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Atlantic Technological University

Research Methods In Computing & IT.

Computing & Applied Physics.

INTEGRATING LARGE LANGUAGE MODELS INTO PROGRAMMING EDUCATION: OPPORTUNITIES, CHALLENGES, AND LEARNING IMPACTS

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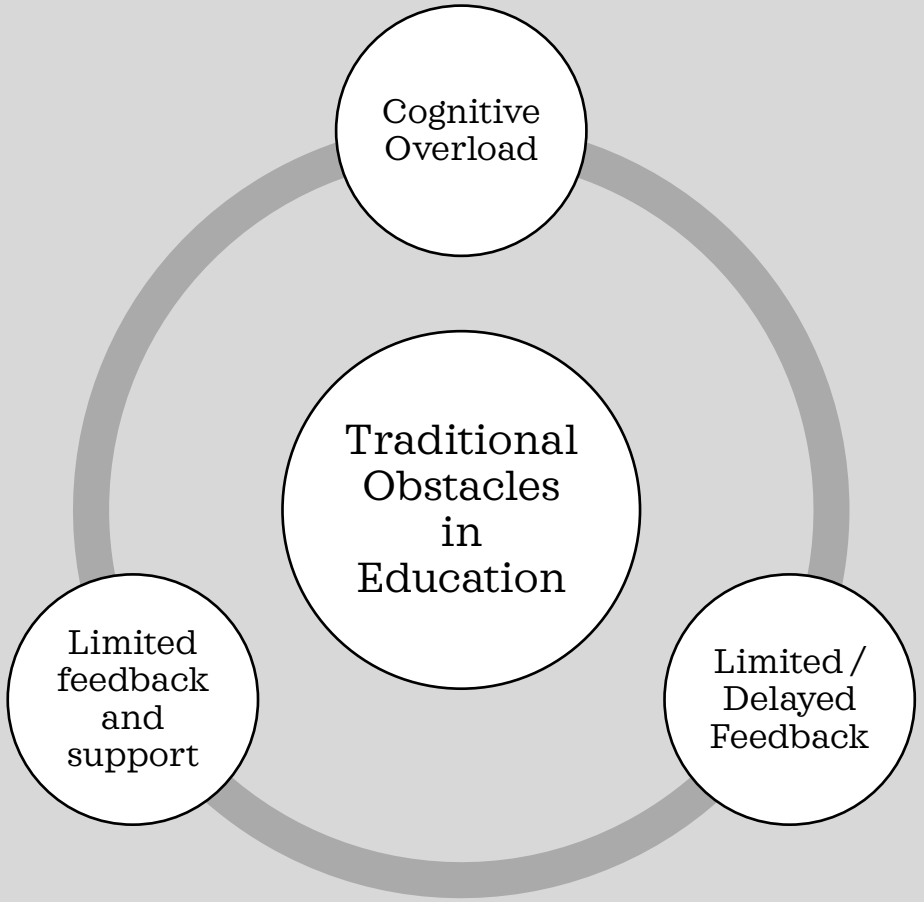
Why This Topic Matters (Context & Problem)

- Programming education has had long-standing **challenges**.
- Recent LLM tools have entered classrooms rapidly.
- However, we need to understand the **educational impact.**



Methodology

- ACM, IEEE, MDPI, arXiv.

Inclusion Criteria:

- Relevance to LLMs in programming education.
- Focus on programming, feedback and adaptive learning.
- Methodological soundness.

Exclusion Criteria:

- Absence of peer review or formal archive status, opinion pieces, and non-academic commentary.
- A lack of direct relevance.
- Insufficient methodological detail (e.g. anecdotal reports).

Applications of LLMs

Code Generation

Code Explanation

Debugging Support

Automated Feedback

Code Generation

Mary has been collecting daily rainfall data and has stored the data in a list. She wants to calculate the average of the rainfall data (excluding any negative values) and the maximum. Write a function that returns these two values as a tuple, or -1 if there is no valid data.

```
def rainfall(data):
    total = 0
    count = 0
    max_rain = 0
    for i in range(len(data)):
        if data[i] >= 0:
            total += data[i]
            count += 1
            if data[i] > max_rain:
                max_rain = data[i]
    if count == 0:
        return -1
    else:
        return total / count, max_rain
```

