The Power of AI in Teaching Mathematics

Peter Gates & ChatGPT

There have been a few posts on X from teachers (often those who also want mobile phones banned) bemoaning AI because their pupils were using it to do their homework. How might we respond to such a concern? When I asked ChatGPT it came up with the following – which I have slightly adapted and reworded.

First this is identifying a real problem, but often drawing the wrong conclusion from it. AI has exposed something that was already weak in a lot of homework design. If a pupil can complete the task by copying from an AI tool, then very often the task was mainly testing answer production, not understanding. That is not entirely the teacher's fault - schools have relied on that model for years because it is quick to set, easy to mark, and familiar. But AI has made its weakness impossible to ignore.

There is actually a very interesting educational shift happening right now because of AI. This is forcing universities and schools to move from "solve this problem" homework to "analyse this solution" homework. It changes the intellectual skill being tested.

First, the concern is legitimate

Of course, some pupils will use AI lazily, just as some copied from friends, used solution websites, or got help from parents. Pretending otherwise is naive.

Second, banning the tool does not solve the educational problem

You can ban phones in school, but you cannot ban the existence of AI outside school. If homework can be done in five seconds by a chatbot, then the long-term answer is not endless policing. It is to set work that depends on thought, choice, explanation, checking, and class follow-up.

Third, this is not just a discipline issue

It is a curriculum and assessment issue. If pupils are rewarded for polished final answers alone, many will outsource the thinking. If instead they are asked to explain methods, compare strategies, create examples, critique errors, and defend conclusions in class, AI becomes much less useful as a shortcut.

Fourth, teachers should not be blamed for feeling frustrated

Many are overworked already. Redesigning homework takes time, and schools do not always give staff the freedom or support to do that. So, we should have some sympathy. The irritation is understandable. What is less helpful is turning that frustration into moral panic. AI has not broken homework. It has revealed which homework was never very robust in the first place. There are really three sensible responses:

1. **Set better homework** - tasks that require personal reasoning, handwritten working, reflection, or later discussion in class.
2. **Use more in-class checking** - a short starter, mini-viva, or "explain your homework to your partner" routine quickly reveals who understood it.
3. **Teach pupils how to use AI honestly** - for hints, checking, revision, and alternative explanations, not for replacing thought.

Teachers who connect this to mobile phones are often really expressing a broader anxiety: loss of control, distraction, shortcut culture, declining attention, and the feeling that every new technology makes teaching harder. That feeling is understandable. But one has to be careful not to become nostalgic for an earlier system that was already imperfect.

So, teachers are right to worry, but wrong to panic, and wrong if they think prohibition alone will rescue learning.

The deeper challenge is to design educational tasks so that thinking still matters when answers are cheap. That, in truth, is now the central task for schools.

What AI can do, is function rather like a very patient research assistant or teaching aide. For example, it can help with:

- designing homework tasks or exam-style questions
- generating investigation-style maths problems
- drafting history or genealogy explanations
- analysing records, certificates, or census entries
- producing summary sheets for learning topics (as you prefer to call them)
- helping structure research notes or essays

In other words, the sort of background work that often takes teachers and researchers a lot of time.

Looking Ahead

Since we have wandered into this topic, there is actually a very interesting paradox about AI and mathematics education that a number of mathematicians have pointed out recently. In some ways AI may improve maths teaching rather than weaken it, because it forces teachers to design deeper questions.

That argument is quite thought-provoking and it is quite an interesting argument, and a number of mathematicians and education researchers have been making it over the last couple of years. The paradox is this - *AI may actually force mathematics teaching to become better.* For decades a lot of school mathematics - especially homework - has relied heavily on procedural exercises:

- solve these ten quadratics
- factorise these expressions
- simplify these fractions
- differentiate these functions

Those tasks made sense when the only way to get the answers was to do the mathematics yourself. But AI, computer algebra systems, and even advanced calculators can now do many of those tasks instantly. So, AI exposes a question that was already there but often ignored but pushes teaching in some productive directions:

If a machine can do the procedure instantly, what mathematical thinking do we actually want pupils to learn?

So what do we want young people to learn for over a decade of mathematics teaching in schools and how do we need to respond to developments in technology? There seem to be 6 overarching issues.

1. More Emphasis on Mathematical Reasoning

Instead of just solving equations, pupils might be asked to:

- explain why a method works
- compare two different methods
- analyse incorrect reasoning
- predict the type of solutions before calculating.

These are closer to the way mathematicians actually think.

