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Atlantic Technological University

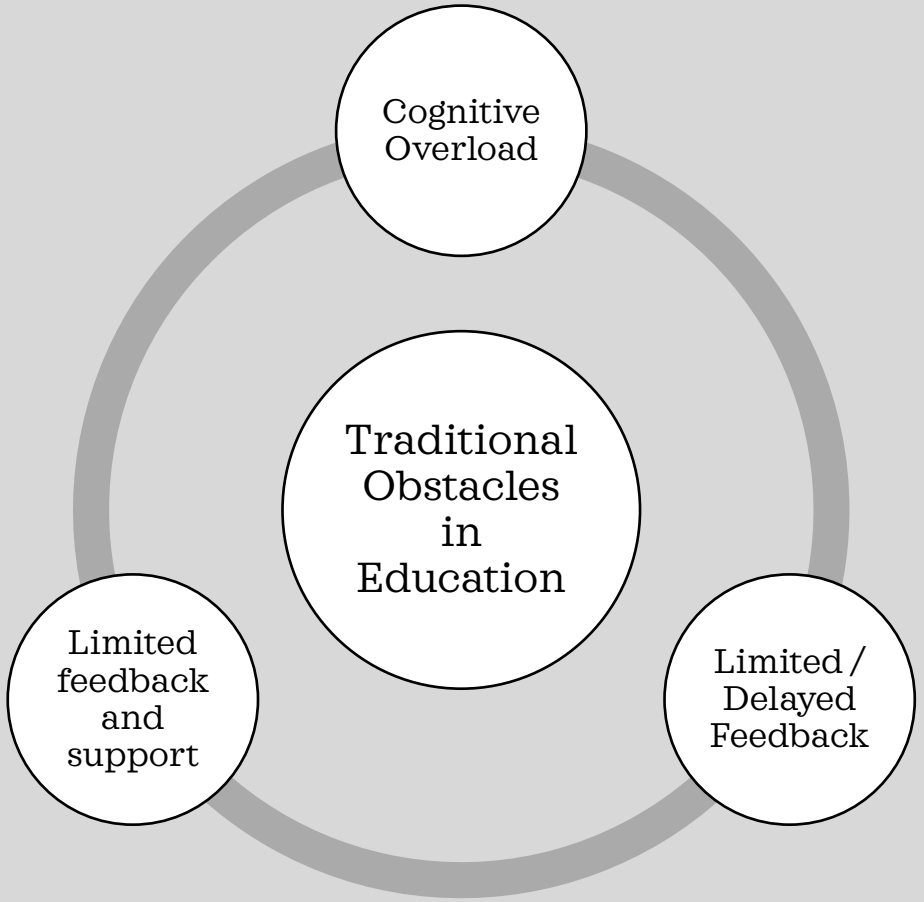
Research Methods In Computing & IT

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

Fionn McGoldrick
G00422349

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
```

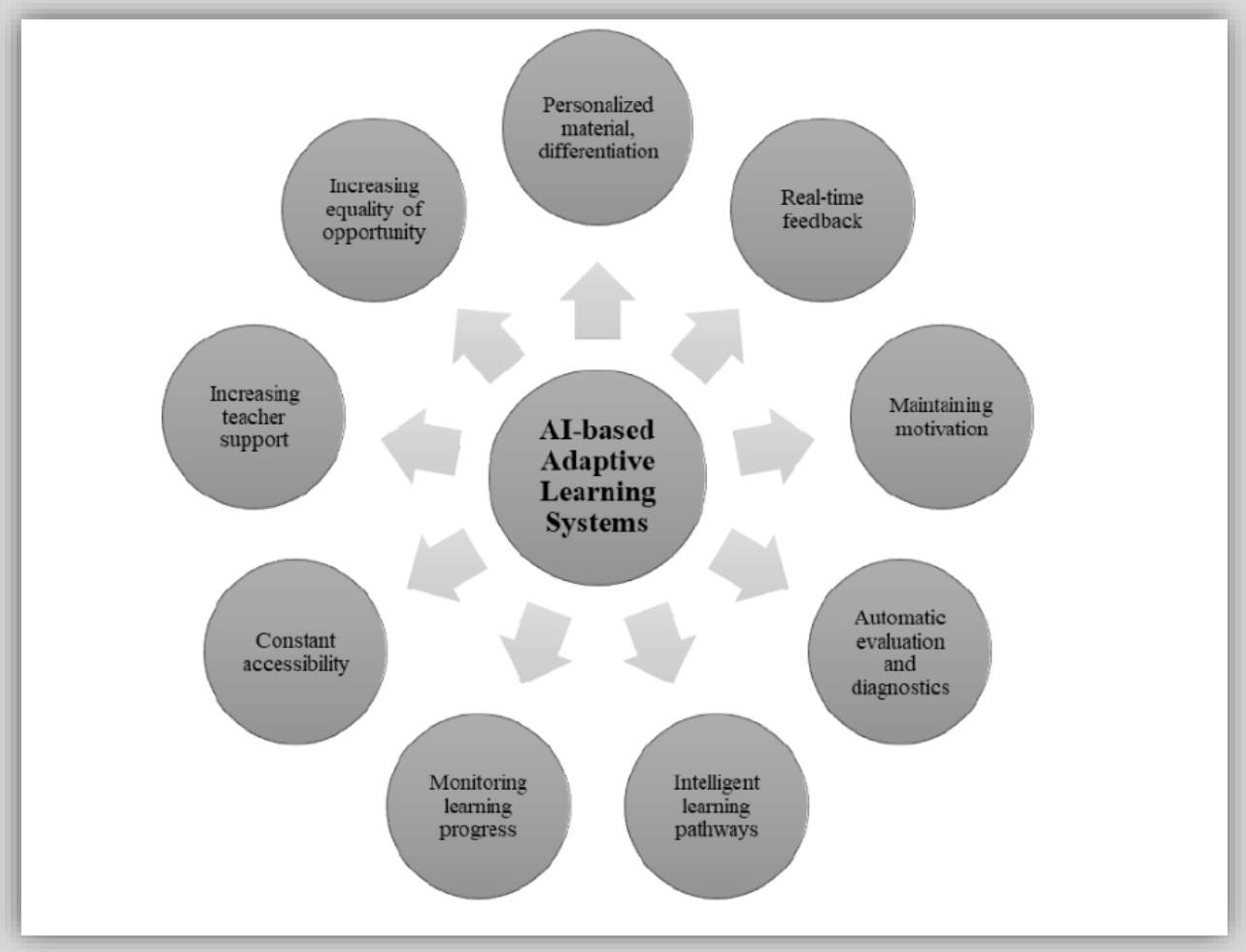
```
def rainfall_data(rainfall):
    valid_data = []
    for i in rainfall:
        if i > 0:
            valid_data.append(i)
    if len(valid_data) == 0:
        return -1
    else:
