ICTE 2025
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THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

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Human-AI Collaboration in the STEM Classroom:

A Systematic Literature Review of GenAI as a Complement in Higher Education

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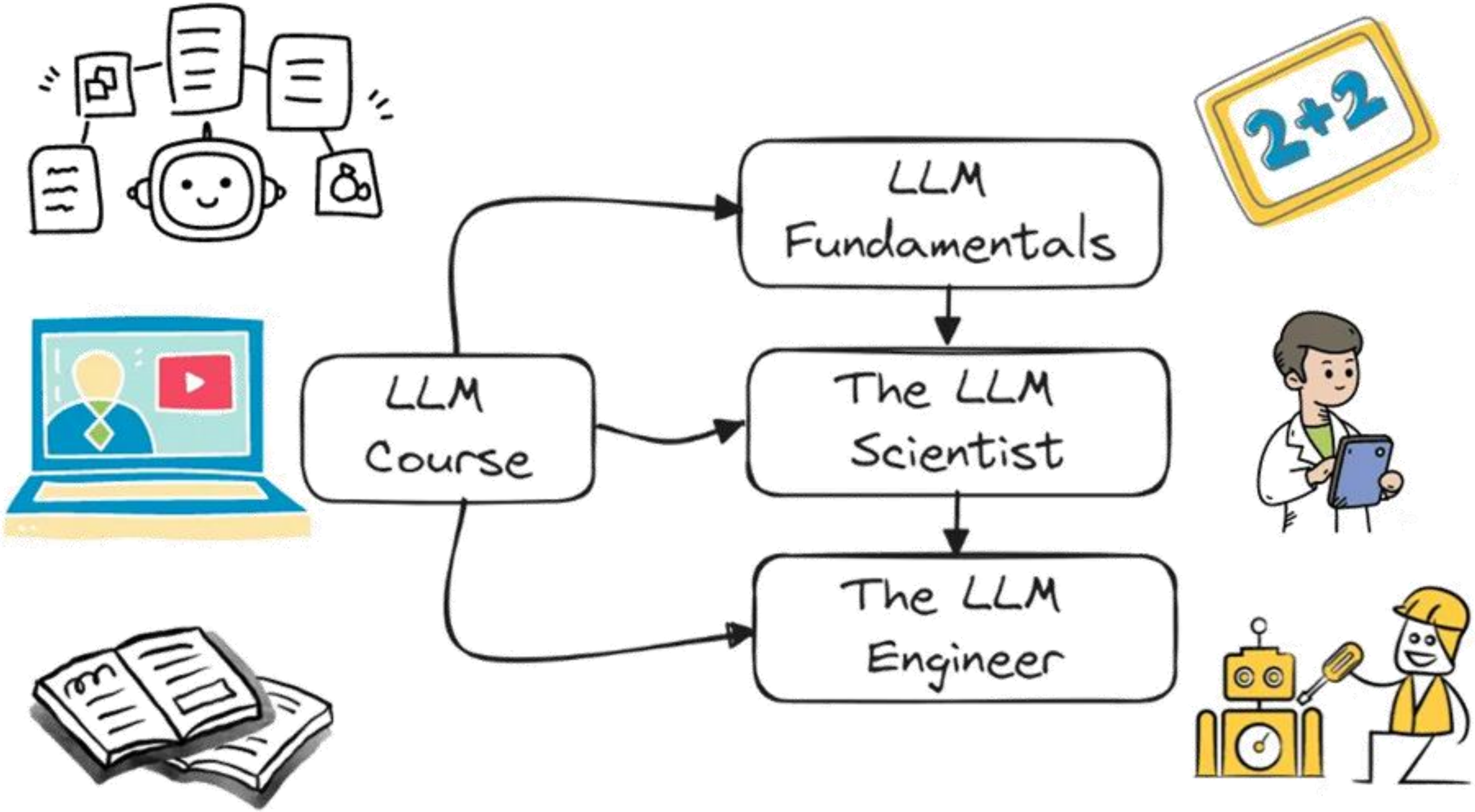
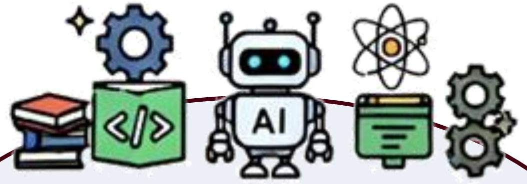
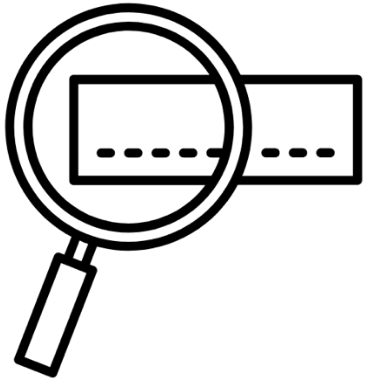


