

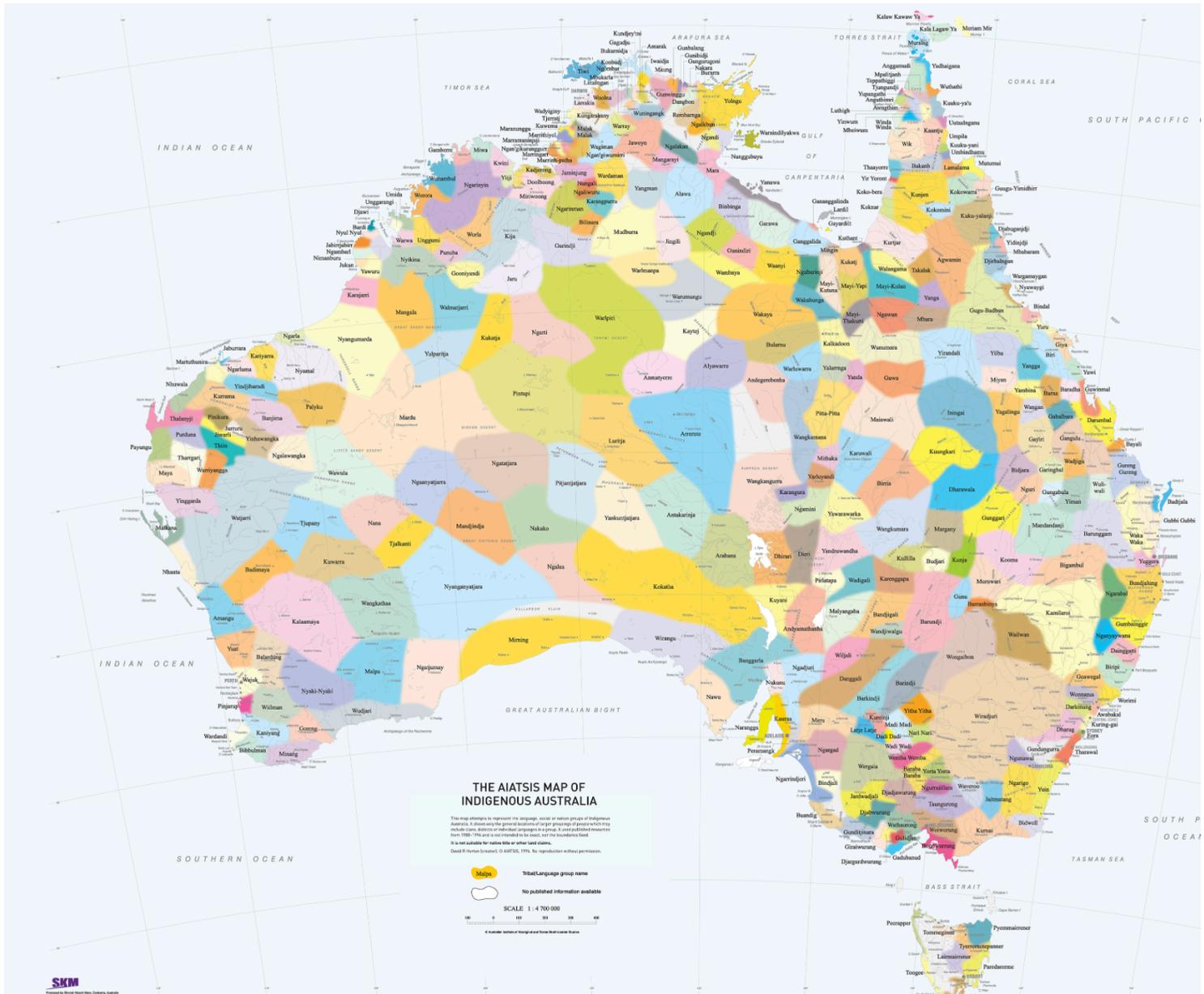


THE UNIVERSITY OF
MELBOURNE

Generative AI is (not) going to ruin mathematics education

Dr Christopher Duffy
School of Mathematics and Statistics
Centre for Studies in Higher Education
University of Melbourne

Calculus Instruction in Atlantic Canada Conference 2025



Australian Institute of Aboriginal and Torres Strait Islander Studies 1996

Caveat



Perspectives on education are personal, contextual
and shaped by place and experience

Caveat



The research in this space is thin. The recent pace of change far outstrips the pace of the scientific process.

Context



CBC

[Top Stories](#) [Local](#) [Climate](#) [World](#) [Canada](#) [Politics](#) [Indigenous](#)

Canada

5 years after COVID-19 started, parents and experts say the impact on kids remains

Lags in math and literacy reported worldwide, while parents note problems with social, emotional health

[Deana Sumanac-Johnson](#) · CBC News · Posted: Mar 24, 2025 5:00 AM ADT | Last Updated: March 24

Context



☰ Menu CBC

NEWS Top Stories Local Climate World Canada Politics Indigenous

PEI

Housing, cost of living among top concerns UPEI students tell government officials

About 100 students met with government officials Thursday night to discuss issues that matter to them

 [Sheehan Desjardins](#) · CBC News · Posted: Jan 17, 2025 6:24 AM AST | Last Updated: January 17

Context



The screenshot shows the top portion of a news article on The Globe and Mail website. The red header bar contains a menu icon, a search icon, the word "SEARCH", a watchlist icon, the word "WATCHLIST", and the newspaper's name "THE GLOBE AND MAIL" with a small maple leaf icon. Below the header, a navigation bar lists categories: HOME, FOR YOU, CANADA (underlined), WORLD, BUSINESS, INVESTING, PERSONAL FINANCE, OPINION, POLITICS, and SPORTS. The main headline reads "How one Ontario school board is getting teachers to try AI in the classroom". Below the headline, the author is listed as "DAVE MCGINN >" and the publication date is "PUBLISHED MARCH 16, 2025", with an update date of "UPDATED MARCH 17, 2025".

