



Exploring metacognitive regulation activities and their roles in prompt literacy development among humanities and social science researchers in GenAI

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Abstract

Introduction. Generative artificial intelligence (GenAI) has profoundly influenced research paradigms in the humanities and social sciences (HSS) while imposing greater demands on users' prompt literacy. There is an urgent need for empirical inquiry into how HSS researchers leverage metacognitive regulation activities to develop prompt literacy.

Method. Seventeen HSS researchers were recruited to participate in semi-structured interviews designed to examine their metacognitive activities and prompting behaviors when interacting with GenAI and to explore the role of metacognition in developing prompt literacy.

Analysis. The interview data were analysed using thematic analysis, with initial coding and theme identification conducted through iterative clustering.

Results. Our research shows that metacognitive regulation activities—planning, monitoring and evaluation—enhance prompt literacy in HSS researchers through four distinct stages. Prompt literacy manifests as a normative attitude toward prompts, the ability to design prompts, the ability to evaluate prompts, and the ability to think critically about prompting.

Conclusions. These findings reveal how metacognitive regulation shapes prompt literacy and provide theoretical and practical insights for cultivating prompt literacy in the GenAI era.

Introduction

AI literacy, as a key competence for understanding and applying artificial intelligence, has in recent years become one of the topics widely discussed in academia (Ng et al., 2021). The rapid advancement of Generative Artificial Intelligence (GenAI) is reshaping the way humans think and learn (Han et al., 2025; Yan et al., 2024), while simultaneously transforming research paradigms in the humanities and social sciences (HSS) (Grossmann et al., 2023). In this process, AI literacy has extended into the more specialised domain of prompt literacy, a new form of literacy in the context of human-AI collaboration (Hwang et al., 2023). However, many knowledge workers still face challenges when using GenAI (Jia et al., 2025), such as inadequate prompt design skills, insufficient critical thinking abilities, and difficulty assessing information quality and credibility (Lee et al., 2025). Therefore, cultivating prompt design capabilities among HSS researchers is crucial for leveraging GenAI to drive innovation in these fields.

When interacting with GenAI, users must identify task requirements, plan prompting strategies, monitor system outputs, and refine prompts iteratively (Lo, 2023a; Tankelevitch et al., 2024). This cyclical process exemplifies metacognitive regulation and represents search as learning (SAL) within GenAI environments (Zhao et al., 2025). Understanding the metacognitive regulation mechanisms underlying effective prompt formulation is essential for improving prompt literacy (Gagnière et al., 2012; Saks & Leijen, 2019). The main research questions are as follows:

RQ1. What typical metacognitive regulation activities are exhibited by HSS researchers when interacting with GenAI?

RQ2. How do these activities contribute to the prompt literacy development among HSS researchers?

The study aims to deepen the understanding of cognitive regulation activities in human-AI collaboration by exploring these questions. It also seeks to provide theoretical and practical insights for improving prompt literacy and designing human-centered GenAI systems. Additionally, our study aims to strengthen the utilitarian value of GenAI in HSS research.

Literature review

Research on prompting behaviors and prompt literacy remains in its infancy. On one hand, existing studies predominantly adopt a technical perspective, focusing on the investigation of prompt engineering (White et al., 2023) and how to design prompts that enhance the reliability of GenAI models (Liu & Chilton, 2022). On the other hand, scholars have clarified the concept of prompt literacy (Federiakin et al., 2024; Gattupalli et al., 2023; Hwang, 2023; Lo, 2023b) and have explored practical approaches to cultivating it. Notably, university libraries have emerged as the primary agents in this endeavor (Krakowska & Zych, 2025; Lo, 2023; Lund, 2023). Only a handful of empirical studies—typically using user experiments—have examined the impact of prompt literacy on human-AI interaction (Hwang et al., 2023; Kim et al., 2025; Knoth et al., 2024; Zamfirescu-Pereira et al., 2023).

From a macro perspective, metacognitive activity typically encompasses three core elements: metacognitive knowledge, regulation, and experience. In the context of human-AI interaction, metacognitive activities has received some attention (Juhaňák et al., 2025; Urban et al., 2024). Compared to traditional search as learning contexts, GenAI environments present users with diverse metacognitive challenges throughout the prompt design, interaction, and evaluation processes (Tankelevitch et al., 2024). At the micro level, metacognitive prompts have expanded from computer-assisted or mediated learning environments to human-AI collaborative scenarios (Wang & Zhao, 2023). For example, Lee et al. (2024) developed the ChatGPT-assisted Learning Aid (GCLA), which provides prompts rather than direct answers to guide students and foster adaptive learning abilities, higher-order thinking skills, and other metacognitive developments.