I. Introduction:



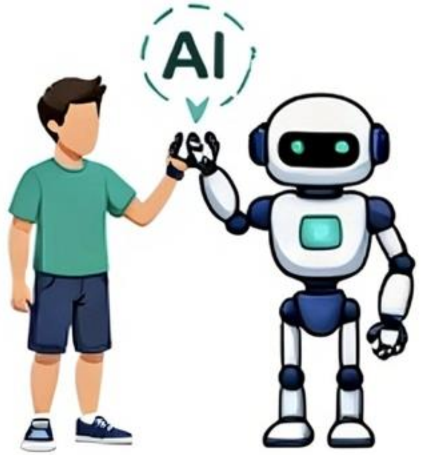


Information Retrieval Tool

From

Gen-AI is transforming STEM higher education.

To



Educational Partner

GAP: Despite widespread applications, there is a lack of systematic reviews on human-machine collaboration models, role changes, and challenges in STEM fields

I. Introduction:

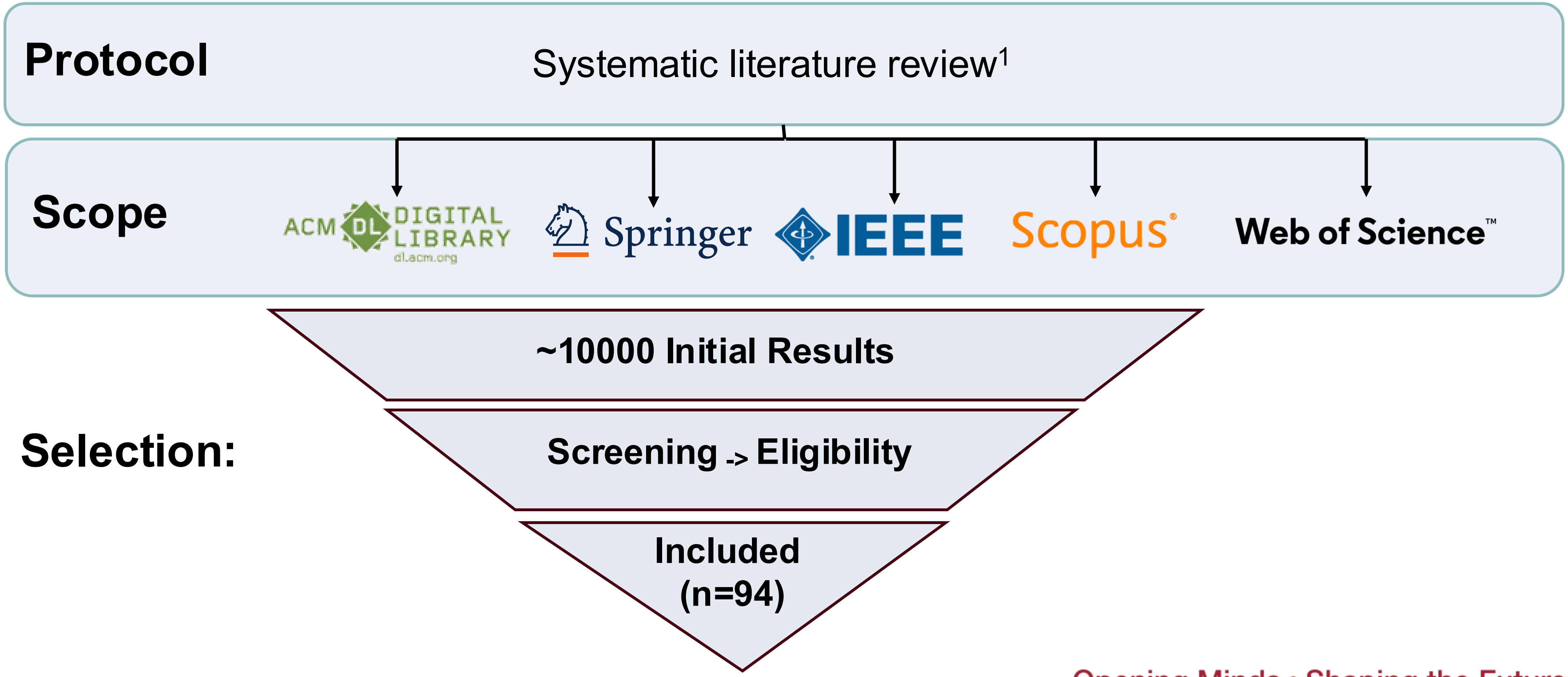
Objective

To map the landscape of Human-LLM collaboration based on empirical studies from the last two years.

II. Research Questions:

- **RQ1:** What models of Human-LLM collaboration are described in the literature for STEM education?
