

AI, ASSESSMENT, AND THE STUDENT AND EDUCATOR EXPERIENCE

Facilitators

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LAND ACKNOWLEDGEMENT



We would like to begin by acknowledging that the land on which we gather is the unceded territory of the Coast Salish Peoples, including the territories of the xwmə@kwəyəm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Səlílwəta?/Selilwitulh (Tsleil- Waututh) Nations.



AGENDA



- □ Introduction (15 minutes): A (brief) discussion of AI, LLMs, and consequences to the educator.
- □ Finding the limits of LLMs (15 minutes); Breakout Activity: Led by Noureddine, learn the limits of LLMs
- **Examples from different fields (10 minutes)**: Some examples from chemistry, statistics, mathematics about using AI in student work and student assessment.
- □ Short Break (5 minutes): Stretch! Get water!
- □ Your own course/activity design; Breakout Activity: Working with the provided guiding worksheets, consider how you can use AI to design your own assessment activities OR how you can design an activity that will be assessed where students use AI.
- □ Final Wrap-up: suggestions, questions, and future working groups!

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- Dr. Nahid Walji (MATH 200, MATH, Faculty of Science, UBC)
- Dr. Joel Östblom (DSCI 573, DSCI 100, STATS, Faculty of Science, UBC)

AI FOR SCIENCE EDUCATION: WHICH AI?





AI SUB-DISCIPLINES LEVERAGED TO CREATE THE INTERNAL ARCHITECTURE OF AN LLM





POTENTIALS OF USING AI IN SCIENCE EDUCATION



Educational Content Generation (De Felice & Petrucco, 2019)

Automated Curriculum Design (Bull et al., 2018)

Administrative Efficiency (Shapiro et al., 2017)

Enhanced Student Engagement (Alkhathami & Al-Samarraie, 2020)

Virtual Laboratories and Simulations (Hämäläinen et al., 2019)

Enhanced Accessibility (Zhang et al., 2019)

Personalized Study Plans (McCormick et al., 2019)

AI-Powered Writing Assistance (Li et al., 2020)

Interactive Virtual Laboratories (Mestre, 2018)

Simulation-Based Assessments (Akçayır & Akçayır, 2018)

Automated Grading of Scientific Experiments (Sinapov et al., 2019)

Data-Driven Decision Making (Bichsel, 2019)

Collaborative Learning Environments (Rosé et al., 2014)

Content Curation and Recommendation (Zawacki-Richter et al., 2019)

Intelligent Tutoring, Metacognition (Conati (1999); Conati & VanLehn (2000))

Potentials of Using AI in Education

LLMS ARCHITECTURAL (CONTEXT WINDOW) LIMITATIONS & IMPLICATIONS FOR SCIENCE EDUCATION



IMPLICATION: Misinterpretation of Relationships

		between Concepts
	LIMITATION: Limited Contextual Understanding	IMPLICATION: Difficulty in Grasping Cause-Effect Relationships
		IMPLICATION: Inability to Handle Multistep Problem Solving
/		IMPLICATION: Incomplete Comprehension of Scientific Concepts
		IMPLICATION: Loss of Contextual Continuity
	LIMITATION: Difficulty in Long-Term	IMPLICATION: Difficulty in Retaining Cumulative Knowledge
	Dependency Learning	IMPLICATION: Inability to Address Complex Queries
LLMs Architectural	/	IMPLICATION: Impaired Learning Assessment
(Context Window)		IMPLICATION: Inability to Infer Long-range Dependencies
for Science Education	LIMITATION: Overreliance on Local Context	IMPLICATION: Loss of Global Context
for science Education		IMPLICATION: Difficulty in Handling Complex Relationships
		IMPLICATION: Distortion of Meaning Of Semantic Spaces
	LIMITATION: Dependency on Preprocessing	IMPLICATION: Introduction of Biases
	Techniques	IMPLICATION: Difficulty in Handling Complex Structures
		IMPLICATION: Loss of Contextual Information
		IMPLICATION: Loss of Coherence
		IMPLICATION: Difficulty in Providing Adaptive
	LIMITATION: Vulnerability to Contextual Drift	Instruction
		IMPLICATION: Increased Risk of Error Propagation
		IMPLICATION: Misinterpretation of Context

DELIMITING THE COGNITIVE (IN)-ABILITIES OF AN LLM



COGNITIVE TESTS	GPT	Claud	Gemini	Co-Pilot
Antonyms	?			
Temporal reasoning	?			
Spatial reasoning	?			
Causal relationships	?			
Inference & deduction	?			
Analogical reasoning	?			
Counter-factual reasoning	?			
Belief Evaluation	?			
Truth verification	?			
Metacognition	?			