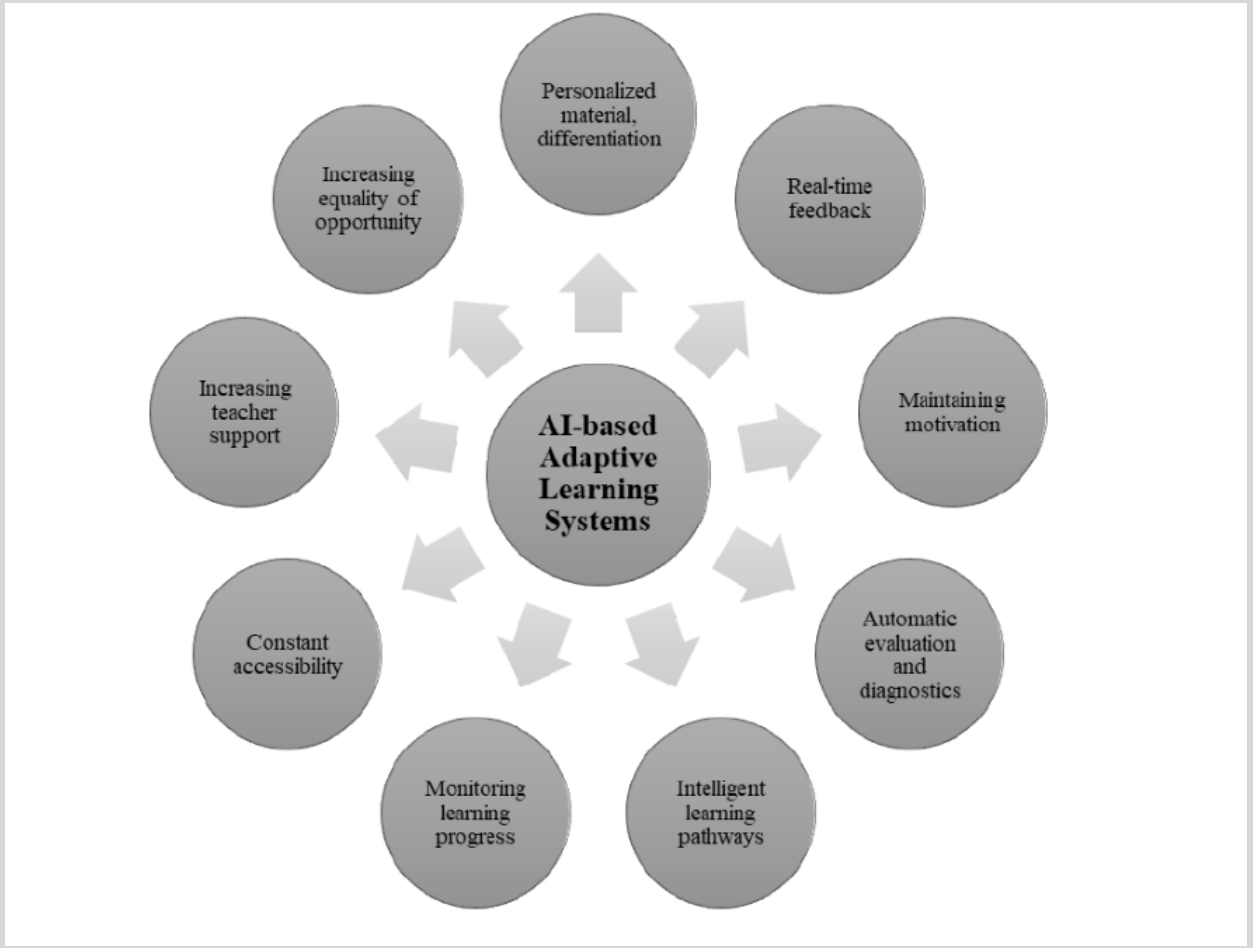
```
def rainfall_data(rainfall):
    valid_data = []
    for i in rainfall:
        if i > 0:
            valid_data.append(i)
    if len(valid_data) == 0:
        return -1
    else:
        return (sum(valid_data)/len(valid_data),
                max(valid_data))
```

Finnie-Ansley, J., Denny, P., Becker, B. A., Luxton-Reilly, A. & Prather, J. (2022). *The Robots Are Coming: Exploring the Implications of OpenAI Codex on Introductory Programming.*

- LLMs can turn natural language prompts into working code.
- Most effective when students analyse, not copy, generated solutions.