☰ SEARCH WATCHLIST

THE GLOBE AND MAIL

HOME FOR YOU | CANADA WORLD BUSINESS INVESTING PERSONAL FINANCE OPINION POLITICS SPORTS

How one Ontario school board is getting teachers to try AI in the classroom

DAVE MCGINN >
PUBLISHED MARCH 16, 2025
UPDATED MARCH 17, 2025



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Technology and the Evolving Role of the Mathematics Educator

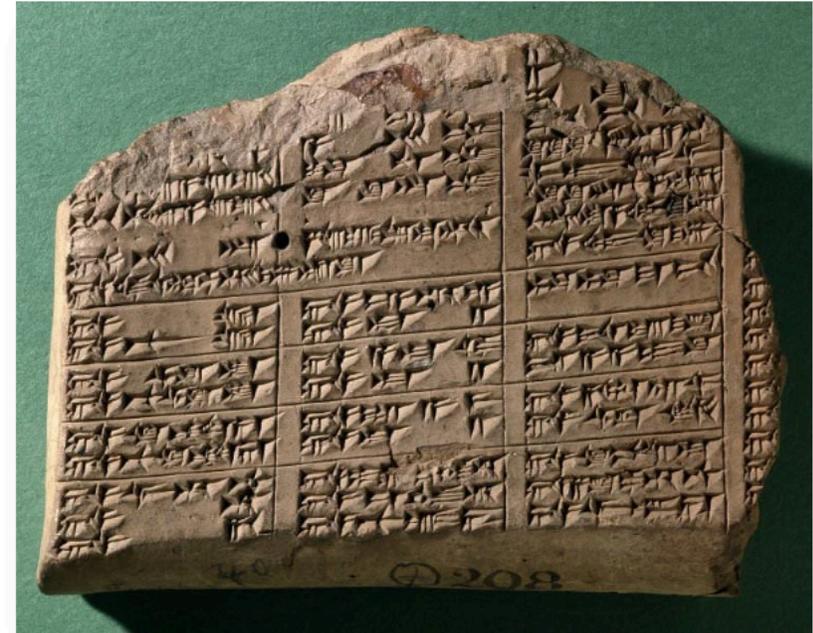
A brief history of technology and tools for mathematics education



Writing (~3500 BCE)

Developed by Sumerians of Mesopotamia to record commodity accounts

First deciphered in late early 19C



Neo-Assyrian Cuneiform Lexical List

The Trustees of the British Museum

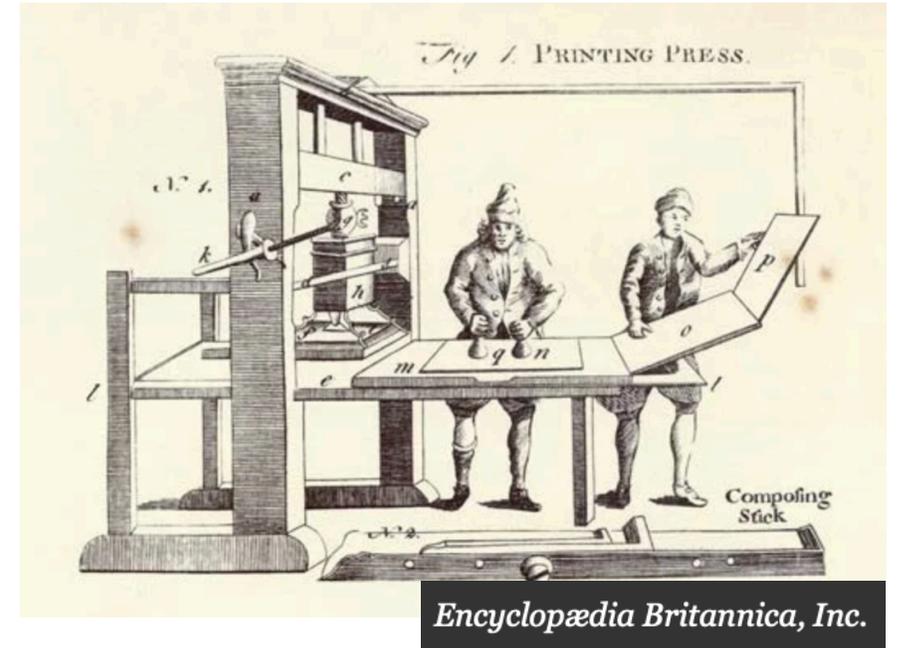
(Copyright)

A brief history of technology and tools for mathematics education

Printing Press (1440 CE)

Developed by Gutenberg, a goldsmith in Germany

Enables mass reproduction of text at a lower cost than employing monks in scriptoria



A brief history of technology and tools for mathematics education



Calculator/Programmable Calculator (1967/1974)

Developed by Texas Instruments /
Hewlett Packard

No longer do you need an “expert”
to check your computation.



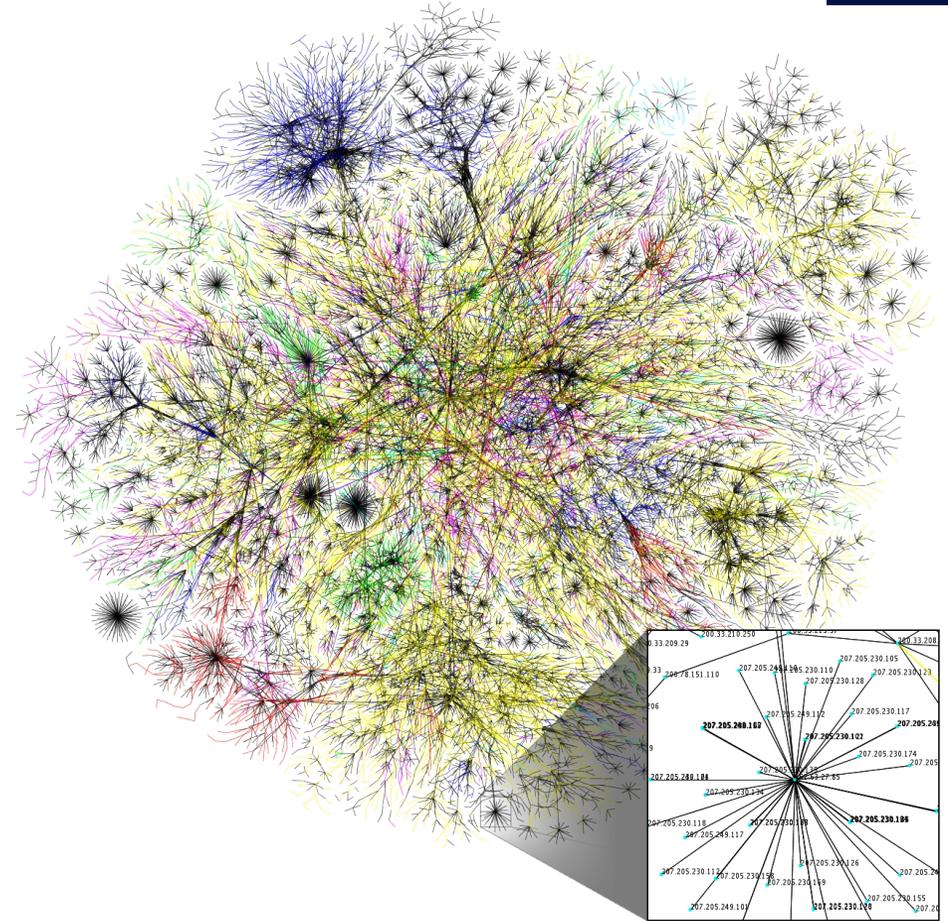
Photo Credit: [Heinz Nixdorf Forum](#)