LLMS COGNITIVE LIMITATIONS & IMPLICATIONS FOR SCIENCE EDUCATION



		IMPLICATION: Inaccurate Assessment of Student Understanding	
	LIMITATION: Logical Reasoning	IMPLICATION: Risk of Propagating Inaccuracies	
		IMPLICATION: Difficulty Recognizing Misconceptions	
		IMPLICATION: Limited Ability to Provide Constructive Feedback	
	LIMITATION: Causal Reasoning	IMPLICATION: Vulnerability to Misinformation	
		IMPLICATION: Inability to Predict Outcomes	
		IMPLICATION: Limited Ability to Identify Root Causes	
		IMPLICATION: Difficulty in Understanding Complex Systems	
		IMPLICATION: Challenges in Interpreting Diagrams and Graphs	
	/	IMPLICATION: Inability to Navigate Virtual Models	
	LIMITATION: Spatial Reasoning	IMPLICATION: Limited Ability to Solve Geometry Problems	
		IMPLICATION: Difficulty in Understanding 3D Structures	
LIMS Cognitive Limitations & Implications		IMPLICATION: Difficulty in Explaining Temporal Concepts	
for Science Education	LIMITATION: Temporal Reasoning	IMPLICATION: Misinterpretation of Historical Events	
		IMPLICATION: Limited Support for Time-dependent Experiments	
		IMPLICATION: Difficulty in Explaining Temporal Concepts	
		IMPLICATION: Misinterpretation of Complex Scientific Concepts	
	LIMITATION: Inferential Reasoning	g / IMPLICATION: Ineffective Support for Problem-based Learning	
		IMPLICATION: Difficulty in Addressing Misconceptions	
		IMPLICATION: Limited Ability to Assess Higher-order Thinking	
		IMPLICATION: Limited Ability to Provide Contextualized Feedback	
	LIMITATION: Semantic Reasoning	IMPLICATION: Difficulty in Addressing Ambiguity and Complexity	
		IMPLICATION: Ineffective Assessment of Student Knowledge	
		IMPLICATION: Misinterpretation of Scientific Concepts	

DELIMITING THE COGNITIVE (IN)-ABILITIES OF AN LLM



COGNITIVE TESTS	GPT	Claud	Gemini	Co-Pilot
Antonyms	FAIL/PASS			
Temporal reasoning	FAIL			
Spatial reasoning	FAIL			
Causal relationships	FAIL			
Inference & deduction	FAIL			
Analogical reasoning	FAIL/PASS			
Counter-factual reasoning	FAIL			
Belief Evaluation	FAIL			
Truth verification	FAIL			
Metacognition	FAIL/PASS			

SOME OF THE IMPLICATIONS FOR THE EDUCATOR



- Understanding the limitations of Al systems: Draw a clear distinction between situations where Al can help streamline part of the logistics of learning (e.g. information retrieval and organization) and situations where Al can hinder critical thinking.
- □ Shifts in role of the educator: the use of AI might induce a shift in the role of the educator, shifting more towards facilitating learning, scaffolding learning, enabling critical thinking.
- □ Narrowing of Curriculum: By design, AI algorithms are designed to assess the easily quantifiable skills and knowledge aspects. This might narrow the aspects of the curriculum that enable critical thinking and deeper understanding and synthesis of complex concepts.
- □ **Epistemic atrophy**: Bake into the design of the assessment rail-guards to guard against the "epistemic atrophy", which might be caused by excessive and unprincipled use of AI to "consume" information (information is not insight).
- Depersonalization: Mitigate the depersonalization impact that might be created by Aldriven assessments that might lack the personal touch and individualized attention. Al algorithms (especially black box algorithms type) may prioritize objective metrics and quantifiable data in assessment processes, neglecting the subjective aspects of learning.

LIMITATION TESTS WITH LLM



Breakout Activity : 15 minutes

CHEM 300: COMMUNICATING CHEMISTRY



- □ 3rd year course for students in a Chemistry of Chemical Biology specialization.
- □ Focus is on communication in written, oral, and pictorial forms.
- □ Classes are 25-27 students; 4 sections run each year.
- □ In Fall 2023, supported by a SOTL Seed Grant, we implemented an assignment using Generative AI



CHEM 300: COMMUNICATING CHEMISTRY



Course Policy: Students <u>could</u> use Generative AI (for all but one assignment) but they had to write a small section on how and why they used it and they had to submit their chat logs.