- **RQ2:** What are the documented domains of impact of Human-LLM collaboration on student learning outcomes in STEM?
- **RQ3:** How does the adoption of LLMs as collaborative partners affect the traditional roles of students and educators in the STEM subjects?
- **RQ4:** What are the primary challenges and limitations identified in the literature regarding the use of LLMs in a collaborative capacity in STEM higher education?

III. Methodology:



1 Keele, S. & others. (2007). Guidelines for performing systematic literature reviews in software engineering. Technical report, ver. 2.3 ebse technical report.

IV. Result:

Computer Science
(n=61)

Biology
(n=5)

Physics
(n=4)

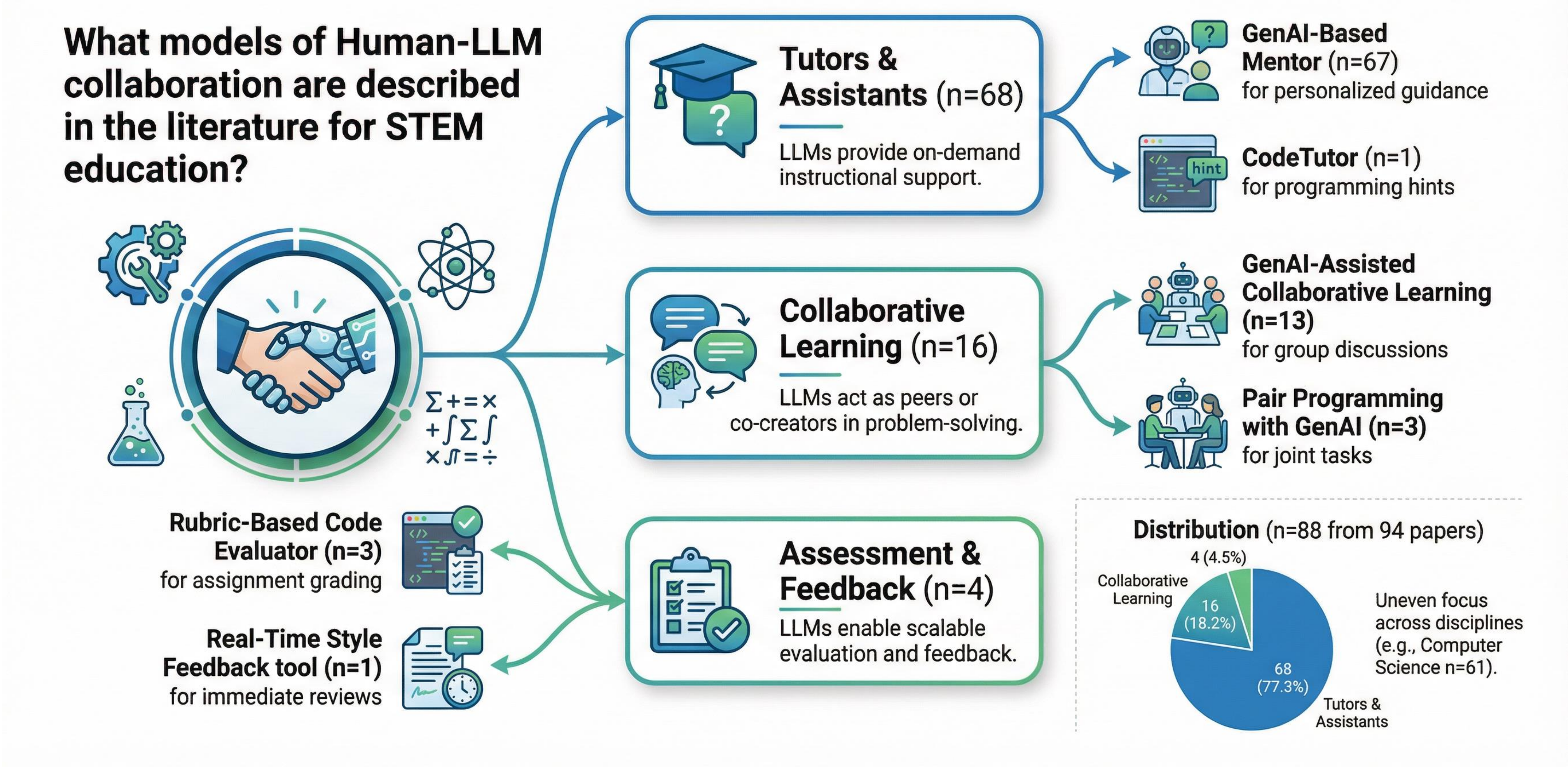
Engineering
(n=13)

