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Title : Human–AI Collaboration in Education: Enhancing Pedagogy through Large Language Models

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1. Introduction & Background

The emergence of Large Language Models (LLMs) such as GPT-4/5 has transformed how people access, produce, and reason with information. In education, they offer unprecedented opportunities: adaptive tutoring, feedback generation, co-writing, and automated assessment. Yet their impact on pedagogy, teacher agency, and student learning remains under-explored. Early studies show promise for personalized feedback and metacognitive scaffolding, but also raise concerns about bias, over-reliance, and equity.

This research proposes to investigate **human–AI collaboration in teaching and learning**, focusing on how LLM-enabled tools can enhance pedagogy while maintaining human creativity, critical thinking, and ethical responsibility.

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2. Research Aims & Questions

Aim: Develop and evaluate pedagogical frameworks and interaction designs that leverage LLMs to support meaningful human–AI collaboration in education.

Key Questions:

1. How can LLMs be integrated into instructional workflows to scaffold learning rather than replace reasoning?
2. What interaction designs (prompting, co-editing, reflective questioning) best support teacher agency and student metacognition?
3. What are the effects of LLM-assisted pedagogy on learning outcomes, motivation, and equity across diverse learners?
4. How can ethical principles—fairness, transparency, privacy—be operationalized in AI-supported classrooms?

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3. Literature & Gap

Current research in learning analytics and AI-supported instruction has examined automated feedback, question generation, and dialogue systems. However:

- Most studies treat AI as an *autonomous tutor*, not a collaborative partner.
- Little is known about **prompt literacy** and how teachers/students co-construct knowledge with LLMs.
- Empirical work rarely integrates **learning sciences** theories (constructivism, self-regulated learning) with **LLM affordances**.
- Ethical and cultural dimensions of LLM use in classrooms remain nascent.

This project addresses these gaps by uniting LLM engineering, pedagogy, and human-computer interaction.

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4. Methodology

Design: Mixed-methods, design-based research over three phases.

1. **Exploration & Co-Design**
    - Conduct interviews and participatory workshops with teachers and students to map needs and concerns.
    - Synthesize findings into design principles for LLM-enabled learning activities.
2. **Prototype Development & Pilot**
    - Build or adapt LLM-powered tools (e.g., guided writing coach, reasoning assistant) using prompt engineering or lightweight fine-tuning.
    - Pilot in small classes; collect interaction logs, learning artefacts, and user reflections.
3. **Evaluation & Theory Building**
    - Large-scale field experiments comparing traditional instruction, AI-only support, and human–AI collaboration.
    - Quantitative metrics: learning gains, engagement, equity of outcomes.
    - Qualitative data: interviews, think-aloud protocols, classroom observations.
    - Derive a **Pedagogical Human–AI Collaboration Framework**.

Ethics: Obtain IRB approval, ensure data privacy, address bias in training data, promote informed consent and explainability.

5. Expected Contributions

- **Theoretical:** Model of human–AI collaborative pedagogy grounded in learning sciences and HCI.
- **Practical:** Design guidelines and open-source prototypes for responsible use of LLMs in teaching.
- **Methodological:** Instruments for measuring agency, metacognition, and collaboration quality in AI-augmented classrooms.
- **Societal:** Evidence-based recommendations for policy and teacher professional development.

6. Resources & Supervision

The research will benefit from an interdisciplinary supervisory team (learning sciences, NLP, HCI), access to LLM APIs or open-weight models, cloud compute, and partnerships with local schools/universities for field trials.

7. Conclusion

As education enters an era of ubiquitous generative AI, understanding and shaping **human–AI collaboration** is essential. This PhD will provide robust evidence and practical strategies for integrating LLMs into pedagogy in ways that enrich teaching, foster deep learning, and uphold ethical values.