Week 2: Unit of Academic Integrity (searching, citing the literature)

Week 2: Pre-Generative AI survey

Week 3: Submission of "Who Are You?" Assignment

Week 6: Generative AI training (2.5 hours of class time on prompt engineering, text transformations, and citations; 1 hour class time working on class project)

Week 8: Submission of reflection on Generative AI-generated "Who Are You?"

Week 14 (Last Week): Post-Generative AI survey

CHEM 300: COMMUNICATING CHEMISTRY



Who Are You?

500 words

Who are you as a chemist/writer/person

Generative AI can not be used

Graded based on a *specifications grading* rubric which assesses students on a sentence, paragraph, and assignment level (7 specifications)

Who Are You (Now with Generative AI)?

Students asked to replicate their original "Who Are You?" assignments (to the assignment details we provided)

Students **<u>not</u>** required to use ChatGPT (we provided alternatives)

500 word *reflection* on their experience and their annotated chat logs

Graded based on a *specifications grading* rubric which assesses students on a sentence, paragraph, and assignment level (7 specifications)

Types of Proofs

To prove that the square root of 22 is irrational, we need to show that it cannot be expressed as a ratio of two integers, that is, it is not a rational number.

Suppose, for the sake of contradiction, that the square root of 22 is rational. Then we can write it in the form of: $\sqrt{22} = p/q$ where p and q are coprime integers (i.e., they have no common factors other than 1) and q is not zero. Squaring both sides, we get:

$$22 = p^2/q^2$$

Multiplying both sides by q^2 , we get:

$$22q^2 = p^2$$

This means that p^2 is even since $22q^2$ is even (the product of an even number and any other number is even). Therefore, p must be even, and we can write p = 2k for some integer k.

Substituting 2k for p in the above equation, we get:

$$22q^2 = (2k)^2 = 4k^2$$

Dividing both sides by 2, we get:

$$11q^2 = 2k^2$$

This means that $2k^2$ is odd since $11q^2$ is odd (the product of an odd number and any other number is odd). Therefore, k must be odd, and we can write k = 2m + 1 for some integer m.

going Substituting 2m + 1 for k in the above equation, we get:

sideways

$$11q^2 = 2(2m+1)^2 = 8m^2 + 8m + 2$$

Dividing both sides by 2, we get:

 $11q^2/2 = 4m^2 + 4m + 1$

This means that $11q^2/2$ is odd since $4m^2 + 4m + 1$ is odd. Therefore, q^2 is odd (since 11 is odd), which means that q is also odd.

But this contradicts our assumption that p and q are coprime, because both p and q are even. Therefore, our initial assumption that the square root of 22 is rational must be false. Hence, we have proven that the square root of 22 is irrational.

Courtesy of Dr. Nahid Walji (Course 220, Maths department, Faculty of Science, UBC

- The questions used are typical of what I would assign to students in Math 220 (a class on an introduction to proofs).
- ChatGPT was asked to prove something that isn't true, and it duly obliged.
- ChatGPT response shows that the proof could have been finished off earlier, but it continues with unnecessary wrong work.



incorrect conclusion

SOME STORIES FROM THE TRENCHES(MATH-200)

Types of Proofs

Prove that the square root of 49 is irrational

The square root of 49 is 7. We can prove that 7 is irrational by assuming the opposite, that it is rational and then arriving at a contradiction.

Suppose, for the sake of contradiction, that the square root of 49 is rational. Then we can write it in the form of:

$$\sqrt{49} = p/q$$

where p and q are coprime integers (i.e., they have no common factors other than 1) and q is not zero. Squaring both sides, we get: $49 = p^2/q^2$

Multiplying both sides by q^2 , we get:

This means that p^2 is divisible by 7, and hence p is divisible by 7. Let p = 7k for some integer k. Substituting 7k for p in the above equation, we get:

invalid

This means that q is also divisible by 7. But this contradicts our assumption that p and q are coprime. Therefore, our initial assumption that the square root of 49 is rational must be false. Hence, the square root of 49 is irrational.

 $a^2 = k^2$

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- ChatGPT response shows that the proof could have been finished off earlier, but it continues with unnecessary wrong work.



$$49q^{2} = p^{2}$$

$$49a^2 = (7k)^2 = 49k^2$$



Breakout Activity : 40 minutes

A THANKS AND WHAT COMES NEXT



- □ Please fill out the Padlet below with any follow-up questions or requests! We will plan some future workshops/working groups based on your feedback here.
- Please access the OneDrive below for resources from today and your future course planning.
- □ You can reach us at:
 - Emma: <u>edavy@chem.ubc.ca</u>
 - □ Noureddine: <u>noureddine.elouazizi@science.ubc.ca</u>



Access the Feedback Padlet here!

