding inherently increases cognitive load, challenging assumptions that prompts always ease learner effort. Instructional designers and educators must strategically tailor MCP implementation by carefully considering:

- Prompt timing and frequency (avoiding unnecessary interruption)
- Modality preferences (prioritizing video prompts over text)
- Prompt design (clarifying the intent: reflective vs. directive guidance)

- Contextual factors (learner control, complexity of content)

Future research should focus on developing personalized and adaptive metacognitive support systems, possibly leveraging AI-driven adaptive learning technologies, to dynamically adjust prompt types, timing, and modalities to each learner's evolving cognitive and affective states. Such research would further refine our understanding of how tailored scaffolding can optimize cognitive engagement while minimizing extraneous cognitive burdens.

## Scholarly Significance

This study supports significant scholarly value as it bridges two foundational learning theories Cognitive Load Theory (CLT) and Metacognitive Theory to explore the complex relationship between MCPs and CL in multimedia learning environments. The CLT provides the framework for understanding how our instructional design influences learning through intrinsic, extraneous, and germane loads (Flavell, 1976), while Metacognitive Theory emphasizes learners' awareness, ability to self-regulate, and evaluation of cognitive strategies to explore how MCPs can support meaningful learning and execute cognitive demands.

A key scholarly contribution of this research is its focus on advanced learners, in this case, doctoral students, who face high cognitive demands and are expected to self-regulate effectively while understanding the complex interactions between emotion, motivation, cognition, metacognition, and behavior (Zimmerman, 2008). Using a mixed-methods design, this study combines quantitative analysis (e.g., Spearman correlation, descriptive statistics) with qualitative thematic insights to validate and deepen understanding. The results reveal a moderately strong positive correlation between MCP use and cognitive load, suggesting that while MCPs promote metacognitive engagement and germane load, they may also contribute to extraneous load if the information is poorly designed or delivered.

The practical implications for instructional design emphasize the importance of prompt timing, delivery modality, and the significance of context relevance (Wong, et al., 2022). One specific challenge of the study is the assumption that MCPs are universally beneficial and highlight the need for strategic, learner implementation. Overall, this study imparts valuable theoretical, methodological, and practical insights that advance the field of educational technology and learning sciences, particularly in the design of effective, cognitively supportive multimedia instruction.

## References

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