Mathematics
(n=5)

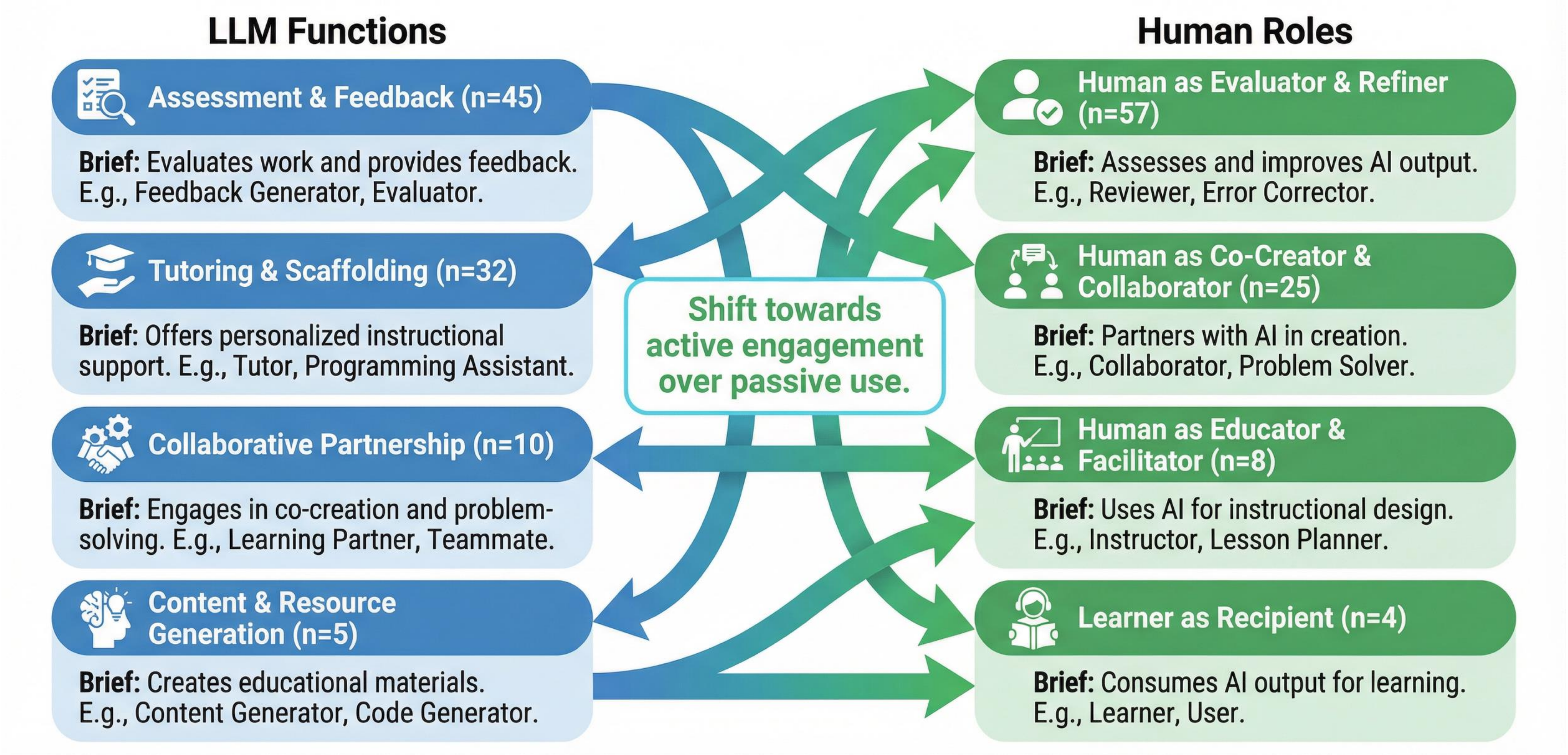
Mixed STEM
(n=6)