Although research on metacognitive activities is well-developed, analyses of individual metacognitive levels in GenAI contexts are scarce. Grounded in metacognitive theory (Schraw & Moshman, 1995), this study examines the full research workflow of HSS scholars using large language models and GenAI tools for academic tasks and scholarly communication. In particular, this study explores how metacognitive activities and regulation processes promote the development of prompt literacy among HSS researchers.

Method

Participants

This study employed semi-structured interviews to elicit participants' in-depth reflections on the relationship between their prompting strategies, cognitive regulation, and research goals. This method emphasises understanding participants' experiences in specific contexts (Matysek, 2023), making it well-suited for capturing the complex cognitive and prompting behavior patterns that emerge when HSS scholars interact with GenAI.

From April 3 to April 13, 2025, recruitment posters were distributed on the popular social media platform Xiaohongshu, initially reaching 28 potential participants. To ensure data quality, the final interview sample consisted of 17 HSS researchers, exhibiting diversity in gender, educational background, disciplinary fields, research focus, and years of research experience. Interviews were conducted either online via Tencent Meeting or in person. Participants included 8 males and 9 females, ranging in age from 20 to 45 years old, with research experience spanning 2 to 15 years.

Data collection and analysis

The interviews were guided by the research questions that focused on the participants' specific approaches of prompt design. Participants were encouraged to share the challenges they encountered during interactions with GenAI and their suggestions for the future application and improvement of GenAI tools in research. Each interview lasted approximately 60 minutes. After obtaining informed consent, all interviews were audio-recorded and transcribed for analysis.

Data were analysed using NVivo 15, following the thematic analysis procedure proposed by Braun and Clarke (2006). This process includes data familiarisation, initial coding generation, theme development, theme review, and final theme definition and naming (Braun et al., 2019). The research team repeatedly reviewed and interpreted the transcripts in relation to the research questions, identifying major themes and subthemes by clustering semantic units (Terry et al., 2017). To ensure analytical reliability, two additional senior researchers conducted independent coding. The team held multiple meetings to verify that potential themes aligned with coded segments and the overall dataset. In cases of disagreement, the relevant segments were reanalysed following the same procedure. Consensus was reached through cross-checking and negotiation. Inter-coder reliability, assessed using Cohen's Kappa coefficient, exceeded 0.8 for all themes, indicating high consistency.

Findings

Types of metacognitive regulation activities in the interactions of HSS researchers with GenAI

Based on the three dimensions of metacognitive regulation activities—metacognitive planning, monitoring, and evaluation—a coding analysis was conducted on the types of metacognitive regulation activities exhibited by HSS researchers in their interactions with GenAI. Table 1 presents the specific categories.

Metacognitive Regulation Activities	Subcategories	Specific Information Activities
Metacognitive planning	Define the query task	Knowledge retrieval; Text comprehension; Language processing; Contextual expression; Cognitive restructuring; Academic writing
	Formulate the prompt structure	Formulate the prompt language structure; Formulate the prompt logical structure
Metacognitive monitoring	Progress monitoring	Prompt_task alignment; Prompt_generated content consistency; Logical bias detection; Generated content and format verification
	Error detection in AIGC	Identification of AI hallucination; Recognition of AI sycophancy; Awareness of potential bias
	Adjust prompt strategies	Detect informational bias; Refine prompt instructions; Coordinate multimodal prompts; Cross-GenAI model collaboration
	Remove obstacles	Self-verification of information; Prompting GenAI to correct errors; Prompt query and save
Metacognitive evaluation	Evaluation of prompt	Evaluation of prompt effectiveness; Internalisation of prompting strategies
	Assessment of goal attainment	Task completion assessment; Efficiency reflection; Evaluation of insightfulness

Table 1. Types of metacognitive regulation activities in GenAI interaction.

In the prompting process of HSS researchers, metacognitive planning is primarily reflected in clarifying task objectives and considering how to design prompts to convey information needs. Most participants reported that they first determined the type of task to be completed with GenAI assistance, and then designed the prompt structure accordingly. As one participant explained, *‘When using Doubao to polish English writing, I can use technical terms in English to maintain rigor and consistency while expressing my own logic and ideas in Chinese. This ensures the accuracy of the terminology’* (R7).

Furthermore, they systematically monitor the compatibility of prompts with tasks and generated content. They also assess whether ongoing interactions advance toward established objectives and proactively detect misinformation generated by GenAI. For example, R13 noted, *‘Large language models adjust their wording based on the tone of my query. Indeed, some information is either not mentioned or cannot be verified, yet they still generate answers that satisfy you.’* Upon identifying issues, HSS researchers make corrections and optimisations by adjusting prompts. For example, one participant said, *‘The AI’s response was not sufficiently connected to previous interactions, so it is necessary to add <please refer to your previous answer>’* (R11).