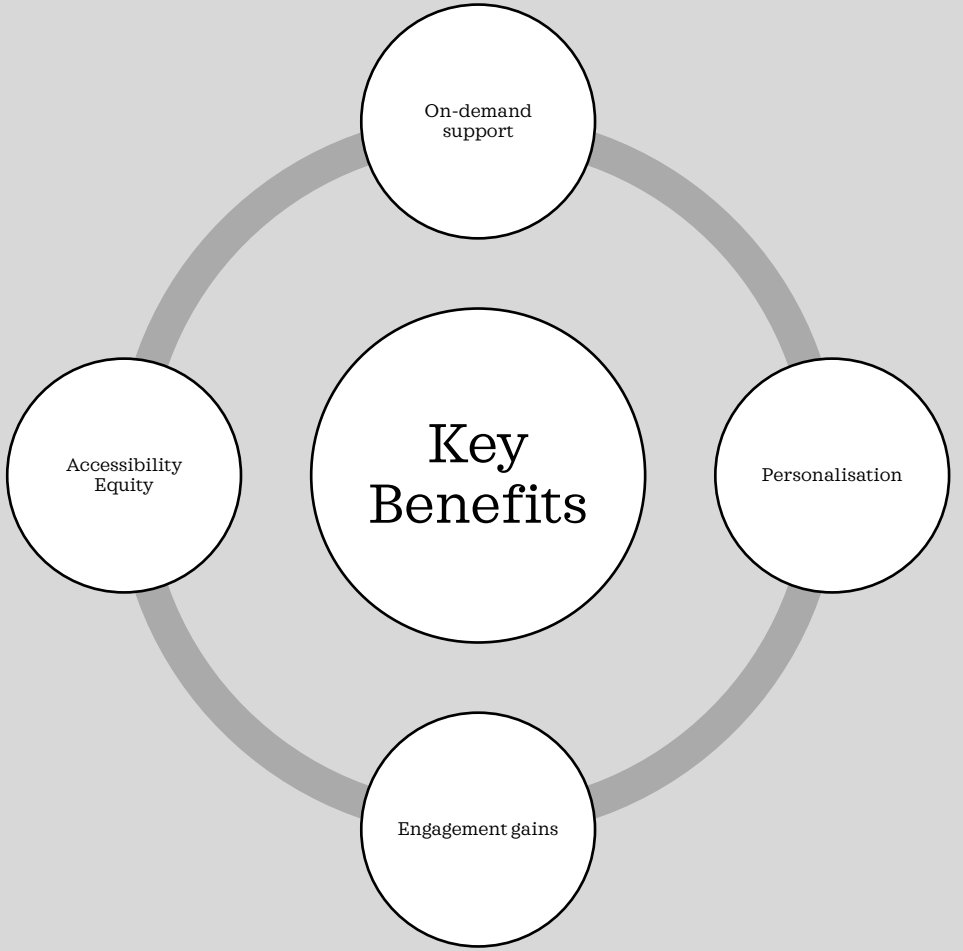
Debugging, Explanation, and Feedback

LLM Feature	What it Provides	Educational Benefit	Limitation
Debugging	Error identification	Fixing errors faster	May hide reasoning
Explanation	Concept breakdown	Helps novices understand	Risk of inaccuracies
Feedback	Personalised comments	Enables personalised feedback to be delivered at scale	Over-reliance risk



Gyonyoru, I. K. K. (2024). *The Role of AI-based Adaptive Learning Systems in Digital Education*. Journal of Applied Technical and Educational Sciences

