Solving without reasoning: What AI means for learning mathematics-Implications for Initial Teacher Education in Primary Mathematics



UNIVERSITY OF JOHANNESBURG

FACULTY OF EDUCATION

21 YEARS OF IMPACT

Our Future Reimagined

IS IT AN ANSWER PROBLEM?

If every learner in South Africa had free access to ChatGPT tomorrow, would South Africa's mathematics crisis be solved?

- Many learners struggle not because answers are unavailable.
- They experience difficulties with number sense, proportional reasoning, conceptual understanding, problem solving, and mathematical communication.

WHAT ARE WE REALLY CONCERNED ABOUT?

- The real goals of mathematics have always been broader:
- understanding
- explanation
- justification
- reasoning
- problem solving

WHAT DOES MATHEMATICAL REASONING MEAN?

What do you expect from a mathematically proficient learner?

Most responses will include:

- explain your thinking
- justify your answer
- identify errors
- compare strategies
- convince others
- solve unfamiliar problems

Reasoning is not an additional strand added onto mathematics

Reasoning allows learners to know not only that something works but why it works

Reasoning is how mathematical understanding develops

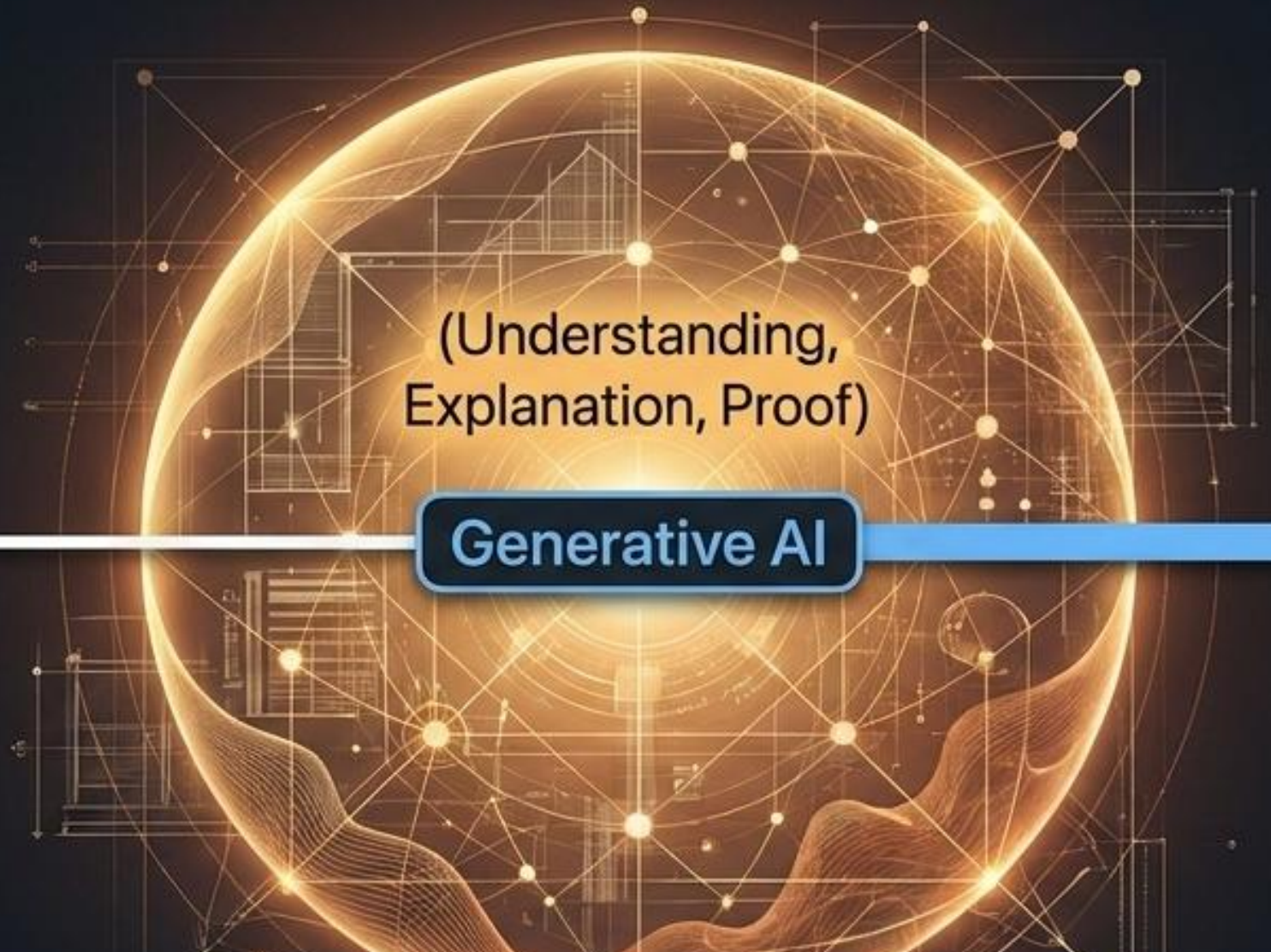
IF PROBLEM SOLVING IS THE HEART OF MATEMATICS, PROVING IS ITS SOUL

- Many disciplines generate answers
- What makes mathematics unique is that mathematical claims require justification.
- Mathematicians ask:
- Why does this work?
- How do we know?
- Is it always true?
- What evidence supports this conclusion?

The Illuminated Middle

Point A: The Question

$$\int_0^\infty e^{-x^2}\,dx = \frac{\sqrt{\pi}}{2}$$



CALCULATION IS NOT REASONING

Calculation involves	Reasoning involves
