

The Impact of Generative AI on Critical Thinking: Self-Reported Cognitive Effort and Confidence Effects in High School Students

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ABSTRACT

Students in secondary schools utilize generative artificial intelligence quite frequently. This paper aims to investigate the effects on students' learning processes, critical thinking, and cognitive effort. The study examines how high school students use AI tools for academic assignments and the connections between effort investment, critical thinking, trust, perceived learning, self-confidence, and confidence in AI. A poll was administered to twenty students in grades 9-12, who also reported using AI frequently. Likert-scale measurements of confidence, effort, trust, and learning perspectives, as well as assessments in the areas of critical thinking and qualitative remarks, were collected. Spearman's rank-order correlations and descriptive statistics showed that for our set of self reported data, higher levels of self-confidence are significantly correlated with better critical thinking and greater effort to comprehend and improve AI outputs. It also hints at higher estimates of self evaluation of generated content during AI use. Increased confidence in AI was associated with less evaluative effort, less checking behavior, and greater trust. The results, although being constrained by a smaller number of participants, pointed at a relationship of cognitive offloading and themes of AI serving as a cognitive scaffold for self-assured users. These results imply that the redistribution of cognitive effort brought on by generative AI is moderated by self-confidence. This paper therefore, highlights the importance of promoting self-control and metacognitive awareness.

1. INTRODUCTION

Cognitive control, a core concept of neuroscience, is the ability to govern thought, behavior, and effort in accordance with internal goals. The prefrontal cortex plays a major role in supporting these cognitive faculties, which are frequently categorized under executive functions, such as attention regulation, decision-making, mistake monitoring, and effort allocation (Friedman & Robbins, 2021). According to neurodevelopmental research, metacognitive awareness, self-regulation, and deliberate decision-making vary throughout late adolescence as a result of the functional maturation of prefrontal and frontoparietal networks. This makes adolescence a crucial period in the context of development of executive functioning. Consequently, when performing cognitively difficult tasks, teenagers depend more on

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external scaffolding (Satterthwaite et al., 2013). One way that external tools impact cognition is by cognitive offloading, or allocating mental work to external resources. Offloading can improve short-term task performance and reduce cognitive stress. However, when used excessively, it can also impede deeper learning, undermine monitoring procedures, and reduce internal effort (Chirayath et al., 2025). Recent research indicates a dissociation between cognitive engagement and performance, since AI-supported environments often lower perceived effort and stress without necessarily improving learning outcomes (Bassner et al., 2025). However, cognitive offloading is not always detrimental. When paired with self-control and careful observation, it can free up brain resources for higher-order reasoning. Accordingly, the degree of adaptability of offloading depends on how individuals allocate effort and retain control over the task (Grinschgl et al., 2021).

Instead of merely storing data, generative AI presents a new type of cognitive companion that actively creates explanations, content, and outputs that resemble thinking. According to new research, users who have a high level of trust in AI-generated solutions may be less inclined to critically evaluate and invest effort in AI systems. Self-confidence may be a key factor in determining how AI is employed in adolescents, whose executive and metacognitive systems are still maturing (Lee et al., 2025). Evaluating the cognitive and educational effects of generative AI use in secondary education requires an understanding of whether AI redistributes critical thinking effort and how self-confidence influences this process (Pokhrel et al., 2013) and whether the use of generative AI modifies where and how cognitive effort is expended.

Individuals with greater self-confidence maintain stronger oversight and evaluative control when using AI. In contrast, higher confidence in AI systems is associated with reduced critical evaluation, weaker monitoring, and lower cognitive effort. Rather than replacing thinking, AI functions as a cognitive scaffold (Mei & Weber, 2025).

Whether AI use results in maladaptive cognitive offloading or adaptive augmentation largely depends on the user's self-confidence. Students with higher self-confidence are more likely to challenge AI outputs, conduct thorough analysis, and integrate the generated content with their own reasoning. Conversely, lower self-confidence often leads to greater reliance on AI responses, which reduces internal cognitive effort and critical engagement.

AI tools can widen existing differences in cognitive control. Overconfidence in AI systems may cause premature termination of cognitive effort, resulting in superficial understanding despite completed tasks. Therefore, understanding how self-confidence shapes effort allocation is essential when evaluating the long-term impact of generative AI on critical thinking development (Gerlich, 2025).