2. Greater Focus on Structure and Patterns

Mathematics is not really about producing answers; it is about understanding structures. For example, rather than asking pupils to solve the equation $x^2-7x+10=0$, a more interesting question might be:

- How do the numbers in a quadratic relate to its solutions?
- What does the discriminant tell us before we solve the equation?
- How does changing b or c change the graph?

AI does not remove the need for this understanding.

3. More Discussion and Explanation

Good mathematics learning often involves explaining ideas to others. We can offer tasks which require genuine understanding - AI cannot replace the pupil's thinking here:

- "Explain this solution to a Year 8 pupil"
- "Why is this reasoning wrong?"
- "Create an example that breaks this rule"

4. Mathematics Becomes More Like Real Mathematical Work

Professional mathematicians rarely spend their time doing long repetitive calculations. They spend their time:

- looking for patterns
- asking "what happens if…?"
- testing conjectures
- explaining ideas.

AI pushes school mathematics slightly closer to that style.

5. Routine Computation May Become Less Central

This is controversial, but historically mathematics education has always adapted to technology. For example:

- logarithm tables replaced tedious multiplication
- calculators replaced long arithmetic
- computer algebra systems replaced some symbolic manipulation.

Yet mathematics itself did not disappear - it shifted towards conceptual understanding. AI may simply be the next step in that progression.

The Real Risk

The real danger is not AI itself. The danger is pretending nothing has changed and continuing to set tasks that AI can complete instantly. That leads to frustration for teachers and temptation for pupils.

A More Productive Attitude

A healthier approach is something like:

"Since AI can solve routine problems, let's ask better questions."

That does not mean abandoning skills. Pupils still need to learn algebra, number sense, and mathematical reasoning. But it may mean spending less time on large sets of repetitive exercises and more time on thinking tasks.

Interestingly, some mathematicians have noted something else:

AI is very strong at routine algebra but surprisingly weak at mathematical insight. Good students can sometimes spot patterns or elegant shortcuts that AI completely misses.

AI and creative approaches to quadratics

If a homework task is purely "*solve these equations*", pupils can simply paste it into an AI tool. The trick is to design something that requires their own working, reasoning, and reflection, not just answers.

So, I asked ChatGPT "**Can you write me a secondary school maths homework task on quadratic equations that pupils could not do by just asking AI."**

Here is a set of tasks it came up with for that – which I have slightly adapted and reworded. I actually don't think these are particularly paradigm-breaking because they are the sort of tasks many teachers have been doing for some time – we were doing similar things in the 1980s under the guise of "investigative teaching" for example.

However, this does suggest to me that part of the problem and panic over AI is down to it exposing a rather poorly designed curriculum and pedagogy which is not unfit for purpose as we move forward.

Investigating Quadratic Equations

The teacher is looking for: the original equations chosen by the pupil, handwritten working, the explanation and reasoning and the sketch

So, copying answers from AI would not match the student's own equation choices or reasoning. Mathematics homework is actually one of the easiest areas to redesign so that simply asking AI for answers does not work very well. The key idea is to assess thinking, choices, and explanation, not just final answers.

You may use a calculator, your notes, or a textbook.

For this task, you **may not use AI tools** to generate answers. Your marks will be awarded mainly for **your reasoning and explanation**, not just the final answers.

Part 1 - Create Your Own Quadratic

Write down three different quadratic equations of the form:

$$ax^2+bx+c=0$$

They must satisfy the following conditions:

- One quadratic with two different integer solutions
- One quadratic with one repeated solution
- One quadratic with no real solutions

For each equation:

a) Solve it using an appropriate method (factorising, completing the square, or the quadratic formula).

b) Show all working clearly.

Part 2 - Explain What Is Happening

For each of your equations:

- Calculate the discriminant b^2-4ac
- Explain how the value of the discriminant relates to the number of solutions you found.
- Write 2–3 sentences explaining why this happens.

Part 3 - Graphical Check

Choose one of your equations.

1. Sketch neatly the graph of $y=ax^2+bx+c$
2. Label:
    a. The x-intercepts
    b. The y-intercept
    c. The vertex
3. Explain how the graph confirms the solutions you found algebraically.

Part 4 - Reflection

Write a short paragraph answering:

- Which method of solving quadratics do you prefer and why?
- In what situations might a different method be better?

1. “Design the Problem” Tasks

Instead of solving given equations, pupils must construct examples that satisfy conditions.

Homework - Build Three Quadratics

Create three quadratic equations that satisfy the following conditions:

1. A quadratic with solutions 3 and -5.
2. A quadratic with exactly one real solution and a negative coefficient of x^2.
3. A quadratic whose graph does not cross the x-axis but has a y-intercept of 4.

For each quadratic:

- Write the equation.
- Show how you know it satisfies the conditions.
- Sketch the graph.