procedures	selecting strategies
algorithms	evaluating claims
rules	making connections
	justifying conclusions
AI makes answers abundant; reasoning becomes scarce and valuable	

WHY THIS MATTER FOR SOUTH AFRICA

- Many learners continue to experience difficulties with:
- number sense
- proportional reasoning
- algebraic thinking
- mathematical language
- problem solving

- **AI may reduce barriers to access and provide support**
- **No technology can replace the need for learners to construct mathematical meaning**



STUDENTS AND AI

- Yoon et al.’s (2024) study on students using generative AI for mathematical proof provides an important warning.
- Students frequently interacted with AI-generated proof during problem solving.
- Some students used AI productively.
- Others treated AI as an authority and accepted outputs without sufficient critique

WHAT THE META-ANALYSIS FOUND

- AI has positive effects on mathematics learning.
- Not all AI applications are equally effective.
- The strongest impacts come from:
- Intelligent Tutoring Systems
- Adaptive Learning Systems

- **The best AI supports thinking**
- **The weakest AI replaces thinking**

THE REAL RISK



There is much discussion about hallucinations and inaccurate AI outputs.



If AI immediately supplies answers, learners may lose opportunities for:



Productive struggle



Exploration



Reflection



justification

The danger is not that AI makes mistakes.

The danger is that learners stop noticing them.

A DIFFICULT TRUTH

Many preservice primary school teachers already struggle with mathematical reasoning.

Common challenges include:

explaining procedures
justifying methods
evaluating arguments
identifying misconceptions



This means AI enters teacher education at a vulnerable point.