A brief history of technology and tools for mathematics education

The Internet

Online resources and communities.

No longer do you need a local “expert” to check your reasoning.



English Wikipedia

A brief history of technology and tools for mathematics education

Wolfram Alpha (2009)



Easy access to symbolic computation.

No need for an expert to check algebraic work. Can generate full solutions.

FROM THE MAKERS OF WOLFRAM LANGUAGE AND MATHEMATICA



A brief history of technology and tools for mathematics education



Each of these innovations permit the move of the learner *away* from the expert.

A brief history of technology and tools for mathematics education

The Evolving Student* Toolkit



	1990	2000	2010	2020
Subject Resources	<ul style="list-style-type: none"> lectures textbooks/course notes consultation hours small-group learning computer labs 			<ul style="list-style-type: none"> +lecture recordings +short videos +discussion boards +online homework systems
External Resources	<ul style="list-style-type: none"> textbooks calculator other students exam banks 	+text/image based online resources	+online video +online fora	+bespoke online help +easy-to-use symbolic computational engines
Formative Assessment	problem sheets: “solve, find, prove”			

*In first-world western-style education

A brief history of technology and tools for mathematics education



The changing roles of higher education: curator, evaluator, connector and analyst

Julianne K. Wolfe and David W. Andrews

Julianne K. Wolfe is Personalized Learning Coach, School of Education, Johns Hopkins University, Baltimore, Maryland, USA.

David W. Andrews is Professor and Dean, School of Education, Johns Hopkins University, Baltimore, Maryland, USA.

Keywords *Higher education, Educational change, Continuing education, Educational practices, Performance-based assessment, Role of education*

Introduction

The mission of universities will be changing from gatekeepers of knowledge to curators, creators, connectors, certifiers and codifiers of knowledge. Due to the global accessibility and constant increase of information, the post-secondary learner no longer needs a university to obtain information. Changes have to be made to keep higher education relevant in the information age. Christenson and Horn (2011) have warned that the current business model characterizing higher education in America is “at – or even past – its breaking point”. Challenges come from escalating tuition; declining endowments and government funding; and the immediate, and often free access to highly credible information.

Citation

K. Wolfe, J. and W. Andrews, D. (2014), "The changing roles of higher education: curator, evaluator, connector and analyst", *On the Horizon*, Vol. 22 No. 3, pp. 210-217. <https://doi.org/10.1108/OTH-05-2014-0019>

A brief history of technology and tools for mathematics education

The Evolving Student Toolkit



	1990	2000	2010	2020	2025+
Subject Resources	<ul style="list-style-type: none"> lectures textbooks/course notes consultation hours small-group learning computer labs 			+lecture recordings +short videos +discussion boards +online homework systems	+tutor bots + ?
External Resources	<ul style="list-style-type: none"> textbooks calculator other students exam banks 	+text/image based online resources	+online video +online fora	+bespoke online help +easy-to-use symbolic computational engines	+genAI tools + ?
Formative Assessment	problem sheets: “solve, find, prove”				?