2. METHODOLOGY

2.1 Aim

This study adopted a mixed-methods approach to investigate high school students' use of AI tools for academic tasks, with a focus on their effects on self-confidence, confidence in AI, critical thinking, mental effort, trust, and overall learning processes.

2.2 Research Design

A cross-sectional survey design was implemented to gather quantitative data via Likert-scale and categorical items, alongside qualitative reflections. Closed-ended questions used 1-5 scales (e.g., 1 = Not confident/Strongly disagree, 5 = Very confident/Strongly agree) or 5-point effort comparisons (Much less effort to Much more effort, relative to non-AI tasks). Critical thinking was measured categorically (Yes/No/Not sure), with a follow-up open response.

2.3 Participants

A sample of 20 high school students (grades 9-12) were sampled randomly. Participants reported regular AI use for schoolwork across different subjects, which served as our inclusion criteria.

Characteristic	Category	Count	Percentage
Grade	9th	4	20%
	10th	5	25%
	11th	6	30%
	12th	5	25%

Table 1: Demographic details of participants (N=20).

2.4 Data Collection

An anonymous online survey was distributed via Google Forms. The instrument consisted of four sections: demographics and AI usage, confidence and critical thinking, mental effort comparisons, views on AI, and self-reflection. Exact questions included:

a. Demographics and AI Usage

- What grade are you in? (9th/10th/11th/12th)
- Which subjects do you usually use AI tools for? (Tick all: English/Writing, Science, Math, History/Social Science, Other)
- Which AI tools do you use most often? (Tick all: ChatGPT, Gemini (Google), Microsoft Copilot, Other)
- Think of one recent school task or project where you used AI. What was it for? (Short answer, e.g., “writing a science essay”)

- How did you use the AI tool for this task? (To get ideas or outlines; To write or edit text; To check or explain information; To create visuals or slides; Other)

b. Confidence and Critical Thinking

- How confident were you that you could do the task without AI? (1-5: Not confident at all to Very confident)
- How confident were you that the AI could do the task well? (1-5)
- Did you have to think critically while using the AI tool? (Yes/No/Not sure)
- Why or why not? (Short answer, e.g., “I trusted it”)

c. Mental Effort Comparisons (Relative to non-AI task: Much less effort to Much more effort)

- Understanding the question or problem
- Checking if the AI answer was correct
- Combining AI ideas with your own
- Deciding what to keep or change in the AI’s response

d. Views on AI and Self-Reflection (1-5: Strongly disagree to Strongly agree)

- I trust AI tools to give me good answers.
- AI makes my schoolwork easier.
- I always double-check what AI gives me.
- AI sometimes makes me think less.
- I learn new things when I use AI.
- Do you feel using AI helps you learn better or depend on it more? (Short answer, e.g., “It helps me understand”)

Data was exported to Excel for analysis.

2.5 Data Analysis

Analyses used Python 3.12 with pandas, SciPy, and Matplotlib. Visuals (pies, bars) were created in Google Sheets, and Python. Descriptive statistics (means, SDs) were used to understand the data. Visualizations were made to help understand the use of AI among the samples better. The self-reported critical thinking variable was coded numerically (Yes=2, No=0, Not sure=1) for correlations. Spearman's rho assessed ordinal relationships (e.g., self-confidence and effort).

2.6 Ethics

While this paper discusses the suitability of AI for teaching, one thing that must not be ignored is the danger of errant and unsolicited responses, especially in education. As AI is a still developing simulation of a human mind, there will always be responses that are not what are intended. Out of these, a few may be harmful, especially if the AI being used has been trained on data from social media.

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When collecting data, there are also ethical considerations to be taken. Firstly, we did not collect any directly personal data, such as emails or names. Furthermore, we did not collect any data that could allow us to identify an individual or small group of people, nor was any of the collected data likely to in any way prove harmful to someone.

3. RESULTS

3.1 Descriptive Statistics

In this section we report the findings of the online survey, the observed trends in use of AI among high school students, and what inferences can be assumed.