IV. Results

Human-GenAI Collaboration’ Models (RQ1)

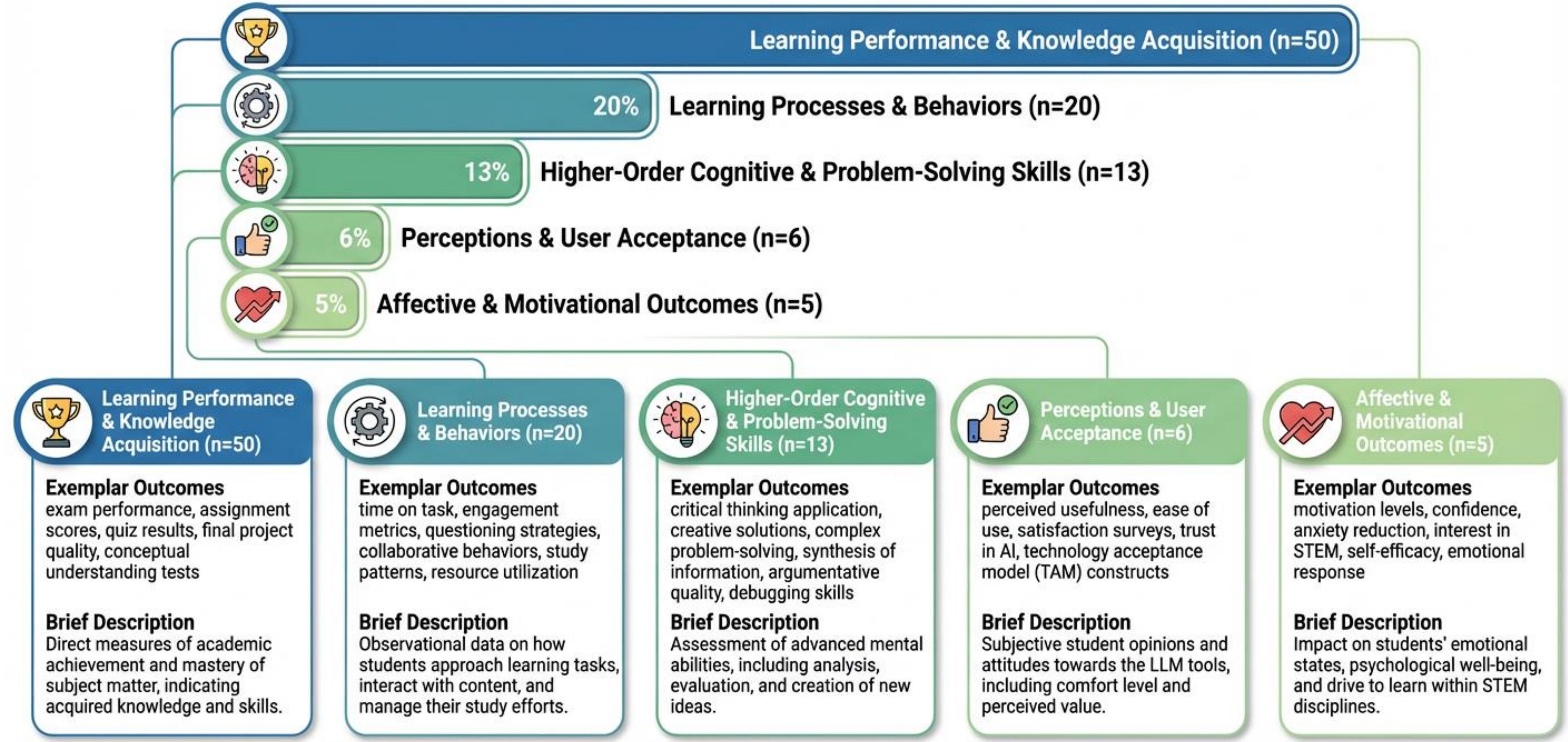


IV. Results LLM’s Role and Human’s role in