Educator as source of knowledge

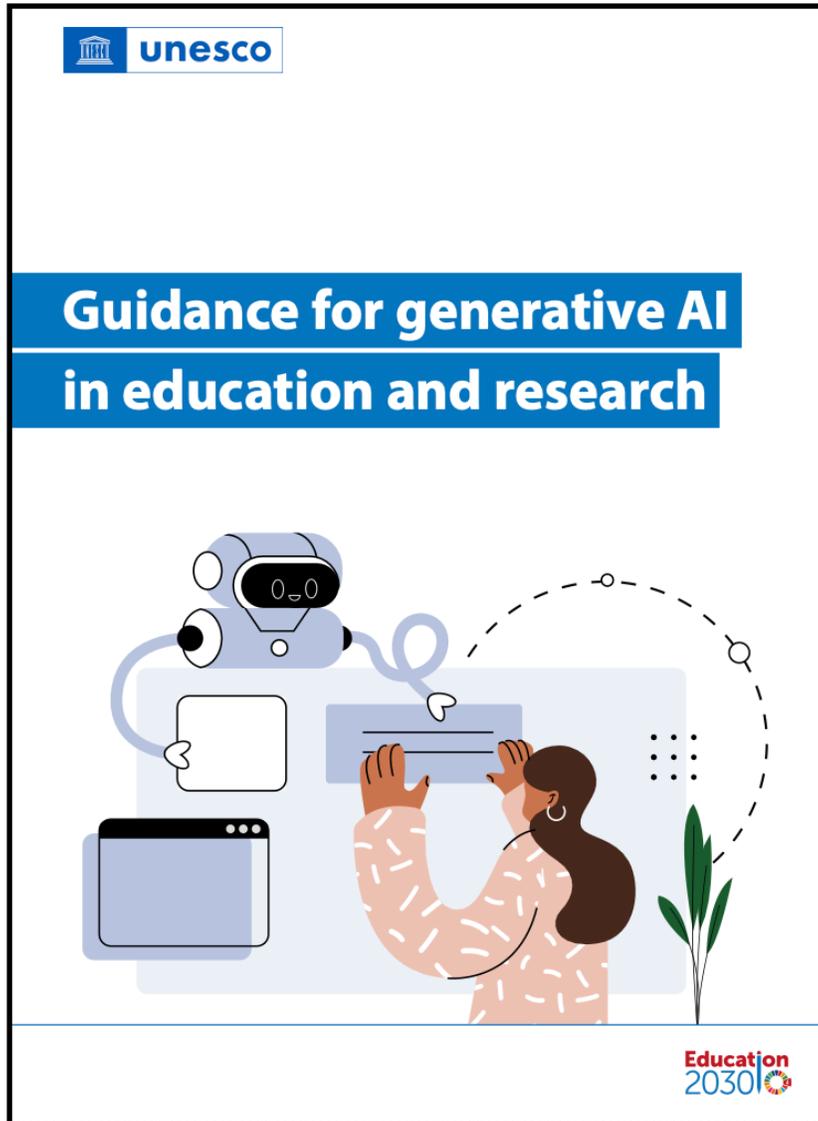
Educator as curator of knowledge



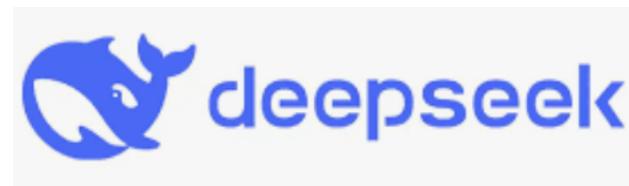
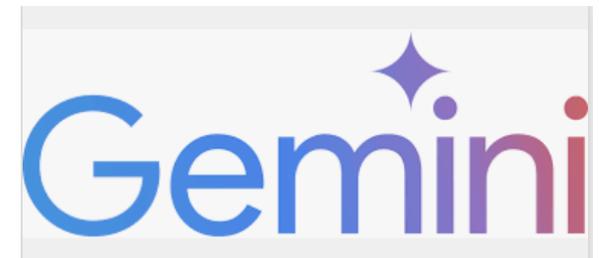
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An Introduction to Generative AI

An Introduction to Generative AI



“Generative AI (GenAI) is an artificial intelligence (AI) technology that automatically generates content in response to prompts written in natural-language conversational interfaces”



An Introduction to Generative AI

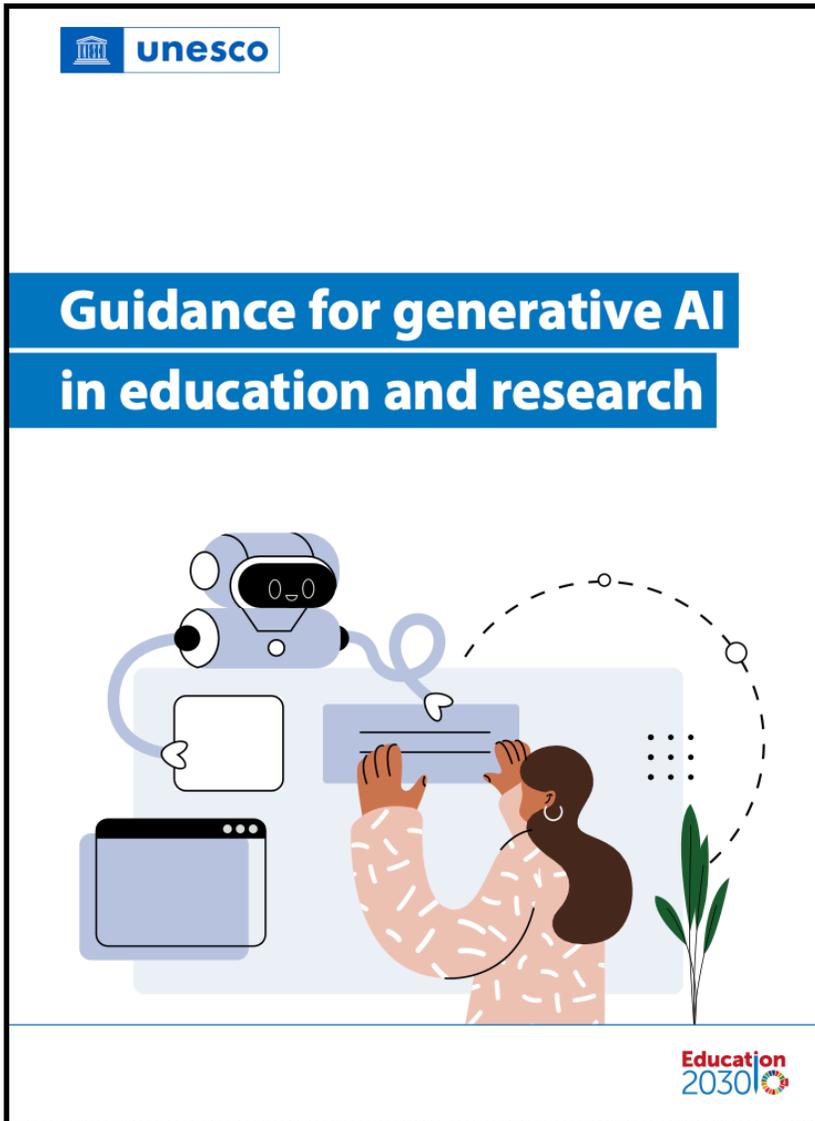


Table 1. Techniques used in generative AI

Machine learning (ML)		A type of AI that uses data to automatically improve its performance.
Artificial neural network (ANN)		A type of ML that is inspired by the structure and functioning of the human brain (e.g. the synaptic connections between neurons).
Text generative AI	General-purpose transformers	A type of ANN that is capable of focusing on different parts of data to determine how they relate to each other
	Large language models (LLM)	A type of general-purpose transformer that is trained on vast amounts of text data.
	Generative pre-trained transformer (GPT)⁴	A type of LLM that is pre-trained on even larger amounts of data, which allows the model to capture the nuances of language and generate coherent context-aware text.