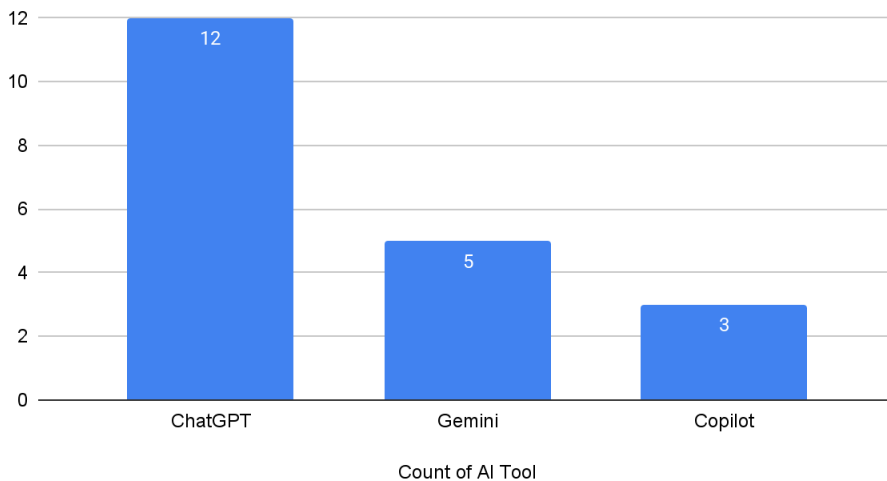


Figure 1: Distribution of AI Tools Used (N=20).

We observe that among the sample (N=20), the most commonly used Gen AI was ChatGPT was the most frequently used tool (60%), followed by Gemini (25%) and Copilot (15%). This gives us the information that we had a group using popular generative AI LLMs, with the most popular one being ChatGPT.

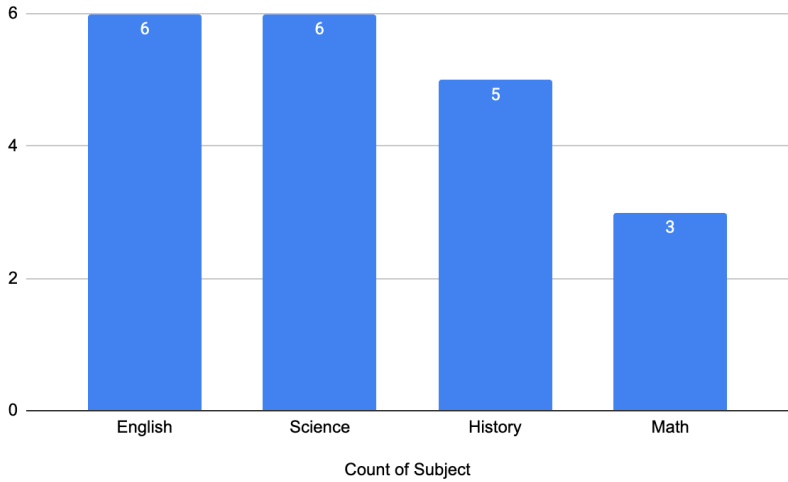


Figure 2: Distribution of Subjects for AI Use (N=20).

We made an observation that 11(55%) students are using AI for humanities subjects(English & History), whereas 9(45%) students are using it for STEM (Science & Maths). This observation helped us confirm that our sample, although small, has been using AI for distributed fields of study.

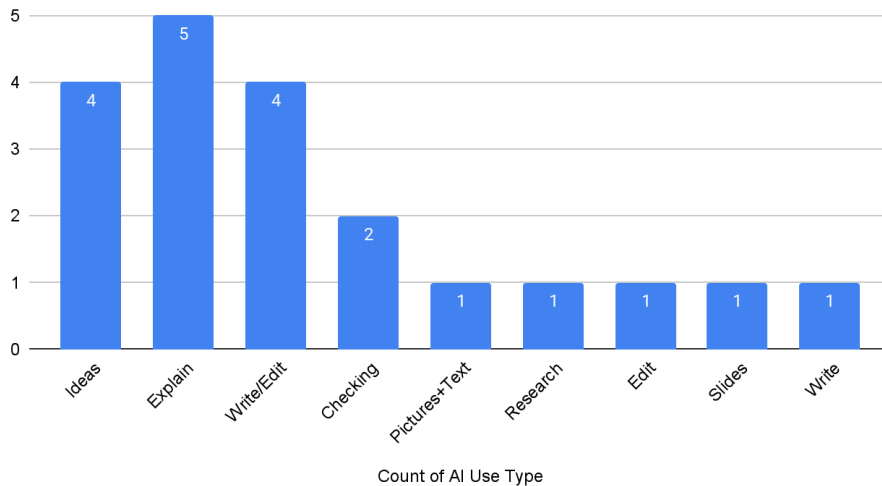


Figure 3: Distribution of AI Use Types (N=20).