Human-GenAI Collaboration (RQ1)



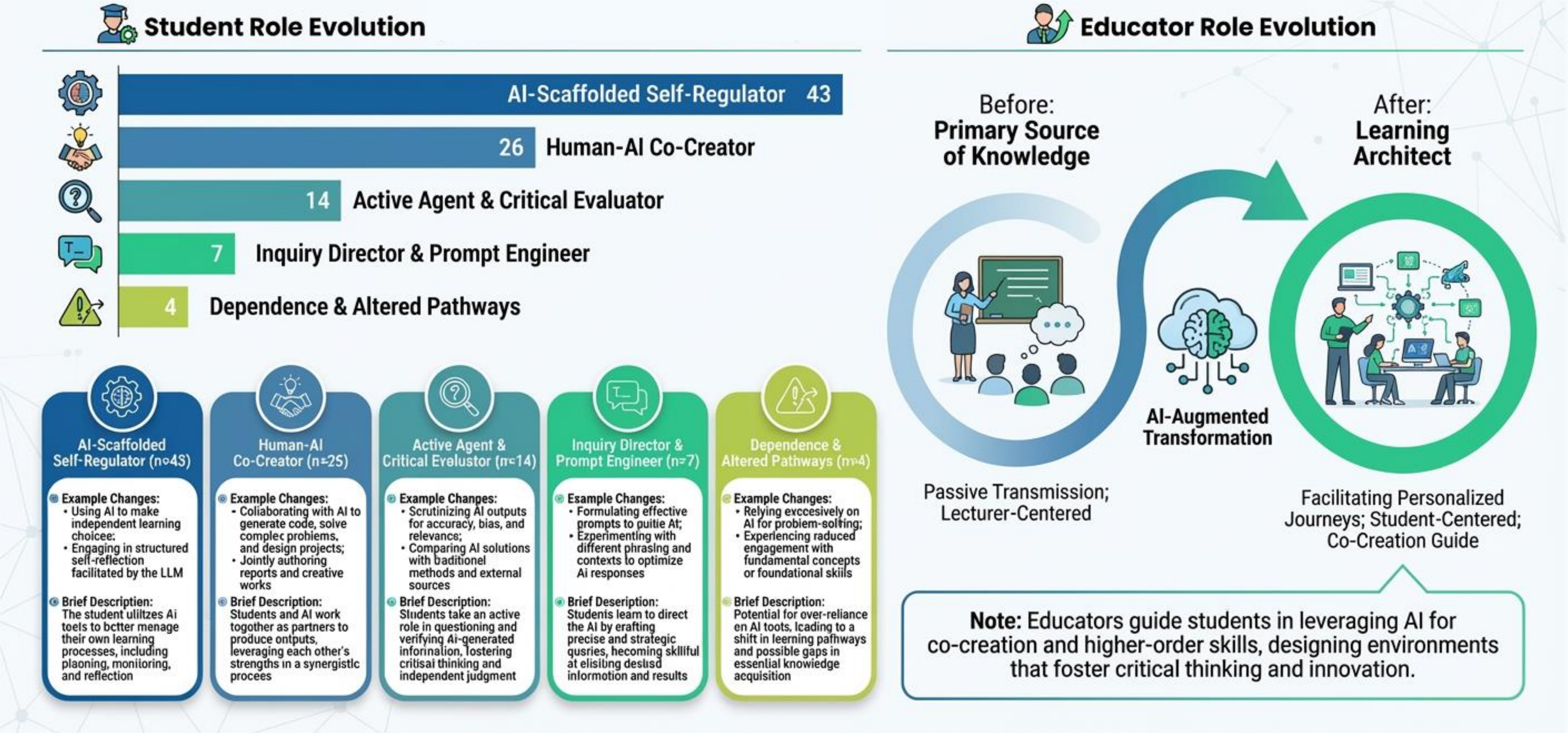
IV. Results

Student learning outcomes in Human-AI Collaboration (RQ2)