Upon identifying issues, HSS researchers engage in metacognitive adjustment to correct and optimise the outputs. They assign roles, supplement content, and revise based on GenAI-

generated suggestions, gradually accumulating reusable prompt strategies. As R9 shared, 'For more academic questions, I need to provide the AI with a prompt such as <Assume you are an expert in specific field> to obtain more effective answers, rather than receiving vague responses.' Another participant emphasised, 'I have summarised some effective prompt templates, so that I can use them directly in similar situations in the future' (R4).

The roles of metacognitive regulation activities in cultivating prompt literacy among HSS researchers

Based on metacognitive theory (Schraw & Moshman, 1995), this study adopts a metacognitive regulation perspective to examine the prompt design process among researchers in HSS. It investigates the role of metacognitive regulation activities across different stages of prompt literacy development, as illustrated in Figure 1. The length of each rectangle represents the proportion of different metacognitive regulation activities (i.e., planning, monitoring, evaluation) reported by participants at each stage.

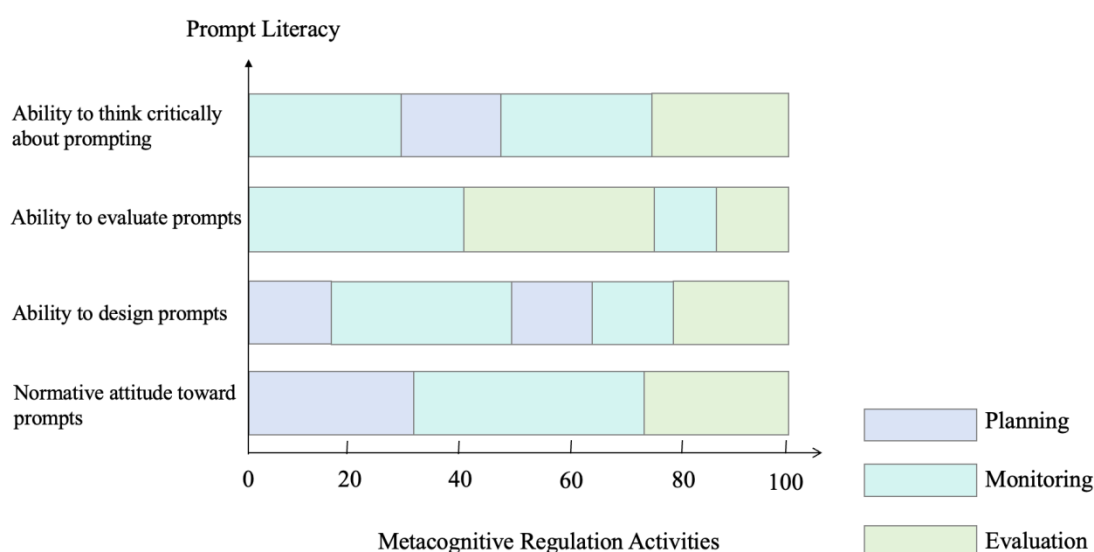


Figure 1. The roles of metacognitive regulation activities in the development of prompt literacy.

Stage 1: Normative attitude toward prompts

In the cultivation of prompt literacy among HSS researchers, the enhancement of the normative attitude toward prompts is reflected in their ability to design prompts that ensure the generated content complies with academic norms, such as grammatical accuracy, proper citation of references, appropriate attribution of data source, and accurate translation. This process is continuously driven through the metacognitive cycle of '**planning—monitoring—evaluation**'.

First, HSS researchers would clarify their inquiry objectives and explicitly articulate their intentions. For instance, R5 stated, 'This time I mainly used GPT to polish an English proposal, the prompts were pretty simple, like just <polish + draft>'. Next, participants indicated that they would verify the form of AIGC. Through this monitoring progress, they can immediately identify errors and biases. For example, R11 noted, 'Gemini Pro still generates fake sources.....it returned a fake reference.' Then, some participants reported that they took targeted corrective measures, such as constraining output structure of GenAI and directly instructing it to correct errors. Finally, they would evaluate the validity of the generated results. As one participant explained 'In translating long sentences, AI may omit some information unless you specifically ask it to pay attention to sentence structure and contextual relationships, and doing so usually gives more accurate translations' (R8).

Stage 2: Ability to design prompts

To develop prompt design ability, researchers' metacognitive regulation activities often follow a dynamic sequence of '**planning—monitoring—planning—monitoring—evaluation**'. The key to this process lies in how clearly the problem is articulated so that the prompts can better convey HSS researchers' information needs.

