*The following summary was written by **Lori Gracey** Executive Director of Texas Computer Education Association (TCEA.org) and published within the community. I'm sharing for those of you who are not TCEA members yet. For those of you who are members, the summary contains links to take you to the source material cited.*

Early Research on the Use of AI for Learning

Examining the early research on using AI for learning by students shows the very great need for structured and pedagogically sound practices. Below you can read "The Impact of Gen AI on Human Learning: A Research Summary" by Dr. Philappa Hardman, published on January 24, 2025.

Study 1: Systematic Review and Meta-Analysis of ChatGPT's Effects on Student Learning
Research Question: How does ChatGPT impact student academic performance, emotional engagement, and higher-order cognitive processes like critical thinking across various educational contexts?
Findings:

- A systematic review of 17 studies revealed that ChatGPT-based learning moderately improved overall student engagement, particularly cognitive engagement (Hedges' g = 0.593) and behavioral engagement (Hedges' g = 0.454).
- Emotional engagement also showed medium improvements, especially among students struggling with traditional instruction.
- However, ChatGPT had inconsistent effects on higher-order cognitive processes like critical thinking. Some studies even reported reduced critical thinking skills when ChatGPT was used without structured guidance.

Key Takeaways:

Surface-Level Gains: Generative AI tools like ChatGPT improve task-specific outcomes and engagement but have limited impact on deeper learning, such as critical thinking and analysis.
Emotional Engagement: While students feel more motivated when using ChatGPT, this does not always translate into better long-term knowledge retention or deeper understanding.

Implications for Educators:

- **Combine ChatGPT with Structured Activities:** Ensure AI tools are part of a structured learning process that promotes deeper engagement rather than simple task completion. **Example:** If students use ChatGPT to draft essays, follow up with an activity requiring them to critique the AI's output by identifying logical gaps, factual inaccuracies, or weak arguments. This encourages analytical thinking.
- **Use ChatGPT as a Supplement, Not a Replacement:** Integrate ChatGPT in ways that support, but do not replace, foundational skills development. **Example:** When teaching math, let students solve basic problems manually first. Then use ChatGPT to check their answers or explore alternative approaches, prompting reflection on why an alternative solution might work.
- **Promote Self-Reflection and Evaluation:** Pair AI tools with activities that require students to reflect on what they've learned and evaluate the AI's role in their understanding. **Example:** After using ChatGPT for research, ask students to write a paragraph summarizing what they learned, what gaps they noticed in the AI's output, and what additional research they needed to conduct.

Study 2: Dual Impact of AI in Coding Education
Research Question: How does LLM usage affect task performance, foundational skill development, and independent problem-solving in programming education?
Findings:

- LLMs improved task performance during assignments but significantly reduced students' ability to solve similar problems independently in controlled settings.

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- Beginners who relied on LLMs for code generation and debugging struggled to develop foundational problem-solving skills.
- Advanced learners benefited from LLMs by tackling complex problems and expanding their understanding.

Key Takeaways:

Over-reliance on AI tools hinders foundational learning, especially for beginners.
Advanced learners can better leverage AI tools to enhance skill acquisition.
Using LLMs for explanations (rather than debugging or code generation) appears less detrimental to learning outcomes.

Implications for Educators:

- **Restrict AI Use in Foundational Courses:** In introductory programming classes, students should be asked to write code manually and debug errors themselves before being allowed to use LLMs like ChatGPT or GitHub Copilot. **Example:** Assign beginners a Python exercise on basic loops or conditionals where LLMs are not permitted. Once they solve it manually, they could use AI tools to compare their approach to the AI's suggestions.
- **Introduce Scaffolding Techniques:** Pair students with structured tasks that encourage reflection and incremental problem-solving before turning to AI for help. **Example:** For a React assignment, provide prompts like "What key component might you need here?" or "How would lifting the state simplify this application?" These scaffolded steps help students plan their code instead of relying on AI-generated solutions.
- **Encourage Independent Problem-Solving:** After using AI to debug or generate code during guided exercises, assign follow-up tasks requiring students to replicate similar outcomes without AI assistance. **Example:** If students debug a syntax error with an LLM's help, they could later work on a problem where they intentionally induce and resolve similar errors themselves.

Study 3: High School Math Tutoring with GPT Tools

Research Question: How can pedagogically enhanced GPT-based tutoring systems, using customized exercises, improve independent problem-solving and long-term skill retention in mathematics education compared to generic AI models?

Findings:

A novel approach, **CEMAL**, uses GPT to generate customized exercises tailored to learners' weaknesses, improving problem-solving skills and overall performance.
Generic AI models like GPT-3 are less effective for skill retention as they lack tailored, iterative scaffolding.
Customized exercises led to significant accuracy improvements in solving math word problems, outperforming both generic AI models and traditional fine-tuned approaches.

Key Takeaways:

Scaffolding Through Customization: Iterative feedback and tailored exercises significantly enhance learning outcomes and long-term retention.
Generic AI Risks Dependency: Relying on AI for direct solutions undermines critical problem-solving skills necessary for independent learning.