We observed that the most common uses of AI were explaining concepts (25%), followed by idea generation (20%), writing/editing (20%), and checking (10%); other uses (research, slides, edit, write, pictures & text) each accounted for 5%. This gives us an angle to understand the nature of use for the companion AI.

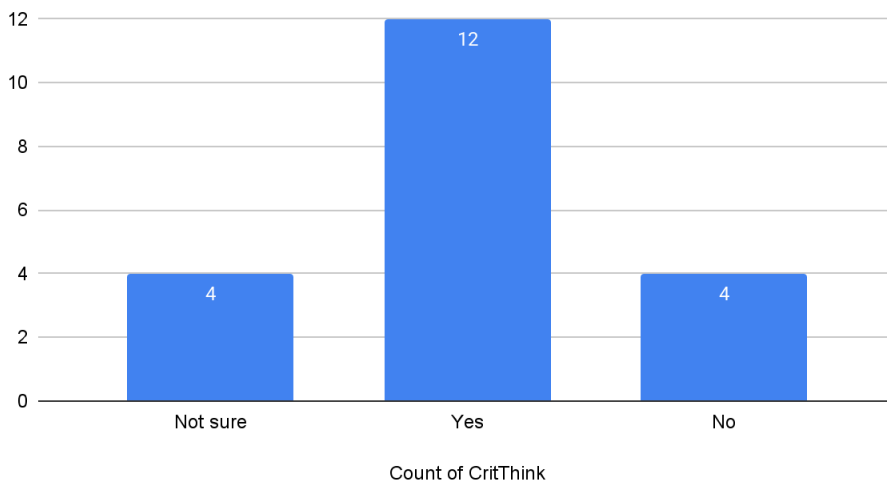


Figure 4: The following table shows the count of participant responses to whether they think critically while using AI (N=20).

We observe that 50% of the respondents report that they do think/evaluate critically while using AI, while 25% are not sure and the rest respond that they don't think critically while using AI.

After this we examined the self reported responses of a few critical questions while considering the sample as a whole. The table below presents it:

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Variable	Mean	SD	Min	Max
Self-Confidence	3.50	1.05	2	5
AI Confidence	4.00	0.73	3	5
Effort: Understanding	3.00	0.55	2	4
Effort: Checking	3.35	1.18	1	5
Effort: Combining	3.25	0.89	2	5
Effort: Deciding	3.25	1.18	1	5
Trust in AI Answers	3.60	0.99	2	5
AI Makes Easier	4.25	0.8	3	5
Double-Check	3.45	1.35	1	5
AI Reduces Thinking	2.85	1.3	1	5
Learning from AI	4.10	0.85	3	5

Table 2: Descriptive Statistics for Key Variables (N=20; scales 1-5).

The above table reports an overall picture of how AI is being used by high schoolers. We observe that the participants overall have high confidence in AI, believe that AI makes their work easier, and that they learn from AI (mean ≥ 4)

The following themes also emerged from the reflection questions, identifying recurring patterns in how students described their thinking, effort, and reliance on AI tools.

Theme	Cognitive Interpretation
AI as cognitive support for learning and understanding	This reflects augmented cognition where AI supports comprehension without replacing executive control
AI as a source of idea generation with Human control	This reflects perceived metacognitive control, suggesting strong self-regulation and evaluative processing.
Over-reliance and Cognitive Offloading	Cognitive offloading happens when reliance on AI reduces internal effort
Convenience and Efficiency Bias	Efficiency bias can either support learning or accelerate offloading depending upon self regulation.

Table 3: Thematic Analysis and cognitive interpretation of reflections question.

3.2 Inferential Statistics

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Spearman's rank-order correlations were computed to examine associations among key self reported variables, including self-confidence, AI confidence, critical thinking, effort measures (understanding, checking, combining, deciding), trust in AI answers, double-checking frequency, and perceived reduction in thinking due to AI. Given the ordinal nature of the data and small sample size (N=20), non-parametric Spearman's rho (ρ) was appropriate, with significance set at $p < 0.05$. Critical thinking was coded numerically (Yes=2, No=0, Not sure=1) for correlations. Effort checking, Effort combining & Effort deciding were collapsed into Effort taking a mean of the 3 values.