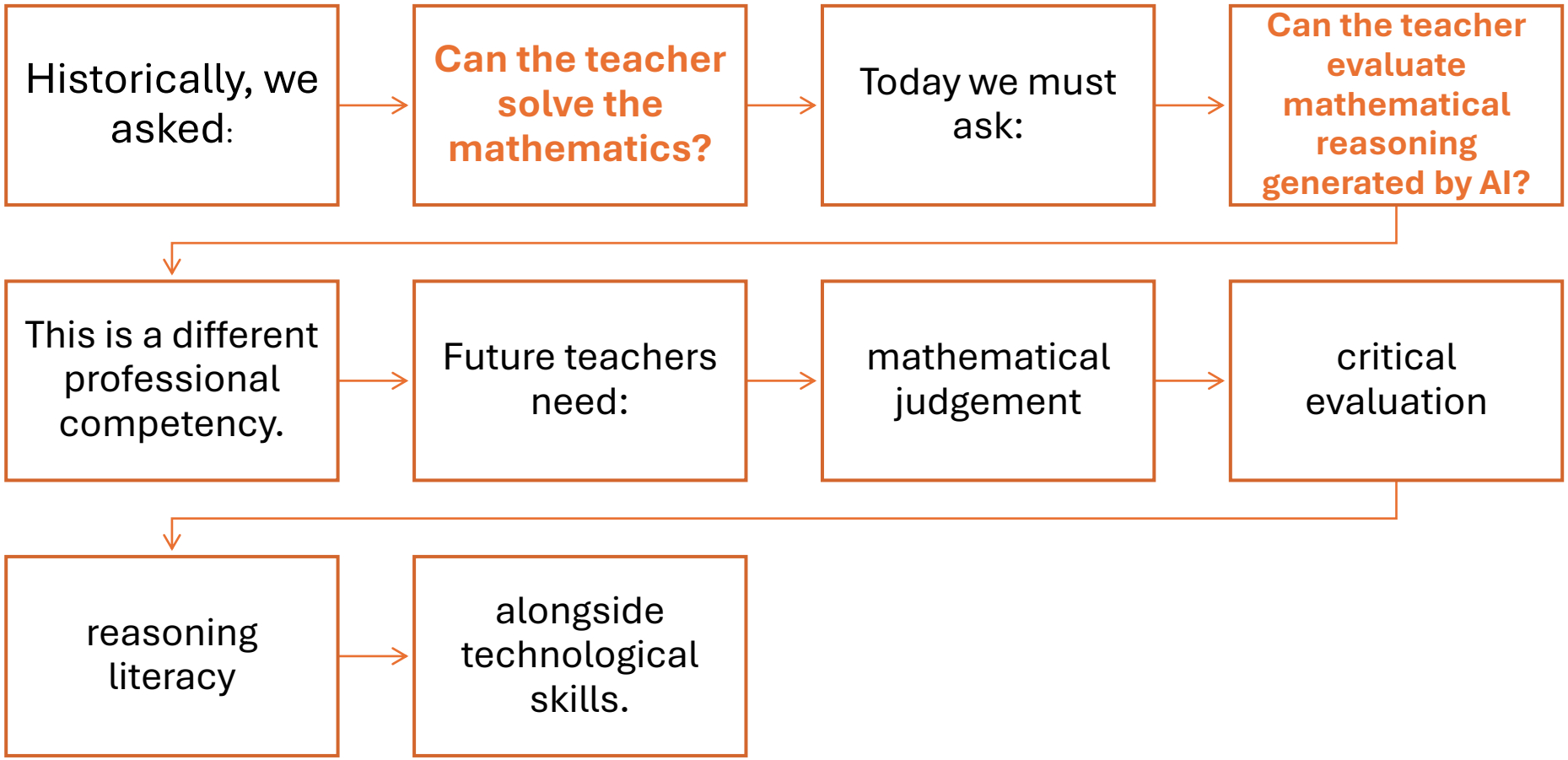


Future teachers must not simply learn to use AI.



They must learn to evaluate AI mathematically.

NEW CHALLENGE FOR TEACHER EDUCATION



CASE STUDY 1

- Imagine a student teacher asks ChatGPT:
- "Why is ¾ larger than ⅔?

- ChatGPT converts both fractions to twelfths.