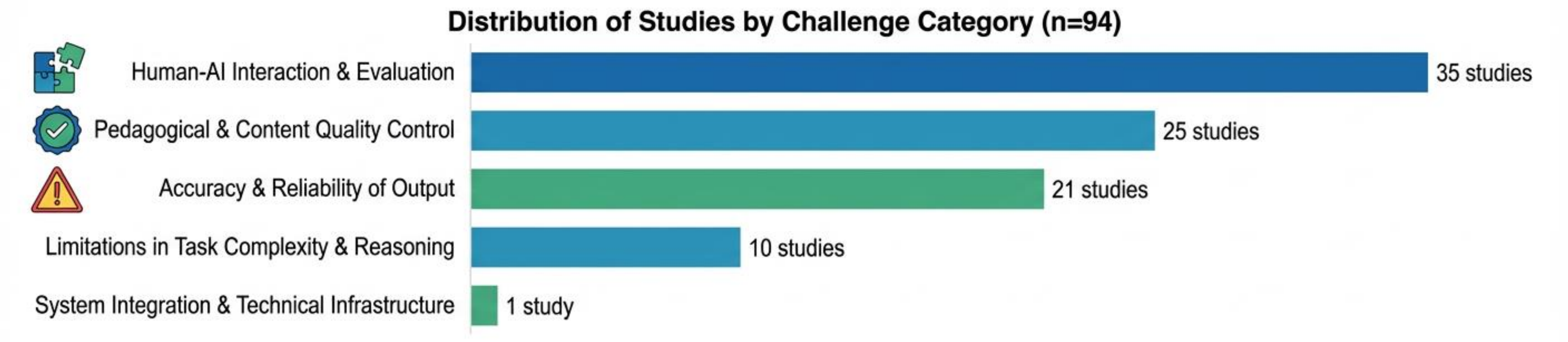
IV. Results

Student learning outcomes in Human-AI Collaboration (RQ3)



IV. Results

Challenges and Limitations in Human-AI Collaboration (RQ4)



Human-AI Interaction & Evaluation (n=35)

Exemplar Challenges
- Over-reliance on AI
- Lack of critical engagement
- Difficulty in prompt engineering
- Misinterpretation of AI feedback
- Ethical considerations in interaction

Brief Description
Focuses on how students and educators interact with AI, including issues of trust, dependence, and the effectiveness of communication and evaluation processes.

Pedagogical & Content Quality Control (n=25)

Exemplar Challenges
- Ensuring alignment with learning objectives
- Maintaining academic integrity
- Preventing plagiarism
- Evaluating AI's pedagogical approach
- Difficulty in assessing original thought

Brief Description
Concerns the integration of AI in a way that supports educational goals, maintains standards, and ensures the quality and relevance of the content provided by the AI.

Accuracy & Reliability of Output (n=21)

Exemplar Challenges
- Hallucinations (generating fabricated information)
- Inaccurate code snicpets
- Factual errors in STEM concepts
- Inconsistent responses
- Bias in generated content

Brief Description
Issues concerning factual correctness, consistency, and trustworthiness of the content generated by the LLM, particularly in scientific and technical domains.

Limitations in Task Complexity & Reasoning (n=10)

Exemplar Challenges
- Inability to solve multi-step complex problems
- Limited understanding of deep domain-specific knowledge
- Failure in abstract reasoning
- Difficulty with open-ended creative tasks
- Lack of contextual understanding

Brief Description
Highlights the current boundaries of LLMs in handling sophisticated STEM tasks that require deep understanding, multi-layered reasoning, and complex problem-solving capabilities.

System Integration & Technical Infrastructure (n=1)

Exemplar Challenges
- Platform incompatibility with existing LMS
- Technical glitches and downtime
- High computational costs
- Data privacy and security concerns
- Limited access to advanced models

Brief Description
Addresses the technical and logistical hurdles in integrating AI tools into existing educational systems, including platform compatibility, cost, and data security issues.

V. Conclusion and Future Work

Current Landscapes:

- Adoption of GenAI is dominated by "human-in-the-loop" model
- LLMs primarily as tutors/assistants to enhance learning performance;
- Humans as critical evaluators for quality and accuracy.