Correlation Pair	ρ	p-value
Self-Confidence & Critical Thinking	0.82	<0.001
Self-Confidence & Overall Effort	0.92	<0.001
Self-Confidence & Effort: Understanding	0.72	<0.001
Self-Confidence & AI Reduces Thinking	-0.78	<0.001
AI Confidence & Effort: Checking	-0.55	0.012
AI Confidence & Double-Check Frequency	-0.61	0.005
AI Confidence & Trust in AI Answers	0.87	<0.001
Self-Confidence & Trust in AI Answers	-0.43	0.0595

Table 4: Spearman's Correlations Between Key Variables (N=20). $p < 0.05$

These correlations hint at the relationship between different self reported variables in our data, we observe that self-confidence correlates strongly & positively with Critical thinking($\rho=0.82$ $p<0.001$), Overall effort($\rho=0.92$ $p<0.001$) and Effort understanding($\rho=0.72$ $p<0.001$), while having a strong negative correlation with having reduced thinking while using AI($\rho=-0.78$ $p<0.001$). We also observed a non-significant moderate negative correlation between self-confidence and Trust in AI answers($\rho=-0.43$, $p=0.0595$).

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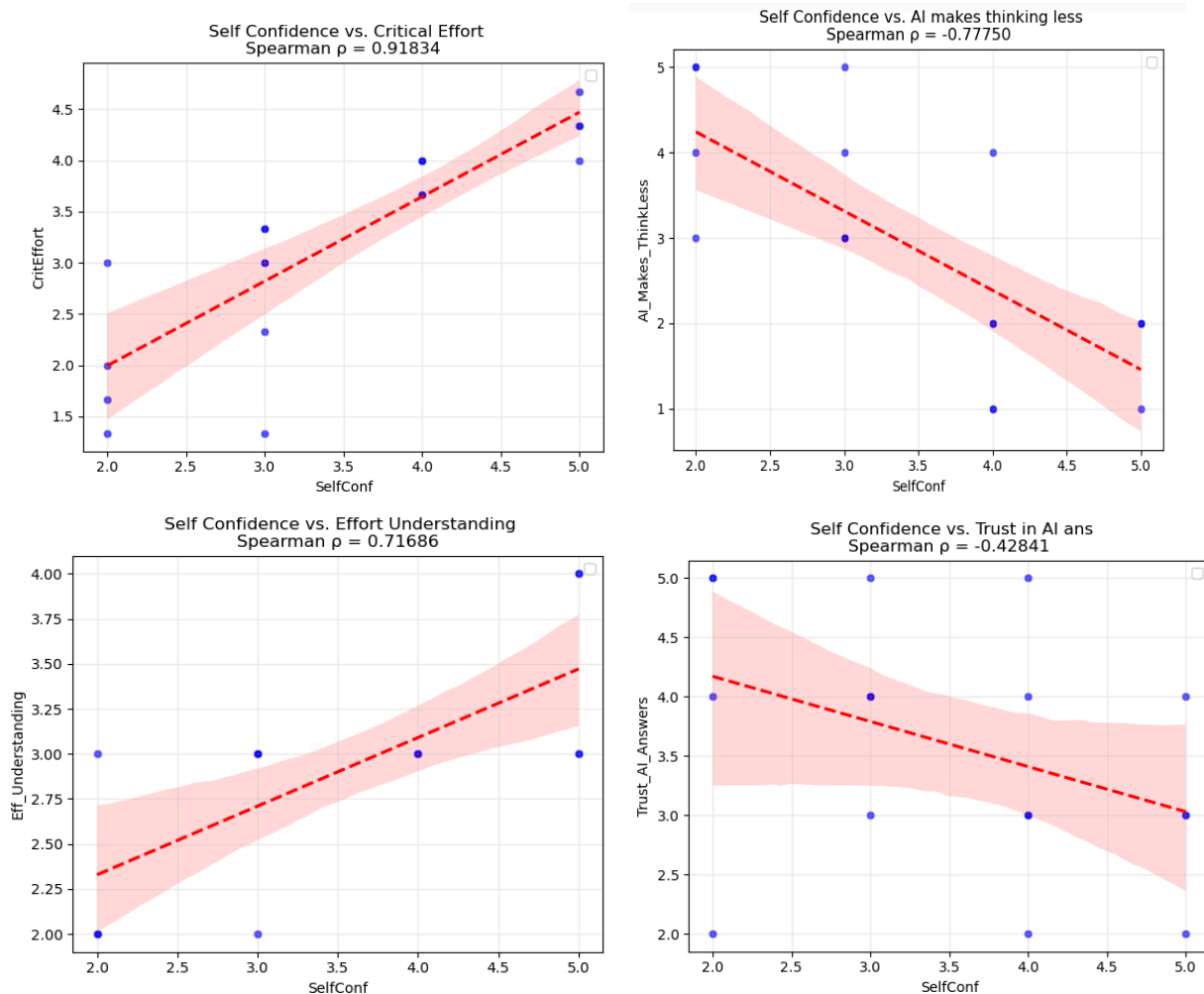