Large amounts of data are used to *train* a model, which *determines* how different parts of the data relate to each other.

The system responds to a query by dynamically generating text that statistically *mimics* the data set.

An Introduction to Generative AI



I went to the station and I waited on the platform for the train.

An Introduction to Generative AI



I went to the station and I waited on the platform for the train.

An Introduction to Generative AI



I was going to miss the train so I had to run to the X

X is a random variable

An Introduction to Generative AI



I was going to miss the train so I had to run to the station

$$Pr(X = station) > 0$$

An Introduction to Generative AI



I was going to miss the train so I had to run to the platform

$$Pr(X = platform) > 0$$

An Introduction to Generative AI



I was going to miss the train so I had to run to the toilet

$$Pr(X = \textit{toilet}) = \epsilon$$

An Introduction to Generative AI



tell me a story about a train

Sure! Here's a short story about a train — with a hint of mystery and heart.

The Last Train to Winthrop Bay

Every evening at precisely 10:47, a faded green train rumbled through the hills and fog to Winthrop Bay. The tracks were rusted, the whistle old-fashioned, and no one had bought a ticket for it in years—not since the station officially closed in 1983. Yet, it came, every night without fail, and then vanished again before sunrise.

An Introduction to Generative AI



Which is heavier a kilogram of feathers or three kilograms of gold?

Oh! That's easy — they weigh the same! A kilogram is a kilogram, whether it's feathers or gold. So they're equal in weight! 😊

An Introduction to Generative AI



Give me a 250 word report on the evolution of the technological tools for mathematics education.

The Evolution of Technological Tools in Mathematics Education

Mathematics education has gone through many changes since ancient times. In the early days, people used sticks and rocks to count, which was the original form of math. Later on, the abacus was invented in Greece and quickly spread to schools in the Middle Ages (Johnson & Lee, 1422). This helped students add and subtract numbers faster than before.

In the 1800s, chalkboards were invented and used in almost every classroom, making it easier for teachers to explain math to all the students at once (Martinez, 1879).

Calculators were introduced in the 1930s and allowed students to do math without learning how to add or multiply. This improved learning dramatically and is still controversial today.

An Introduction to Generative AI



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- Johnson, R., & Lee, P. (1422). *Mathematics and Counting in the Classical World*. Scroll Press.
- Martinez, T. (1879). *The Chalkboard Revolution*. Early Education Publishing.
- Smith, A., & Zhou, L. (1997). *The History of the Internet in Schools*. CyberAge Books.
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- Baker, J., Nguyen, S., & Patel, M. (2020). *AI and the End of Math Homework*. EdTech Review Journal, 17(4), 201–209.

An Introduction to Generative AI



Generative AI is an excellent resource for things with lots of consistent online resources for it to *learn* from.

An Introduction to Generative AI



Consider the function $f : \mathbb{R} \rightarrow \mathbb{R}$ defined by $f(x) = e^{-\sin(x)}$.

(a) Find the set of stationary points of f .

We are given the function:

$$f(x) = e^{-\sin(x)}$$

To find the **stationary points**, we differentiate $f(x)$ and solve $f'(x) = 0$.

Step 1: Differentiate $f(x)$

Using the chain rule:

$$f'(x) = \frac{d}{dx} \left(e^{-\sin(x)} \right) = e^{-\sin(x)} \cdot (-\cos(x)) = -\cos(x)e^{-\sin(x)}$$

An Introduction to Generative AI



Step 2: Set $f'(x) = 0$

$$-\cos(x)e^{-\sin(x)} = 0$$

Since $e^{-\sin(x)} > 0$ for all real x , the only way the product is zero is if:

$$\cos(x) = 0$$

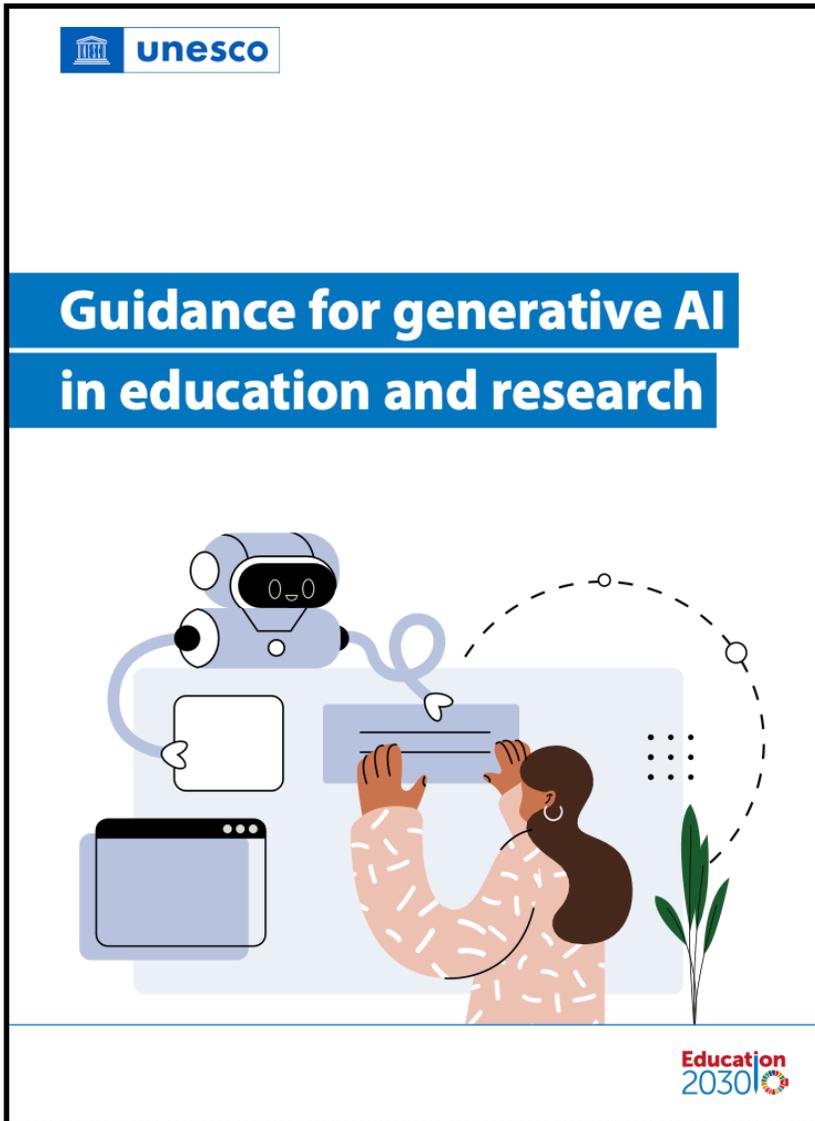
Step 3: Solve $\cos(x) = 0$

$$x = \frac{\pi}{2} + n\pi, \quad \text{for } n \in \mathbb{Z}$$

The set of stationary points of f is:

$$\left\{ x \in \mathbb{R} \mid x = \frac{\pi}{2} + n\pi, n \in \mathbb{Z} \right\}$$