During the initial planning process, HSS researchers formulate preliminary prompt design based on a clear understanding of the research task. For example, R17 stated, *'I first need to think through in my mind what problem I am trying to solve.....Am I describing this problem in the right way? Once I feel it is appropriate, I proceed to ask the AI.'* Next, in the monitoring phase, they review the AIGC, focusing on whether the content contains key information and whether the presentation of figures and tables is appropriate. When discrepancies are found between the generated content and the expected outcomes, HSS researchers engage in a second round of planning, in which they refine the steps of their prompt design and attempt to address the issue through new formulations. For instance, one participant noted, *'The first generated image was too dark and the main subject was unclear. I realised this wouldn't work, so I started think about adding a requirement for <brightness>'* (R11). Finally, during the evaluation progress, those researchers reflect on the effectiveness of their prompting strategies and internalise the useful ones as part of their prompting skills. As R14 described, *'I decided to use the prompting tips I learned from Bilibili, and asked it to generate the figures in HTML format. After a few tries, I was satisfied with the results.'*

Stage 3: Ability to evaluate prompts

This Stage demonstrates the construction process of the ability to evaluate prompts. By iteratively engaging in metacognitive processes of '**monitoring—evaluation—monitoring—evaluation**', HSS researchers continuously assess the effectiveness of prompts and determine whether the generated content is complete, reasonable, and clear.

Specifically, when HSS researchers notice that the generated results drift away from their disciplinary domain, contain inconsistencies, or raise doubts about its authenticity, they take steps to refine it. This can involve correcting errors or rephrasing the prompts. In some cases, they even conduct cross-platform verification, drawing on their professional expertise. For example, one participant explained, *'When DeepSeek generates content, I sometimes even have to look it up online. It sounds so convincing'* (R4). Through repeated metacognitive monitoring and evaluation, researchers gradually cultivate a routine of multidimensional evaluation. As R16 described, *'This time I used DeepSeek + Kimi to create course PPT, but its format didn't really meet my needs.....I provided a more detailed description of the requirements context.'*

Stage 4: Ability to think critically about prompting

Through a dynamic sequence of '**monitoring—planning—monitoring—evaluation**', HSS researchers gradually deepen their understanding of research questions and enhance their critical thinking about prompt design when interacting with GenAI.

In the process of engaging with large language models, they continuously evaluate the alignment between the generated content and their research needs. For example, R5 noted, *'I don't just follow GPT's suggestions directly—like when it asks <Do you want me to draft the proposal structure?>. Instead, I'd follow up with other questions, kind of in a more exploratory, divergent way.'* Some participants actively examine the AI's reasoning logic. As R1 remarked, *'DeepSeek's reasoning logic gives me new directions or topics to think about, and that becomes the inspiration for my follow-up question.'* Next, most researchers said they would either redesign prompts or collaborate across different models. For instance, *'I have already fed ChatGPT too much. So, I'll throw the same question to Gemini and see what kind of different answer it gives me, then compare the results'* (R10). During ongoing interactions, researchers' critical thinking became gradually stimulated, leading to deeper understanding of research questions. R3 illustrated this process, *'A prompt is like a condensed*

version of a paper outline After debating back and forth with ChatGPT, I can see which points might not really hold up.'

Discussion

This ongoing study takes an exploratory, qualitative approach based on the metacognitive theory to preliminarily investigate the typical metacognitive regulation activities in HSS researchers' interactions with GenAI. Our findings indicate that these activities promote the development of HSS researchers' normative attitudes toward prompts, their ability to design and evaluate prompts, and their critical thinking skills regarding prompting, across four distinct stages. Moreover, the metacognitive regulation activities of planning, monitoring, and evaluation emerge in different sequences and with varying proportions across different stages. Theoretically, this study supplements and extends existing research on AI literacy, enriching the understanding of its core competencies (Knoth et al., 2024; Long & Magerko, 2020; Ng et al., 2021). Furthermore, it broadens the application of metacognitive theory (Flavell, 1979) in GenAI contexts by highlighting the role of metacognitive regulation activities in developing prompt literacy. This offers new perspectives cognitive regulation in complex human-AI collaborative tasks (Nguyen et al., 2024).

The practical implications of this study are as follows. First, from the perspective of information professionals, academic libraries can serve as bridges to support HSS researchers, providing resources and methodological guidance (Yang et al., 2025), thereby fostering their prompt literacy. Second, in terms of higher-order digital literacy (Julien, 2018), efforts should focus on strengthening HSS researchers' training in critical thinking during the prompting process, which can foster human-AI collaborative innovation. Third, from a metacognitive control viewpoint, attention should be paid to fostering the ethical awareness and normative understanding, guiding HSS researchers to formulate prompts to GenAI in a proper and compliant manner (Ji et al., 2023).

Limitations and future work

As part of an ongoing study, this research has several limitations. First, the study focuses on the role of metacognitive regulation in enhancing prompt literacy. Future research could expand on this by exploring how metacognitive knowledge and experience influence prompt literacy among HSS researchers. Second, while this study emphasises different types of research tasks, further investigation is needed on how HSS researchers approach creative learning tasks. Specifically, it should explore how they engage in prompting behaviors to bridge the cognitive and content gaps between their research objectives and the content produced by GenAI.

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