Why AI struggles

AI can generate examples, but pupils still have to:

- understand the conditions
- check the discriminant
- explain their reasoning
- produce their own graphs

Teachers can also see if multiple pupils submit identical equations.

2. “Spot the Mistake” Tasks

Students analyse incorrect solutions, which forces conceptual understanding.

Homework - Error Analysis

A student solves the equation

$$2x^2-5x-3=0$$

Their work is shown below:

$$2x^2-5x-3=0$$

$$(2x-1)(x-3)=0$$

$$x=½ \quad \text{or} \quad x=3$$

Tasks:

1. Identify the exact step where the error occurs.
2. Explain why it is wrong.
3. Solve the equation correctly.
4. Explain how you could quickly check the answer is correct.

Why this works

Students must explain their reasoning. If someone simply pastes an AI answer, teachers often spot:

- language beyond their normal level
- missing understanding in class discussion.

3. “Always / Sometimes / Never” Reasoning Tasks

These require logical thinking rather than computation.

Homework - Quadratic Statements

For each statement decide whether it is:

Always true, sometimes true, or never true

and justify your answer with examples.

1. A quadratic equation has two solutions.
2. If the discriminant is positive, the solutions are integers.
3. If $c=0$, one solution is $x=0$.
4. A quadratic graph with a positive a value has a minimum point.

Students must:

- give examples
- give counterexamples
- explain their reasoning.

Why AI cannot shortcut it easily

Students must construct their own examples, which vary across the class.

When Does a Quadratic Have Integer Roots?

This type of task forces pupils to generate their own examples, organise results, identify patterns and explain mathematical reasoning.

Even if a pupil asked AI, they would still need to create their own table, interpret the results and write explanations in their own words.

Asking pupils to handwrite their investigation usually shows false starts, corrections, messy exploration. AI-generated work rarely looks like that.

Consider the quadratic equation

$$x^2+bx+c=0$$

where b and c are integers.

Part 1 - Exploring Examples

Choose five different pairs of values for b and c.

For each pair:

- Write down the quadratic equation.
- Solve the equation.
- Record whether the solutions are:
    - two integers
    - two non-integers
    - or not real.

Organise your results in a table.

Part 2 - Look for Patterns

Answer the following questions:

1. What do you notice about the discriminant b^2-4c when the solutions are integers?
2. What do you notice when the solutions are not real?
3. Can you find a rule that predicts when integer solutions will occur?

Explain your reasoning clearly.

Part 3 - Test Your Rule

1. Choose three new quadratics.
2. Before solving them use your rule to predict the type of solutions.
3. Then solve them and check whether your prediction was correct.

Part 4 - Challenge Question

Find a quadratic of the form

$x^2+bx+c=0$

that has integer coefficients but irrational solutions.

Explain why this happens.

The Missing Coefficients

Students must: find multiple possible answers, justify them mathematically and explain their thinking. Different pupils will produce different valid solutions, which makes copying obvious. There is a very simple quadratic homework question that completely defeats most AI tools and calculators, yet good GCSE pupils can solve it with clever thinking. It is often used in mathematics competitions.

Three quadratics are shown below. In each case some numbers are missing.

Your task is to work out what the missing numbers could be.

More than one answer may be possible.

Puzzle 1

$$x^2+\square x+6=0$$

The equation has two integer solutions.

1. What numbers could go in the box?
2. What are the corresponding solutions?
3. Explain how you know.

Puzzle 2

$$2x^2+\square x+8=0$$

The equation has exactly one real solution.

1. What number must go in the box?
2. Explain why this guarantees only one solution.

Puzzle 3

$$x^2+4x+\square=0$$

The equation has no real solutions.

1. Find three possible values that could go in the box.
2. Explain how you know the graph does not cross the x-axis.

Puzzle 4 - The Challenge

Create your own quadratic equation of the form

$$x^2+bx+c=0$$

that has solutions 4 and −7.

1. Write the equation.
2. Explain how you constructed it.

Final Question

Which part of this task did you find most difficult?

Write 2–3 sentences explaining why.

Quadratic Challenge Problem

This task tests algebraic manipulation, recognition of structure and mathematical creativity rather than routine application of the quadratic formula.

Without solving the equation using the quadratic formula or a calculator, given that:

$$x^2-5x+1=0$$

find the value of

$$x + \frac{1}{x}$$

Explain each step of your reasoning.

Extension Challenge

Now find the value of

$$x^2 + \frac{1}{x^2}.$$

Again, do not solve the quadratic directly.