An Introduction to Generative AI



- 2.1 Worsening digital poverty**
- 2.2 Outpacing national regulatory adaptation**
- 2.3 Use of content without consent**
- 2.4 Unexplainable models used to generate outputs**
- 2.5 AI-generated content polluting the internet**
- 2.6 Lack of understanding of the real world**
- 2.7 Reducing the diversity of opinions and further marginalizing already marginalized voices**
- 2.8 Generating deeper deepfakes**

An Introduction to Generative AI



In a world of generative AI the link between the ability to produce prose on an introductory topic and mastery of that topic is significantly frayed. The ability to produce cogent prose no longer strongly implies credibility.

An Introduction to Generative AI



In a world of generative AI the link between the ability to produce prose on an introductory topic and mastery of that topic is significantly frayed. The ability to produce cogent prose no longer strongly implies credibility.

When should the ability to write (in English) contribute to a student's achievement in mathematics?



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Generative AI as a tool for calculus teaching and learning

Generative AI as a tool for students



Generative AI as a tool for students



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CheatGPT

AI has made it easy for post-secondary students to fake their way to a degree. They argue that ChatGPT is just another study tool. Schools say it spells the end of university education as we know it. Maybe that's not a bad thing

BY SIMON LEWSEN | PHOTOGRAPHY BY LUIS MORA | AUGUST 16, 2023

Generative AI as a tool for students

An elephant in the room: academic integrity.



What is academic integrity?

Academic integrity means acting with core values of honesty, trust, fairness, respect, responsibility and courage in all academic endeavors, ensuring ethical and transparent scholarship.

As a member of the University of Melbourne community, you share responsibility for establishing and maintaining appropriate standards of scholarship.

Academic integrity is the way you demonstrate good scholarship, by:

1. Being honest and ethical in scholarly work.
2. Acknowledging the work and ideas of others.
3. Using your own words.

Generative AI as a tool for students



Julian is working on some formative assessment. After working through their assignment, they go talk to their older sister about the questions and their solutions. Following their conversation, Julian makes some changes to their assignment before submitting it.

Generative AI as a tool for students



Has Julian violated:

- the *letter* of your institution's academic integrity policy?
- the *spirit* of your institution's academic integrity policy?
- your own sense of the meaning of academic integrity?

Generative AI as a tool for students



Some things one might consider:

- did Julian's sister tell them the answers or provide them support in finding it themselves?
- does Julian understand the answers they have submitted?
- did Julian learn something about mathematics as a result of having the conversation?

Generative AI as a tool for students



How does your perspective change if we substitute Julian's sister for:

- their teacher?
- a classmate?
- a paid private tutor?
- a online "help" website?
- chatGPT?

Generative AI as a tool for students



If formative assessment exists to help students recognise the limits of their own understanding and take steps to *fill in the gaps*, then why do we care how/when a student *acting in good faith* does this?

Generative AI as a tool for students



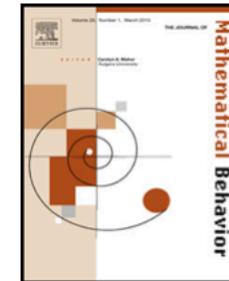
Journal of Mathematical Behavior 42 (2016) 33–48



Contents lists available at [ScienceDirect](#)

The Journal of Mathematical Behavior

journal homepage: www.elsevier.com/locate/jmathb



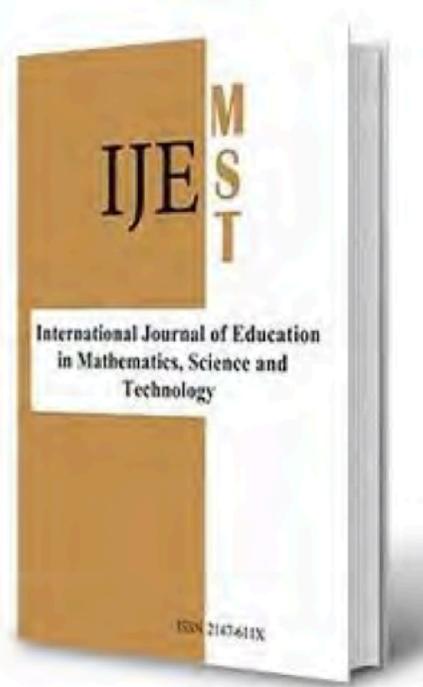
Discovering and addressing errors during mathematics problem-solving—A productive struggle?

Carina Granberg*

Department of Applied Educational Science, Umeå University, Umeå SE-901 87, Sweden



Generative AI as a tool for students



www.ijemst.net

How Productive is the Productive Struggle? Lessons Learned from a Scoping Review

Jamaal Rashad Young 
Texas A&M University, United States

Danielle Bevan 
Houston Baptist University, United States

Miriam Sanders 
Texas A&M University, United States

A brief history of mathematics technology and tools for education

The Evolving Student Toolkit



	1990	2000	2010	2020	2025+
Subject Resources	<ul style="list-style-type: none"> lectures textbooks/course notes consultation hours small-group learning computer labs 			+lecture recordings +short videos +discussion boards +online homework systems	+tutor bots + ?
External Resources	<ul style="list-style-type: none"> textbooks calculator other students exam banks 	+text/image based online resources	+online video +online fora	+bespoke online help +easy-to-use symbolic computational engines	+genAI tools + ?
Formative Assessment	problem sheets: “solve, find, prove”				?



