The risk of AI chatbots in engineering students' critical thinking, analytical, logical skills, and self-learning motivation attitude

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EXTENDED ABSTRACT

Large Language Models (LLMs), such as ChatGPT, Gemini, and DeepSeek, can help students solve their homework, summarize learning content, and write academic work. Because of their convenience and speed, LLMs are widely used in education. However, using LLMs too much can affect students' thinking skill development. This study focuses on how LLMs might reduce students' development of critical, analytical, and logical thinking skills. And these three thinking skills might affect students' self-learning motivation.

In this study, critical thinking skill is defined as a careful and self-regulatory judgment that includes evaluation, analysis, interpretation, and inference, as well as a clear explanation of what evidence, concepts, or conditions the judgment is based on (Facione 1990, 2015). Analytical thinking skill refers to the ability to break down the complex components of information, arguments, or problems into smaller parts, identify the relationship among the parts in order to understand or solve problems (Halpern, 1998). Logical thinking skill is the ability to apply systematic reasoning, both deductive and inductive, to draw conclusions from evidence or assumptions in order to understand problems, make decisions, and find effective solutions, while being aware of cognitive biases that can distort decisions away from true reasoning (Davidson & Sternberg, 2003). The term self-learning motivation is internal drive and confidence that students have in their ability to study independently and with eagerness, without relying on external support, particularly the tools that provide solutions and answers for them, such as LLMs.

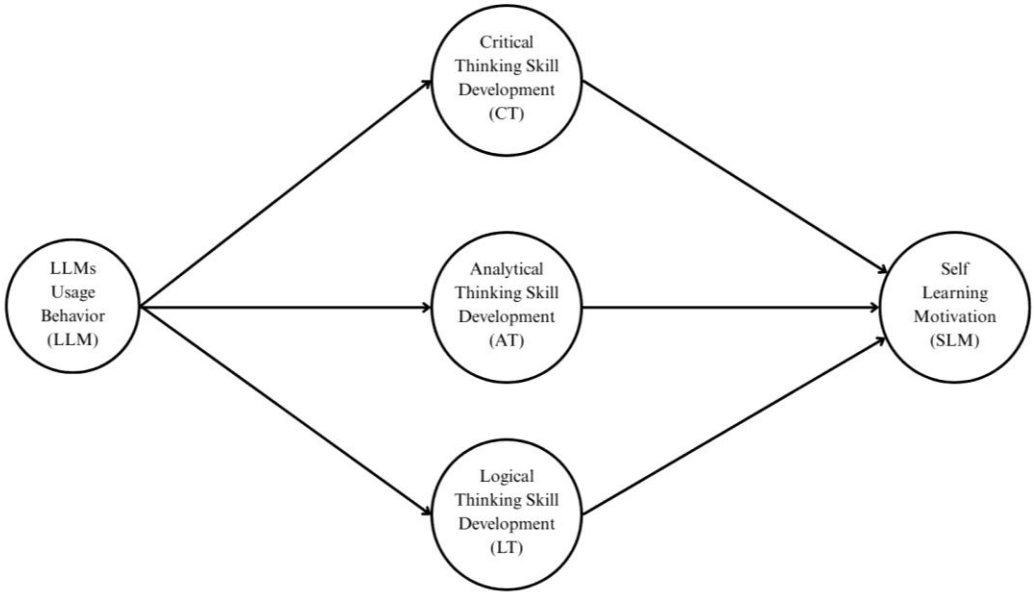

Figure 1: Conceptual Framework for Analyzing the Impact of LLM Usage on Cognitive Skill Development and Self-Learning Motivation

The conceptual framework was developed by reviewing the previous studies on the effects of AI tools on students' cognitive development. Overreliance on LLMs has been found to negatively affect cognitive ability (decision-making, critical thinking, and analytical thinking) because students tend to accept AI-generated answers without verification, which reduces their ability to think on their own and leads to cognitive offloading (Zhai et al., 2024). Frequent LLMs use may also decrease deep thinking activity, resulting in reduced cognitive development (Gerlich, 2025). Similarly, increased use of LLMs has been associated with lower problem-solving skills among students (Çela et al., 2024).

The core structure of the model was influenced by Facione's definition of critical thinking, as well as many existing research studies, which found that overreliance on LLMs can lead to cognitive offloading and a decline in thinking performance (Zhang et al., 2024; Zhong et al., 2024). When students rely on LLMs to generate answers, analyze content, or solve problems, they may avoid the necessary thinking process without realizing it, such as evaluating evidence, comparing alternatives, or constructing logical arguments. They may weaken their critical, analytical, and logical thinking abilities. Furthermore, the decline in these skills may negatively impact students' self-learning motivation. As students lose confidence in their ability to think and learn independently, they may become more passive learners, increasingly relying on external assistance.