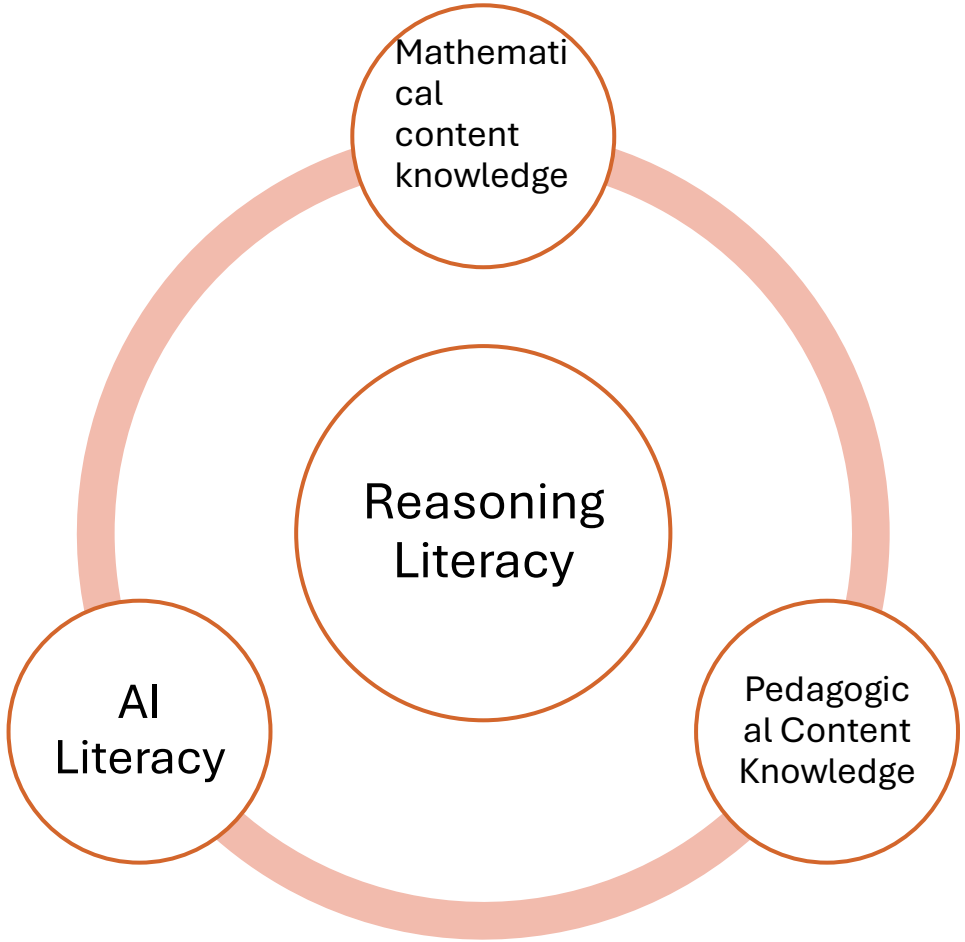
- The answer is mathematically correct.

- But a teacher must know more.

CASE STUDY 2: AI LESSON PLANNING

- Imagine a student teacher asks ChatGPT to create a complete fraction lesson.
- The resulting lesson appears impressive.
- Who evaluates:
- mathematical accuracy?
- Conceptual progression?
- developmental appropriateness?
- learner misconceptions?
- **Professional judgement becomes more important, not less**

FUTURE TEACHER EXPERTISE



AI AS A REASONING PARTNER

- Used wisely, AI can:
- Generate examples
- Suggest alternative strategies
- Identify misconceptions
- Provide feedback
- Stimulate discussion
- These uses align closely with the findings from Yi et al.’s (2025) systemic review.
- **AI can be a reasoning partner**