Educator as source of knowledge

Educator as curator of knowledge

Generative AI as a tool for students



It is possible for a student to use genAI *authentically* as part of their learning:

- study planning
- additional practice problems
- socratic learning
- solution review
- bigger-picture ideas and connections

Generative AI as a tool for students



The role of the *curator* (i.e., educator) is to guide students on helpful use of this technology as part of their mathematical development.

The AI Assessment Scale

1	NO AI	The assessment is completed entirely without AI assistance in a controlled environment, ensuring that students rely solely on their existing knowledge, understanding, and skills You must not use AI at any point during the assessment. You must demonstrate your core skills and knowledge.
2	AI PLANNING	AI may be used for pre-task activities such as brainstorming, outlining and initial research. This level focuses on the effective use of AI for planning, synthesis, and ideation, but assessments should emphasise the ability to develop and refine these ideas independently. You may use AI for planning, idea development, and research. Your final submission should show how you have developed and refined these ideas.
3	AI COLLABORATION	AI may be used to help complete the task, including idea generation, drafting, feedback, and refinement. Students should critically evaluate and modify the AI suggested outputs, demonstrating their understanding. You may use AI to assist with specific tasks such as drafting text, refining and evaluating your work. You must critically evaluate and modify any AI-generated content you use.
4	FULL AI	AI may be used to complete any elements of the task, with students directing AI to achieve the assessment goals. Assessments at this level may also require engagement with AI to achieve goals and solve problems. You may use AI extensively throughout your work either as you wish, or as specifically directed in your assessment. Focus on directing AI to achieve your goals while demonstrating your critical thinking.
5	AI EXPLORATION	AI is used creatively to enhance problem-solving, generate novel insights, or develop innovative solutions to solve problems. Students and educators co-design assessments to explore unique AI applications within the field of study. You should use AI creatively to solve the task, potentially co-designing new approaches with your instructor.



Generative AI as a tool for educators



Generative AI as a tool for educators



Problem: Students might sit tests at different times. I need to create multiple versions. This is tedious and doesn't require the same *creativity* as making the first version of the test.

Generative AI as a tool for educators



CD

MAST10005 MST Version 1.pdf // 0.24MB



I am a lecturer for MAST10005. He is one version of my mid-semester test. Make me an alternate version, with different values. Provide me the latex code for my alternate version. The code should have both the questions and solutions and should typeset to look the same as the original version.

*

Here's an alternate version of the mid-semester test with different values, provided in LaTeX code. The code includes both questions and solutions, and is formatted to look similar to the original version:

```
latex

\documentclass[11pt,a4paper]{article}
\usepackage[margin=1in]{geometry}
\usepackage{amsmath,amssymb,amsthm}
\usepackage{enumitem}
```

Generative AI as a tool for educators



I am a lecturer for MAST10005. He is one version of my mid-semester test. Make me an alternate version, with different values. Provide me the latex code for my alternate version. The code should have both the questions and solutions and should typeset to look the same as the original version.

context + task + output

Generative AI as a tool for educators



Problem: Checking exam solutions is tedious. I usually make mistakes.

I can't rely on genAI to not make any mistakes, but the mistakes it makes will be different to the mistakes I make.

Generative AI as a tool for educators



CD

MAST10005_2024_S1.pdf // 0.35MB



I am a lecturer for MAST10005. Here is a draft of my exam. I want to compare my solutions to your solutions. Provide me fully worked solutions for each of the questions on this exam.

*

I'd be happy to provide fully worked solutions for the MAST10005 Calculus 1 exam. I'll go through each question one by one, providing detailed explanations and steps for each solution.

Question 1 (7 marks)

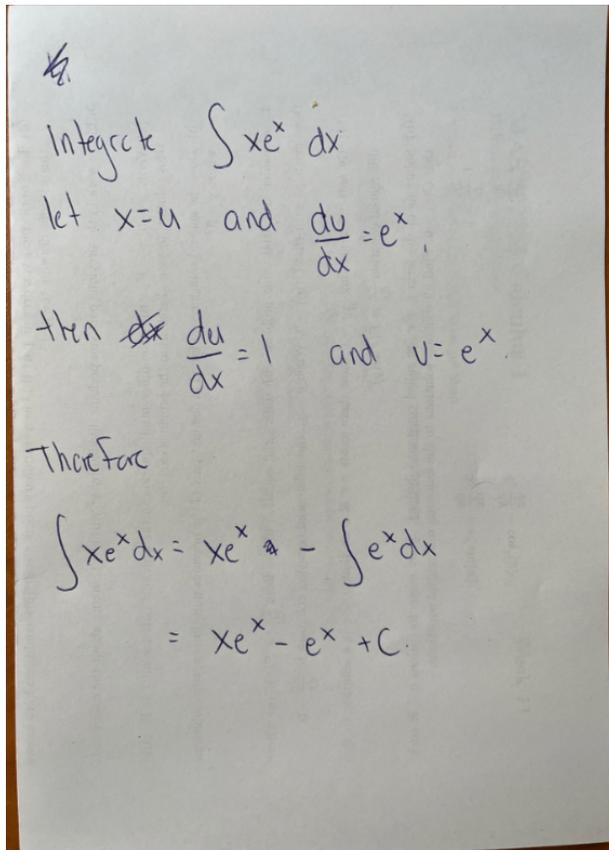
i. To find the imaginary part of $(z+1)/z$ where $z = 4-2i$, we need to rationalize the denominator:

$$\begin{aligned}(z+1)/z &= ((4-2i)+1) / (4-2i) = (5-2i) / (4-2i) = (5-2i)(4+2i) / ((4-2i)(4+2i)) = (20+10i-8i-4i^2) / (16+4) = \\ &= (24+2i) / 20 = 6/5 + (1/10)i\end{aligned}$$