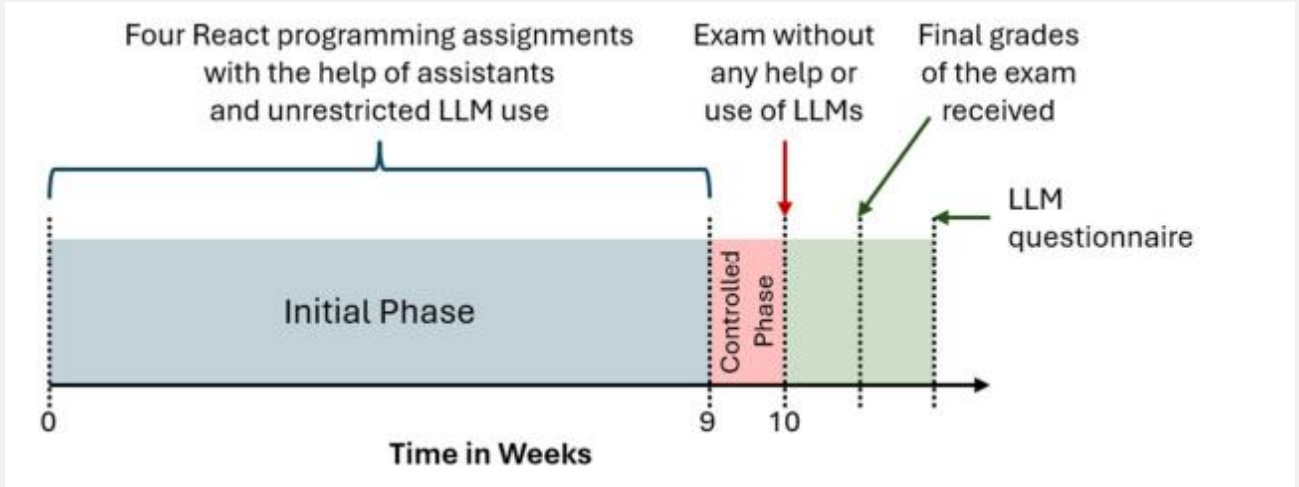
Benefits & Opportunities



Challenges & Limitations

Challenge	Evidence from Studies
Over-reliance	Lower grades with heavy LLM use (Jošt et al.)
Hallucination	Incorrect but confident code (Kasneci et al.)
Academic integrity	AI-generated solutions issues
Bias & transparency	Limited explainability

Negative Learning Outcomes Associated with LLM Dependence



Jošt, G., Taneski, V. & Karakatič, S. (2024). The Impact of Large Language Models on Programming Education and Student Learning Outcomes.

Results:

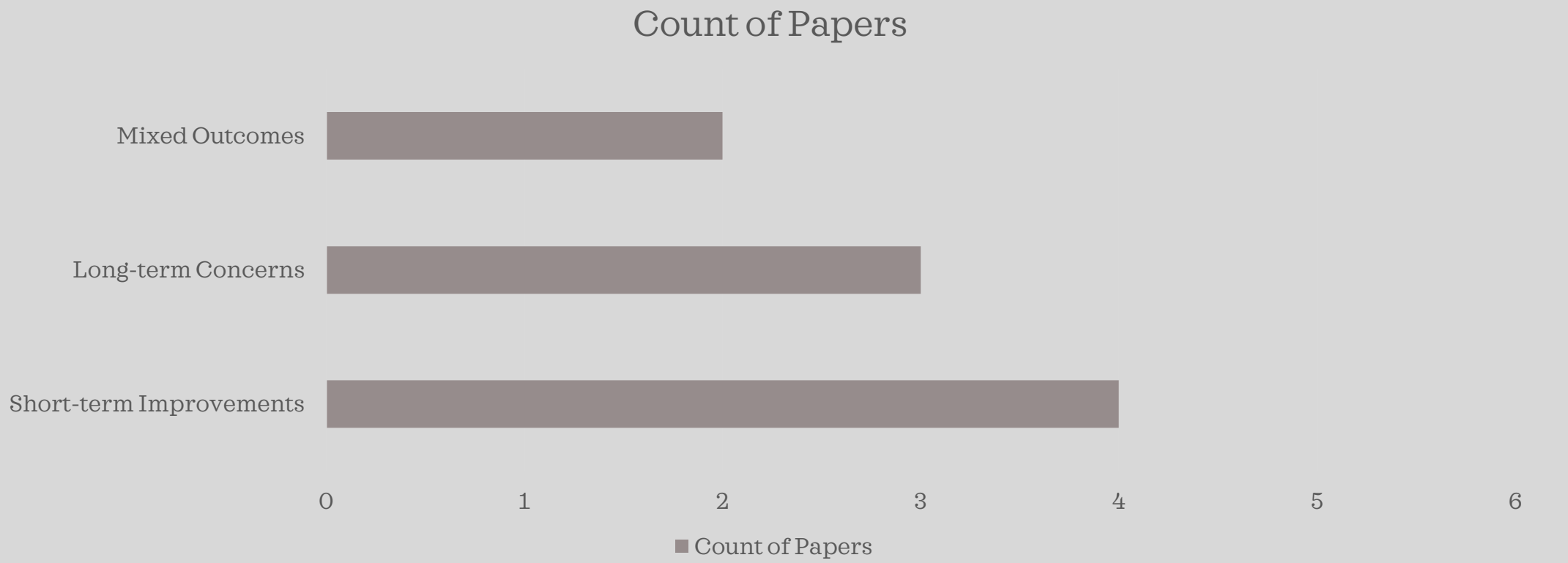
Heavy LLM usage led to lower grade overall.