        return (sum(valid_data)/len(valid_data),
                max(valid_data))
```

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.

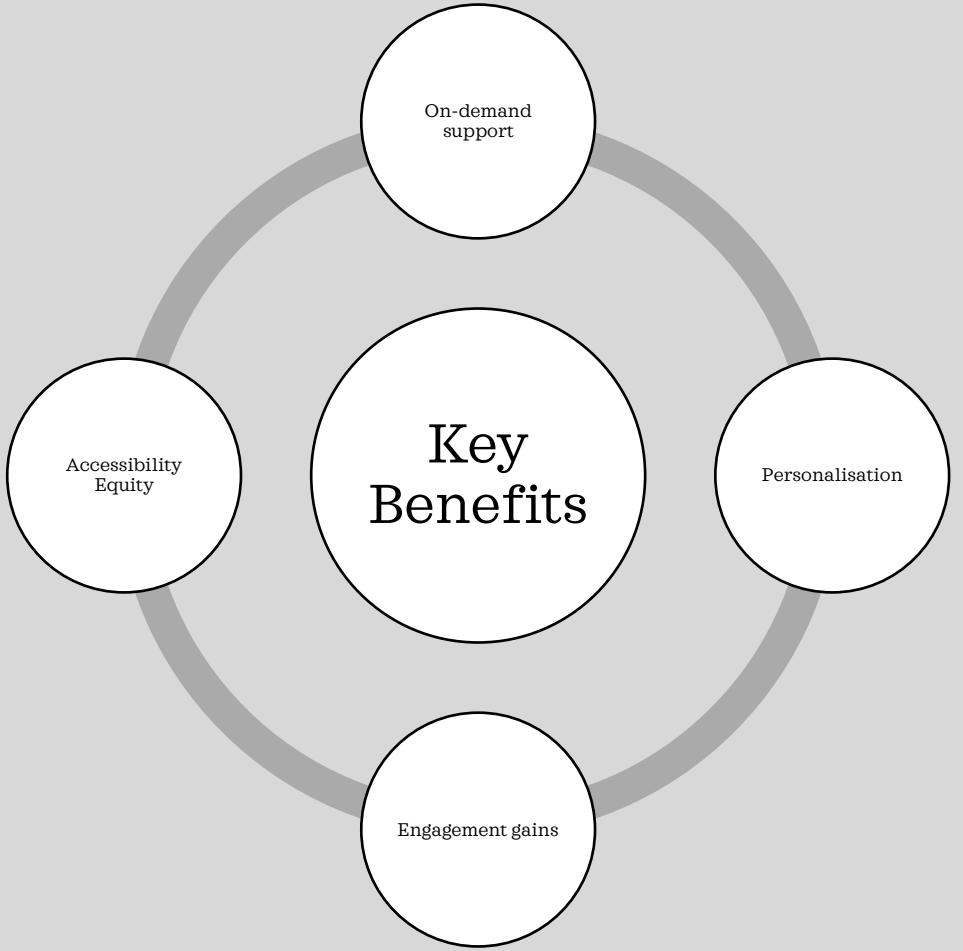
Debugging, Explanation, and Feedback

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



Katona, J. & Katonane Gyonyoru, K. I. (2025). AI-Based Adaptive Programming Education for Socially Disadvantaged Students: Bridging the Digital Divide.

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

Impact on Learning Outcomes

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