The conceptual framework shows the relationship among the five latent variables. In this model, LLM usage behavior functions (LLM) as the independent variable, while self-learning motivation (SLM) is the dependent variable. The three types of thinking skills serve as the mediating variable, connecting the relationship between LLM usage and self-learning motivation. LLM usage has direct effects on three core cognitive skills: critical thinking (CT), analytical thinking (AT), and logical thinking (LT). These skills influence students' self-learning motivation. Each latent variable is measured by survey items developed from the literature review.

The questionnaire was developed based on the conceptual framework and academic research. It contains 25 questions, representing the indicators. These indicators (Observed Variables) are used to measure Latent Variables, which cannot be measured directly. Each question uses a 7-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree). The form was completed via Google Forms, and 128 responses were collected from engineering students at Kasetsart University.

The questionnaire is divided into six sections, each aiming to assess how LLMs may influence student learning and cognitive development. The sections and their focus areas are as follows:

1. Users's General Information
   1.1. Please select your department.
   1.2. Please select your current year of study.
   1.3. Which program are you enrolled in?
   1.4. Are you Thai? If not, please specify your nationality.
2. Basic Information on AI Usage in Learning
   2.1 Which AI do you usually use to assist with your studies?
   2.2 You use AI to do your homework or assignment FIRST every time, before thinking for yourself.
   2.3 You use AI more than listening to lectures in class.
3. Usage Related to Critical Thinking Skills
   3.1 You feel that using AI-Assisted Learning Tools makes you overly dependent on them, rather than analyzing information on your own.
   3.2 Using AI-Assisted Learning Tools makes you neglect verifying the accuracy of the information provided.
   3.3 You mostly use AI responses from AI-Assisted Learning Tools without any modification.
   3.4 AI discourages you from weighing the pros and cons of different solutions since it selects the best response for you.
4. Usage Related to Analytical Thinking Skills
   4.1 Using AI-Assisted Learning Tools eliminates the need to break down problems yourself, as AI structures the information for you.
   4.2 AI reduces your ability to identify connections between pieces of information since it provides conclusions instantly.

4.3 Using AI-Assisted Learning Tools reduces your effort in analyzing solutions since AI provides the "correct" answers immediately.

5. Usage Related to Logical Thinking Skills
   5.1 You tend to trust AI-Assisted Learning Tools' responses without verifying if they follow correct logic.
   5.2 After frequent AI usage, you put less effort into solving problems using your logical reasoning.
   5.3 AI usage reduces your need to analyze the reasoning and logic behind answers since AI has already done it for you.
   5.4 You have used AI-generated information without verifying whether the assumptions and logic behind it are reasonable.
   5.5 After frequent AI usage, you feel less capable of constructing clear reasoning and logic on your own.
6. Usage Related to Self-Learning Motivation
   6.1 When trying to solve problems without AI, you find it more complicated than before.
   6.2 AI discourages you from testing different ideas yourself since it provides an instant conclusion.
   6.3 AI-Assisted Learning Tools make learning more convenient, but they also reduce your analytical thinking ability.
   6.4 Using AI-Assisted Learning Tools has diminished your confidence in your thinking abilities.
   6.5 Using AI-Assisted Learning tools diminishes your creativity because the tools provide answers instead of encouraging independent thinking.

The structural relationship between the latent variables was analyzed by Partial Least Squares Structural Equation Modeling (PLS-SEM) via the SmartPLS 4.0 program. This method evaluates the influence of LLMs usage behavior on the development of critical thinking skills, analytical thinking skills, logical thinking skills, and self-learning motivation.

The results showed that all constructs had composite reliability values ranging from 0.812 to 0.876 and average variance extracted (AVE) values above 0.50, indicating good convergent validity. Additionally, the model passed the criterion for discriminant validity, as evaluated by the Fornell-Lacker Criterion and HTMT ratio.

Table 1: Hypothesis Testing Results

Relationship	Path Coefficient (β)	t-statistics	p-values	Results
LLM → CT	0.321	2.969	0.003	Supported
LLM → AT	0.387	4.290	0.000	Supported
LLM → LT	0.425	5.356	0.000	Supported
CT → SLM	0.101	1.127	0.260	Non-supported
AT → SLM	0.236	2.529	0.011	Supported
LT → SLM	0.522	5.974	0.000	Supported

Moreover, the results show that LLMs usage significantly positively affects all three types of thinking skills. However, only logical and analytical thinking skill development affects self-learning motivation, while critical thinking skill development does not significantly affect self-learning motivation ($p > 0.05$). This could be because analytical and logical thinking skills often lead to immediate, visible problem-solving success (e.g., solving math problems, coding, logical puzzles), which creates a positive feedback loop. Hence, skill improvement could eventually result in motivation to learn more. However, critical thinking skills are often viewed as abstract reasoning, argument evaluation, and nuanced judgment, which may not yield immediate or clear-cut success. Students may not easily see or feel the results of improved critical thinking. Without this visible feedback, self-efficacy and motivation may not increase. This result is not surprising, especially with a group of engineering students, since engineering students are often trained to analyze or use logic to find an answer rather than to debate, discuss, and provide multiple perspectives.

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