- **Most harmful:** relying on LLMs for code generation.
- **Also harmful:** using LLMs for lots of debugging.
- **Least harmful:** using LLMs for extra explanations.

- Students who used LLMs **more frequently** across all tasks showed a **downward grade** trend.

Impact on Learning Outcomes

Data derived from: Jacobs (2024); Deriba (2023); Leinonen (2022); Jošt et al. (2023); Kasneci (2023); Yousef (2025);

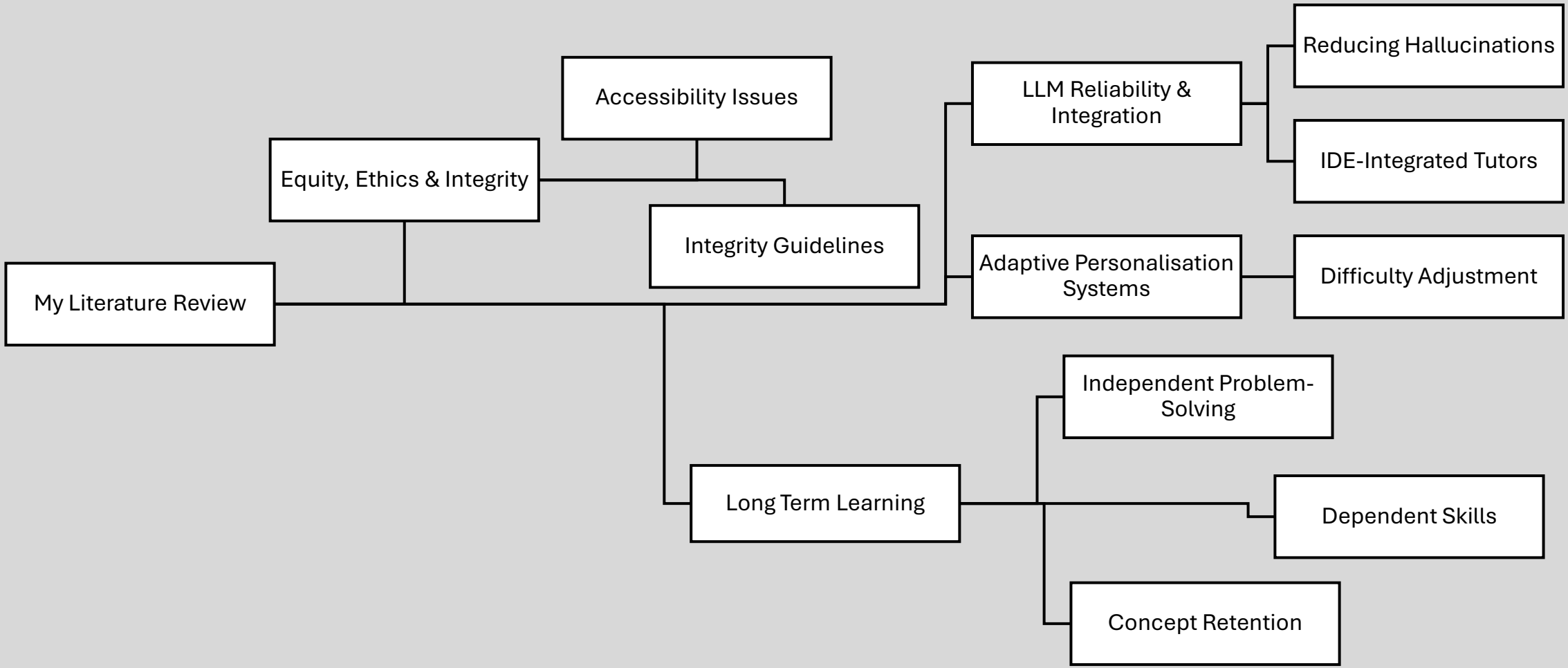


Short-Term Improvements: LLMs boost immediate performance by helping students fix errors faster, understand syntax quickly, and complete tasks more efficiently.

Long-Term Concerns: But heavy reliance can weaken problem-solving skills, *lower* exam scores, and reduce independent debugging ability.

Mixed Outcomes: Some studies show benefits only when use is guided. Unguided use leads to shallow understanding and misconceptions.

Future Research Direction



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THANK YOU.

Questions welcome.

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