

# Using AI for Assessment and Feedback in Physics Labs

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MPTL  
September 6, 2025



 Marina Babayeva

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- Background in **Electrical Engineering, Automation & System Analysis**
- Focused on **AI in Physics Education, LLMs, and Technology-Enhanced Learning**
- International experience through **research stays and conference presentations**
- Publications in **PR-PER** and **IJAIED**

#### Publications (selected)

- *Multilingual AI in Physics Concept Inventories* (PR-PER, 2025)
- *Student Interactions with AI in Physics Labs* (IJAIED, 2025)

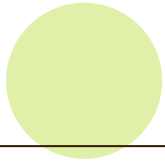


  
Univerzita  
Karlova

 Portland State  
UNIVERSITY

#### Conference Contributions

- **MPTL 2025 (Budapest)** – Workshop
  - **ESERA 2025 (Copenhagen)** – Symposium
  - **GIREP-EPEC 2025 (Leiden)** - Oral presentation
  - **WCPE 2024 (Kraków)** – Oral presentation
  - **GIREP-EPEC 2023 (Košice)** – Workshop
  - **MPTL 2023 (Prague)** – Workshop
  - **MPTL 2022 (Wrocław)** – Oral presentation
- 
- ◆ Bridging engineering background with educational innovation
  - ◆ Passionate about hands-on teaching, mentoring & collaboration



# Sentiment check

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Please scan the QR code to connect to the interactive part of the presentation.

Question 1 - To what extent do you agree with the statement: **'AI tools can enhance student learning and engagement in physics labs.'**



# Roadmap of the workshop

STEP

STEP

STEP

STEP

01

Context and  
motivation

02

Project  
overview

03

Hands-on  
practice


04

Reflection and  
discussion

STEP

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# 01



## Context and motivation

# Hands-On Practice and the Limits of LLMs



## AI in Lab Settings:

- Chemistry AI assistants: Time-saving speaker systems (Lee et al., 2023)
- Math AI tools: Generate and grade student answers (Tan & Lim, 2023)
- Physics Tutor Interfaces: Customizable feedback systems (Steinert et al., 2023)



## Challenges in Experimental Physics:

- Labs need individualized feedback based on real measurements
- AI lacks context about students' hands-on experience
- Older models are unreliable for comparing student-instructor responses
- LLMs perform best with structured tasks, less so with unpredictable lab outputs

STEP

01

Context and  
motivation

# Motivation & Related Work

What is an ideal AI lab assistant for you?

STEP

01

Context and  
motivation

01

02

03

Share your opinion!



# Motivation & Related Work

An ideal AI lab assistant is

STEP

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01

Context and  
motivation

01

**Autonomous**

02

**Language  
independent**

03

**Reliable and  
context aware**

# Study Aims

- Determine the helpful or positive aspects of LLM integration from students' point of view and experts' assessment of the content of interaction between students and LLM.
- Identify the neutral or not helpful aspects of LLM integration according to students' opinions and experts' assessments of the interaction between students and LLM.
- Analyze the accuracy and precision of the LLM responses through expert assessment.



Research Question:

*Can an LLM provide productive feedback in a laboratory environment requiring a high degree of personalization?*