Transformative Shift:

- Emerging models position AI as a co-creator/partner, fostering higher-order cognitive skills (e.g., problem-solving, creativity) essential for STEM.

V. Conclusion and Future Work

Role Evolution:

- Students transition from passive recipients to active agents and prompt engineers;
- Educators become facilitators and designers of AI-augmented environments.

Challenges:

- Technical issues (accuracy, reliability, task complexity)
- Pedagogical concerns (content quality, over-reliance)
- Need for better integration and evaluation methods.

V. Conclusion and Future Work

Future Directions:

- Prioritize longitudinal studies on sustained impacts (e.g., long-term skill development, career preparedness).
- Conduct comparative analyses of models (e.g., AI Tutor vs. AI Partner).
- Develop robust frameworks for GenAI as a transformative educational partner.
- Emphasize rigorous, large-scale experimental research beyond exploratory studies.

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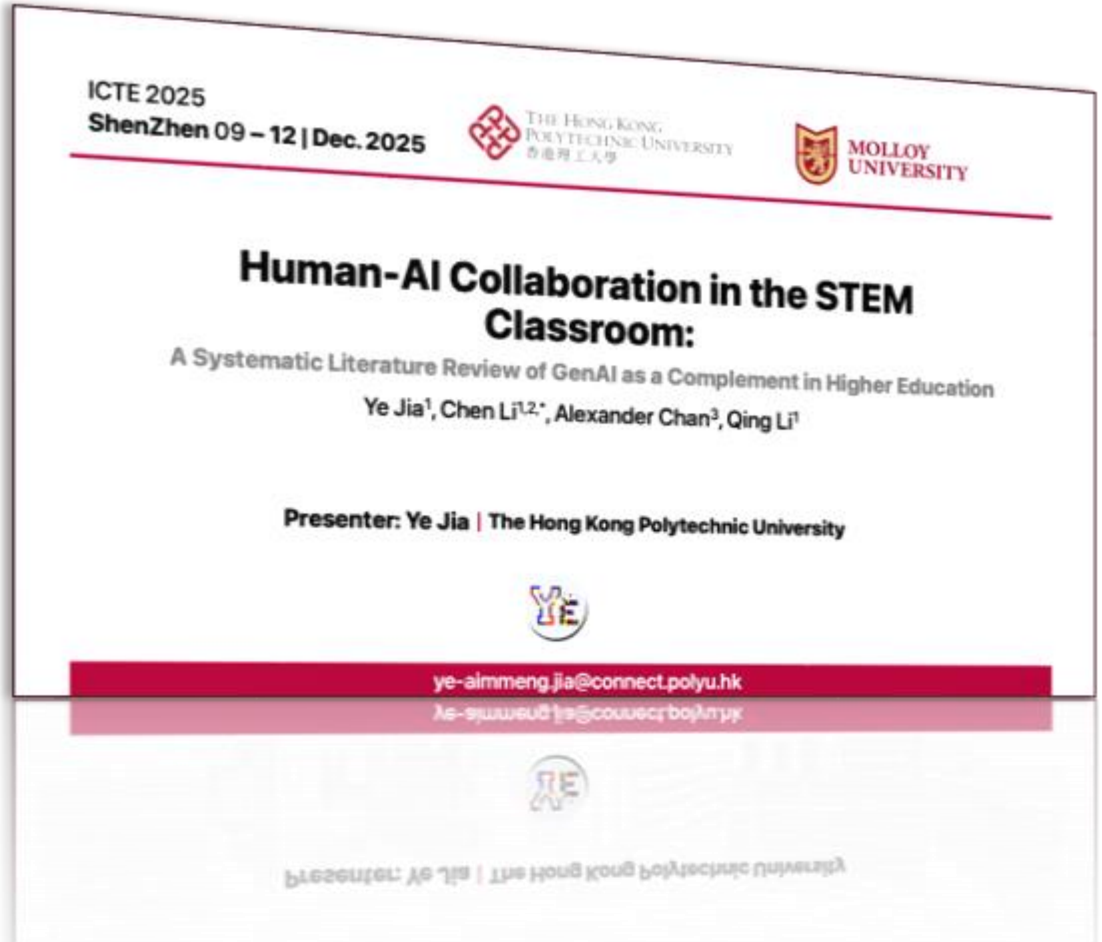

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