Implications for Educators:

- **Integrate Structured AI Tools with Independent Tasks:** Use AI tools for guided practice but ensure learners tackle similar problems independently to reinforce skills. **Example:** After students use AI-generated exercises for guided geometry problem-solving, assign variations of these problems for manual completion.

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- **Identify Weaknesses Through Customized Exercises:** Leverage AI to pinpoint students' problem areas and generate specific exercises to address them. **Example:** If students struggle with fractions, AI tools can produce targeted problems involving fraction addition and subtraction for additional practice.

Study 4: Cognitive Offloading and Critical Thinking

Research Question: How does AI tool usage influence critical thinking skills, and what role does cognitive offloading play as a mediating factor?

Findings:

Cognitive offloading strongly correlates with reduced critical thinking ($r = -0.75$), as reliance on AI tools discourages active engagement in analytical tasks.

Younger participants are more dependent on AI tools and show lower critical thinking scores compared to older, more experienced users.

Higher education levels mitigate the negative effects of AI tool usage on critical thinking.

Key Takeaways:

Offloading Reduces Cognitive Engagement: Delegating tasks to AI tools frees cognitive resources but risks diminishing engagement in complex and analytical thinking.

Age and Experience Mitigate AI Dependence: Older, more experienced users exhibit stronger critical thinking skills and are less affected by cognitive offloading.

Trust Drives Offloading: Increased trust in AI tools encourages over-reliance, further reducing cognitive engagement and critical thinking.

Implications for Educators:

- **Balance AI Use with Critical Thinking Activities:** Integrate exercises that promote critical engagement alongside AI use. **Example:** After students use AI for research summaries, have them identify potential biases or gaps in the information provided.
- **Teach AI Literacy:** Educate students on the limitations of AI tools and how to cross-check AI outputs for accuracy. **Example:** Instruct students to verify AI-generated data by consulting primary sources or alternative viewpoints.

Study 5: Beware of Metacognitive Laziness

Research Question: How does the use of generative AI tools impact learners' motivation, self-regulated learning (SRL) processes, and metacognitive engagement?

Findings:

Learners using AI tools showed significant short-term performance improvements (e.g., essay scores) but no significant differences in intrinsic motivation, knowledge gain, or knowledge transfer compared to other groups.

Interaction with AI reduced engagement in key SRL processes, such as reflection and self-evaluation, leading to **metacognitive laziness**—over-reliance on AI instead of actively regulating learning tasks.

Learners reported inflated confidence in their performance, despite minimal gains in deep learning or transferable knowledge.

Key Takeaways:

Confidence ≠ Competence: Generative AI fosters overconfidence but fails to build deeper knowledge or skills, potentially leading to long-term stagnation.

Reflection and SRL Are Crucial: Scaffolding and guided SRL strategies are needed to counteract the tendency of AI tools to replace active learning.

Implications for Educators:

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- **Combine AI Tools with Reflection Tasks:** Pair AI usage with activities that require learners to reflect on their performance and evaluate AI outputs critically. **Example:** After using ChatGPT for an essay, ask students to identify weaknesses in its suggestions and propose improvements.
- **Scaffold SRL Processes:** Provide explicit prompts that encourage metacognitive activities such as goal setting, monitoring, and evaluation. **Example:** Use checklists or rubrics that guide learners to review their work independently before consulting AI tools.

Conclusion

Current research overwhelmingly suggests that generic Gen AI tools do not just fail to advance human learning, they often actively hinder it. Across all five of the most recent studies on the topic, while tools like ChatGPT, Claude, and Gemini improve immediate task performance, they also reduce cognitive engagement, critical thinking, and self-regulated learning (SRL).

However, the potential of AI to transform education remains huge *if* we shift toward structured and pedagogically optimized systems.

To unlock AI's transformative potential, we must prioritize learning processes over efficiency and outputs. This requires rethinking AI tools through a ***pedagogy-first*** lens, with a focus on fostering deeper learning and critical thinking. For example:

- **Scaffolding and Guidance:** AI tools should guide users through problem-solving rather than providing direct answers. A math tutor, for instance, could ask, "What formula do you think applies here, and why?" before offering hints.
- **Reflection and Metacognition:** Tools should prompt users to critique their reasoning or reflect on challenges encountered during tasks, encouraging self-regulated learning.
- **Critical Thinking Challenges:** AI systems could engage learners with evaluative questions, such as "What might be missing from this summary?"

To achieve this vision, we need a concerted, interdisciplinary effort. For AI to truly transform learning, we must intentionally enable a fundamental cultural shift which prioritize human learning outcomes over efficiency and profit. Most current AI-ed products focus on speeding up tasks or driving user engagement, often at the expense of meaningful learning. We need to redefine "success" by focusing on metrics like knowledge acquisition, skill growth, and behavioral change rather than speed, accuracy, or user love.