Fig 5: Scatter plots for self confidence vs Critical effort*, AI makes thinking less* , effort understanding*, Trust in AI (*indicates $p < 0.05$)

These observations may indicate that, in our sample, participants with higher self-confidence, think critically while using AI, prioritise understanding the AI responses, and exert more effort to make sure the Gen AI responses are what they want. Along with these, they don't reduce their own thinking while using AI.

We also observed that AI confidence correlates strongly and positively with trust in AI answers ($\rho=0.87$ $p<0.001$), strongly and negatively with double-checking AI answers ($\rho=-0.61$ $p=0.005$) & moderately and negatively with effort-checking AI answers ($\rho=-0.55$ $p=0.012$)

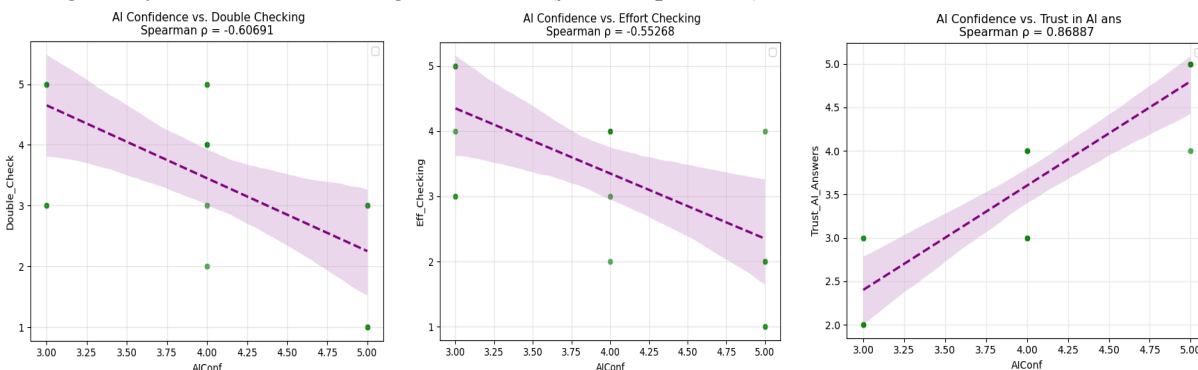


Fig 6: Scatter plots of AI confidence vs Double Checking*, Effort Checking* and Trust in AI answers* (* indicates $p<0.05$)

These Observations may indicate that our sample participants with higher confidence in AI tend to trust AI answers while also putting less effort into checking AI answers and double-checking the Gen AI responses less

Confident students treat AI as a "scaffold" they actively refine, fostering deeper learning. Low-confidence peers may default to passive use, widening achievement gaps. Empowering for the confident, hazardous for the over-reliant. These patterns also align with perceived competence, which modulates effort allocation, monitoring, and control processes, commonly attributed to prefrontal executive systems.

We need to also consider that the observations and following inferences are influenced by the self reporting nature of our experiment

4. DISCUSSION

The participants in our study report extensive use of generative AI tools, particularly for explaining concepts, generating ideas, and completing writing-related academic tasks. They also express high confidence in the tools' efficacy and usability.

The self-confidence variable played a central role in how students report engaging with AI. Higher reported self-confidence was linked to stronger perceptions of learning, greater reported critical thinking, and more effort to understand and refine AI-generated outputs. In contrast, greater reported confidence in the AI itself was associated with increased trust, reduced checking behaviors, and lower evaluative effort.

Overall, we may infer from our sample that generative AI redistributes cognitive work rather than universally reducing it. Students with higher reported self-confidence also reported using AI more adaptively by actively evaluating, selecting, and modifying outputs. Students with lower reported

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self-confidence were more likely to rely on AI passively. This pattern is consistent with cognitive control and executive function processes, which support goal-directed attention allocation, outcome monitoring, and intelligent distribution of mental effort. The prefrontal cortex supports these regulatory mechanisms and allows students to use AI support without fully replacing internal reasoning (Friedman & Robbins, 2021).