Generative AI as a tool for educators

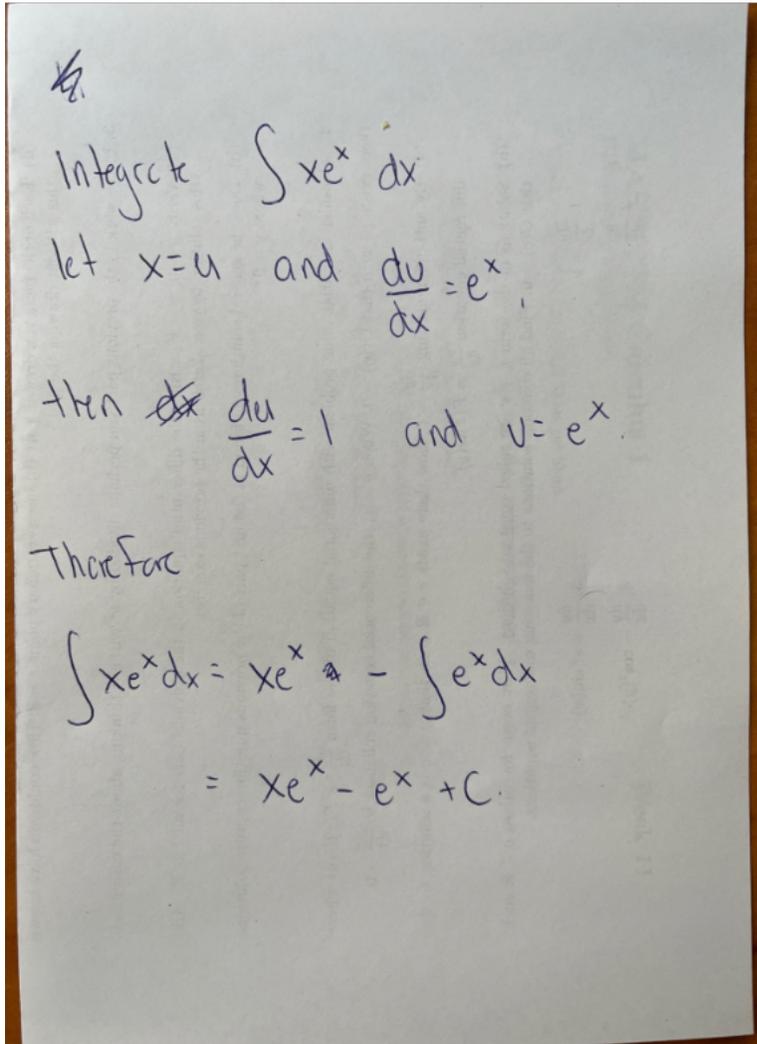


Problem: Mathematical typesetting is a pain.



Here is a screenshot of some mathematics. Typeset the mathematics using latex. Use the package amsmath.

Generative AI as a tool for educators



```
latex Copy code  
  
\documentclass{article}  
\usepackage{amsmath}  
  
\begin{document}  
  
\[  
\int x e^x \, dx  
\]  
  
Let  $(x = u)$  and  $(\frac{du}{dx} = e^x)$ .  
  
Then  $(\frac{du}{dx} = 1)$  and  $(u = e^x)$ .  
  
Therefore,  
  
\[  
\int x e^x \, dx = x e^x - \int e^x \, dx  
\]  
  
\[  
= x e^x - e^x + C  
\]  
  
\end{document}
```

Generative AI as a tool for educators



Generative AI is excellent at doing some the *tedious* work of an educator. It is not a substitute for my content expertise.



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What should I take away from this?

What do we need to do?



Embrace our role as curators of knowledge

What do we need to do?



Play with new technology. Don't rely on advice from "experts". There are no silver bullets.

What do we need to do?



Continuously interrogate the how, the why and the what of our curricula, our teaching and learning activities and the limits we place on student use of technology.

What do we need to do?



Recognise the world has changed. Your students and your junior colleagues are not just younger and more inexperienced versions of yourself.

What do we need to do?



Push our *leaders* for resources to face these challenges.

What do we need to do?



Cultivate an attitude of mathematics (education) as relational, cultural and human endeavour.

What do we need to do?



PETER PETOCZ^{*}, ANNA REID, LEIGH N. WOOD, GEOFF H. SMITH,
GLYN MATHER, ANSIE HARDING, JOHANN ENGELBRECHT, KEN HOUSTON,
JOEL HILLEL and GILLIAN PERRETT

UNDERGRADUATE STUDENTS' CONCEPTIONS OF MATHEMATICS: AN INTERNATIONAL STUDY

Received: 25 June 2006; Accepted: 6 September 2006

TABLE I

Distribution of conceptions of mathematics

Conception	<i>n</i>	%
1. Number	109	9.2
2. Components	515	43.6
3a. Modelling	235	19.9
3b. Abstract	165	14.0
4. Life	71	6.0
(missing/uncoded)	87	7.4

What do we need to do?



$$\mathbb{C} = \{a + bi \mid a, b \in \mathbb{R}\}$$

$$i^2 = -1$$

$$(a + bi) + (c + di) = (a + c) + (b + d)i$$

$$(a + bi)(c + di) = ac + adi + bci + bdi^2$$

$$(a + bi)(c + di) = (ac - bd) + (ad + bc)i$$

$$\mathbb{C} = \mathbb{R} \times \mathbb{R}$$

$$(a, b) + (c, d) = (a + c, b + d)$$

$$(a, bi)(c, di) = (ac - bd, ad + bc)$$

What do we need to do?



PART A (Mathematics and Culture version 1)

The first page of our Lecture Notes contains a statement from Professor Chris Matthews, the founding Chair of the Aboriginal and Torres Strait Islander Mathematics Alliance.

Read the first two pages of our Lecture Notes, and then watch the following short video produced by the Queensland Department of Education, which features Chris Matthews. (This video is geared towards primary educators, though is relevant to us all.)

<https://www.youtube.com/watch?v=2H1pHCXcTrE>

(google 'Chris Matthews changing mindsets')

Write a short response (< 250 words) that answers the following:

- What do you think Prof Matthews means when he says “Mathematics is part of us as people”?
- How have you experienced mathematics in your own life and background?
- How have you used mathematics to solve problems or understand situations in your life?

Dr Sally Kuhlmann MAST10017/18 Foundation Mathematics 1/2



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Thank you.