AI AS A REASONING RISK

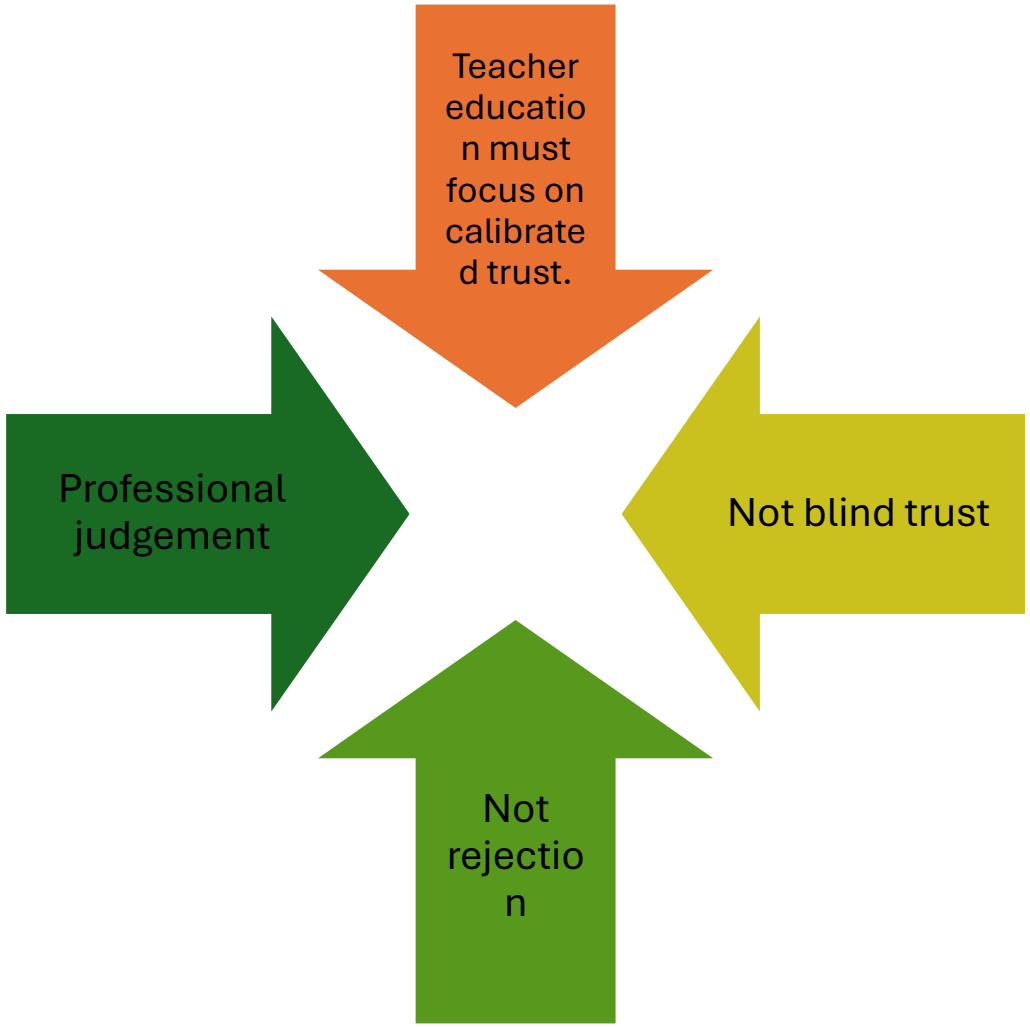
Every benefit comes with a potential risk.

AI can encourage:

Dependency

Superficial engagement

Answer-seeking behaviour



ASSESSMENT: WHAT TO STOP AND WHAT MORE

Many current assessments reward:

- calculation
- procedural fluency
- answer productions

- These competencies remain important.
- They are no longer sufficient

- In an AI-rich world, assessment should increasingly focus on:
- Explanation
- Justification
- Argumentation
- Critique
- Comparison of strategies

Assessment shapes what students value

If we value reasoning, we must assess reasoning

EXAMPLE ASSESSMENT TASK

Provide students with an AI-generated explanation.

Ask them to:

Evaluate correctness.

Identify misconceptions.

Improve the explanation.

Explain how they would teach it

- This assessment simultaneously develops:
- reasoning
- mathematical understanding
- pedagogical content knowledge
- AI literacy

RECOMMENDATIONS

1

First, use AI to support thinking, not replace thinking.

2

Second, explicitly teach learners and teachers to challenge AI outputs

3

Third, assess reasoning more than answers

4

Fourth, use AI in ways that reduce inequality and expand access

5

Finally keep teachers at the centre

THE SOUL OF MATHEMATICS

If problem-solving is the heart of mathematics, proving is its soul.

AI is becoming increasingly good at the heart.

It can solve more and more problems.

The challenge for South African mathematics education is ensuring that we do not lose the soul

- The challenge for ITE is therefore clear:
- Prepare teachers who can use AI
- Prepare teachers who can critique AI
- Prepare teachers who can reason beyond AI
- **Prepare teachers who ensure that learners continue to find meaning in mathematics**