Generative AI enables cognitive offloading by delegating mental effort to external tools. In the short term, this may reduce cognitive load and improve productivity. When used adaptively, AI acts as a cognitive partner that frees mental resources for higher-order thinking, evaluation, and creative integration. However, maladaptive offloading may lead to decreased task engagement, diminished critical thinking, and over-dependence on AI outputs (Chirayath et al., 2025). AI-assisted tasks may improve immediate performance and lower stress levels, but they do not always enhance long-term comprehension. This can create a separation between performance and true understanding (Bassner et al., 2025).

When used thoughtfully, generative AI may scaffold adolescent reasoning and support the development of executive functions, including self-regulation and metacognition (Lee et al., 2025). More self-assured students are more likely to engage critically by carefully monitoring AI outputs and deliberately deciding what to accept or revise. In contrast, less confident students tend toward passive use, which reduces their internal cognitive effort.

As per our observation self reported self-confidence thus served as a key regulator of cognitive effort in AI interactions. For our sample it determines whether AI functions as an augmentative scaffold that maintains meaningful internal work or encourages over-reliance (Gerlich, 2025; Mei & Weber, 2025).

To maximize benefits and minimize risks, educational approaches should promote balanced AI integration. This includes teaching students to critically evaluate AI outputs, integrate them with their own reasoning, and practice metacognitive self-control (Gupta, 2025; Klimova & Pikhart, 2025). Curriculum should encourage intentional and goal-directed AI use, build student self-confidence and metacognition, and use assessments that reward active engagement rather than passive acceptance of generated content (Li & Gao, 2025).

4.1 Limitations

Our reports are not without a few limitations in context of both methods and design, the following should be considered when interpreting our findings. Our experiment mostly relied on self reported measures to assess confidence levels, effort perceptions, and perception of critical thinking; these are hence susceptible to biases, including but not limited to social desirability, inaccuracy in recalling and subjective interpretations of the values in self report scale. The snapshot nature of our survey prevents us from examining casual or temporal relationships about the effects of the nature of AI usage in academic or daily life of the participants. Our findings are tied to specific AI tools and self selected tasks, a more standardized approach may help to generalize to other AI applications or to a more structured educational setting. Although our study observes strong correlational relationships between certain self reported variables, it can't be interpreted as a string effect due to the sample size being small (N=20), furthermore,

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the exploratory nature of the question in our approach may leave a chance that certain strong correlations obtained in our observations may have been due to chance and not an actual effect. The interpretation of our reported results and findings should be carried out considering these limitations.

These limitations highlight opportunities for future research, such as larger, more diverse samples and experimental designs.

4.2 Future Directions

To address the limitations of our current study and build on our current observations, future research may consider the following research ideas; expanding participant recruitment to include diverse demographics such as multiple ethnicities, considering an effect of the socio-economic status, rural/urban locations across multiple schools or regions. This may enhance the generalizability and allow for further in-depth testing. Another crucial implementation can follow up studies tracking the students' AI usage across semesters and checking for academic performance along with the considered variables like self-confidence, etc. This longitudinal approach can help assess long term effects like sustained learning gains or possible increased AI dependency. Shifting the experimental approach to consider objective measures as a supplement to self reported measures can increase the scope of research. Including methods like, eye tracking with pupillometry while AI usage and incorporating neuroimaging techniques like fMRI and EEG to explore prefrontal activity during AI assisted learning can help us review the effect of AI in education from a much broader scope.

5. CONCLUSION

This study examined how high school students use generative AI tools for academic assignments and how using AI affects their views on self reported learning, critical thinking, and cognitive effort. The reports showed that AI is frequently used for generating ideas, providing explanations, and assisting with writing. Students reported high levels of confidence in AI and viewed it as a tool that improves learning and makes schoolwork easier. Cognitive involvement patterns varied. Greater critical thinking, more effort in assessing and improving AI outputs, and less reliance on AI as a thinking substitute were all linked to higher levels of self-confidence. Increased trust, decreased checking habits, and less internal effort were associated with higher confidence in AI, highlighting the possibility of cognitive offloading.

The limitations include the limited sample size and dependence on self-reported measures. Future studies should look at bigger and more varied populations, track the evolution of AI-related cognitive abilities over time, and evaluate interventions that foster metacognition, self-assurance, and adaptive AI use. Educational practices to maximize learning results while reducing the consequences of an over-reliance on AI tools could be informed by such studies.

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