Why This Works Well

Pupils cannot simply "solve the quadratic and substitute", because the task explicitly forbids that method. Instead, they must notice that

$$x^2-5x+1=0$$

can be rearranged to produce relationships involving x and 1/x

Good pupils usually discover that dividing the equation by x is the key step.

Optional Harder Version

Given

$$x^2-7x+1=0$$

Without solving the quadratic, find:

1. $x + \frac{1}{x}$
2. $x^2 + \frac{1}{x^2}$
3. $x^3 + \frac{1}{x^3}$

Quadratic Graph Puzzle

Students must: recognise that the roots give the factor form, introduce an unknown constant a. and substitute the third point to determine it. Many pupils may initially assume the equation is simply (x−1)(x−5) so the key thinking step is realising the scale factor a must be found.

A quadratic graph passes through the points (1,0) and (5,0) and also passes through the point (3, −4)

1. Find the equation of the quadratic.
2. Show your reasoning clearly.

Hint

If a quadratic has roots $r_1$and r_2, it can be written in the form

$$y=a(x-r_1)(x-r_2)$$

Use the extra point to determine the value of a.

Extension Question 1

1. Where is the vertex of the parabola?
2. Sketch the graph.

Extension Question 2

Two different quadratics both pass through the points (1,0) and (5,0) but one passes through (3,−4) and the other through (3,4)

Without solving fully, explain:

1. how the graphs are related
2. where their vertices lie.

Using AI to Explore Quadratic Equations

In this task, students must evaluate explanations, check mathematical accuracy and reflect on learning. So, the task assesses critical thinking about mathematics, not just solving equations.

In this task you will use an AI tool (such as ChatGPT, Copilot, or Gemini) to help you explore quadratic equations. The aim is not to get answers, but to test, question, and evaluate the AI's explanations. You must include screenshots or copied extracts of the AI responses.

Part 1 - Ask the AI to Teach You

Ask the AI the following question: *"Explain three different ways to solve a quadratic equation."*

Write a short summary (in your own words) of the three methods it gives.

Then answer:

- Which explanation did you find clearest?
- Did the AI explain anything poorly or confusingly?
- Explain your reasoning.

Part 2 - Test the AI

Give the AI this equation $3x^2-7x-6=0$

Ask it to solve the equation using two different methods. Check the working carefully.

Tasks:

1. Are both solutions correct?
2. Does the AI explain every step clearly?
3. If there is anything unclear, explain what you would improve.

Part 3 - Challenge the AI

Create your own quadratic equation.

Ask the AI:

"Can you solve this equation and explain each step as if you were teaching a Y10 pupil?"

Now evaluate the response.

Write a short paragraph answering:

- Was the explanation helpful?
- Did the AI skip any steps?
- Could a pupil learn from this explanation?

Part 4 - Try to Catch the AI Out

Ask the AI to factorise $2x^2+5x+7$

1. What does the AI say?
2. Is the response correct?
3. Explain why this expression cannot be factorised using integers.

Final Reflection

Write 4–5 sentences answering:

- When might AI be a useful tool in learning mathematics?
- When might it be misleading or unhelpful?

Teaching AI About Quadratic Equations

Here the pupil is assessed on explanation, checking accuracy, improving explanations and reflection. In other words, the pupil must do the thinking, while AI becomes something to interrogate and critique.

In this task you will treat an AI tool as if it were a student learning about quadratics. Your job is to teach it, test it, and correct it when necessary. You should include short extracts or screenshots of your AI conversation.

Part 1 - Teach the AI

Ask the AI:

"What is a quadratic equation?"

Then write your own explanation that you think would be clearer for a Year 9 pupil.

In 3–4 sentences explain:

- What a quadratic equation is
- What the graph of a quadratic looks like
- Why quadratics can have two, one, or no real solutions

Part 2 - Ask the AI to Solve a Problem

Give the AI this equation $x2-6x+8=0$ and ask it to solve the equation.

Then:

- Check each step of its working.
- Explain whether the method used is clear and correct.
- If you think the explanation could be improved, rewrite one step more clearly.

Part 3 - Correct the AI

Tell the AI:

"A quadratic equation $x^2-4x+5=0$ factorises to $(x-5)(x+1)$

Ask the AI if this is correct.

Then:

1. Check the response carefully.
2. Explain why the statement is true or false.
3. Give the correct solution.

Part 4 - Create a Question for the AI

Create your own quadratic equation and ask the AI to solve it.

Then answer:

- Did the AI explain the solution clearly?
- Did it use a method you understand?
- Would this explanation help another pupil?

Explain your reasoning.

Final Reflection

Write a short paragraph answering:

- What did you learn from checking the AI's work?
- Do you think AI is a useful tool for learning mathematics? Why or why not?