STEP

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01

Context and  
motivation

STEP

STEP

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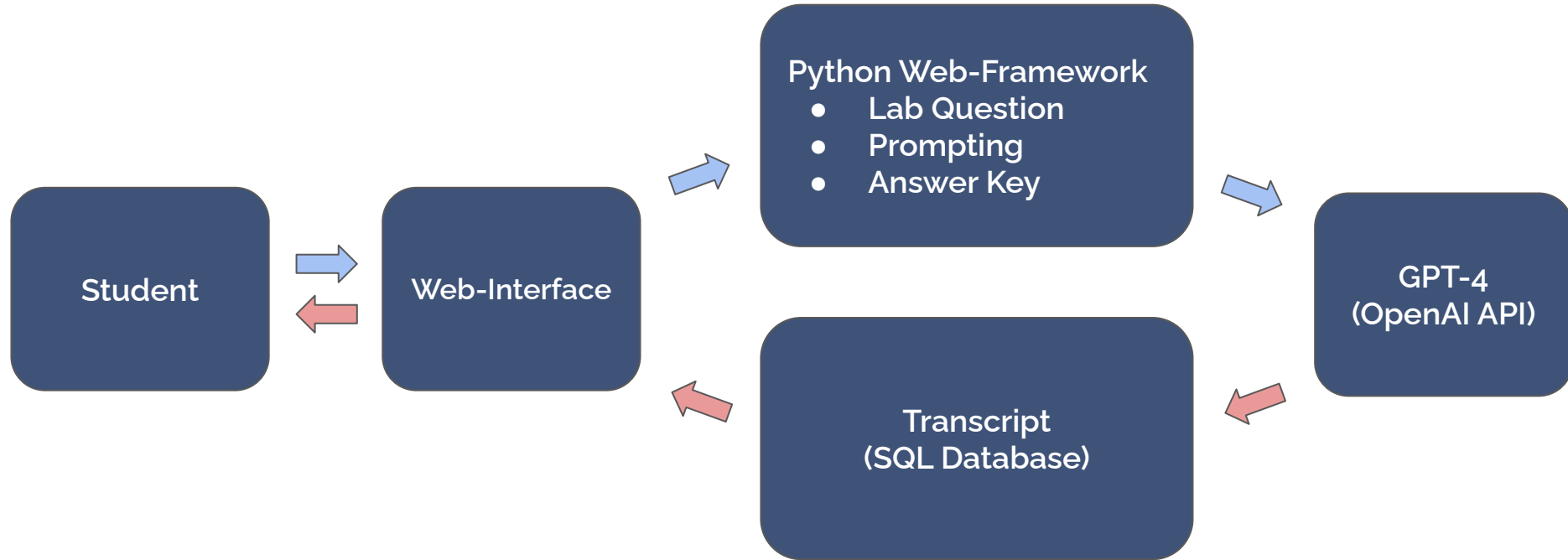
01

Context and  
motivation

02

Project  
overview

# Chatbot Design



# Chatbot setup and prompting

Three types of labs:

Fully prompted labs

- prompt
- question
- correct answer
- PDF manual for specific lab

Partially prompted labs

- prompt
- question
- optionally: correct answer
- PDF manual for the entire lab course

Minimally prompted labs

- prompt
- PDF manual for the entire lab course

STEP

# 02

Project  
overview

# Chatbot Design

Lab question selection

Home AI Chat Transcript Labs Prompt logout

Select Term  
214

Select Lab  
Lab 7

Select Question  
Question 1  
Question 2  
Question 3  
Question 4  
Question 5  
Question 6  
Question 7  
Question 8

Clear History

since torque is N/m and moment of inertia is in  $\text{kg}\cdot\text{m}^2$  then angular acceleration might be rotations per second?

You're on the right track in thinking about the units of torque and moment of inertia, which is a great start. However, you might want to revisit the units for torque - it's not N/m. Also, remember to consider how these units relate to each other in the context of the formulas provided. Keep in mind that angular acceleration involves a change in angular velocity over time, so think about how that might translate into units. Keep going, you're doing well!

ok so torque is  $\text{N}\cdot\text{m}$  and Angular acceleration is rotations per second squared?

You're on the right track with your understanding of torque and angular acceleration. Torque is indeed measured in  $\text{N}\cdot\text{m}$ , which stands for Newton meters. As for angular acceleration, while it is related to rotation, it's not typically expressed in "rotations per second squared". Remember that it's generally more useful to consider angular acceleration in terms of how the speed of rotation is changing with respect to time. So, think about what units might be used to express this concept. Keep going, you're doing great!

okay is it  $\text{rad}/\text{s}^2$ ?

Yes, you're correct! Great job on figuring out that the units for angular acceleration are  $\text{rad}/\text{s}^2$ . Keep up the good work!

Question: "Knowing the units of torque from  $\tau = rF$ , and moment of inertia from  $I=mr^2$ , what are the units of angular acceleration(a)?"

Hello, I am an AI chatbot designed to assist you in your lab. You can ask me questions regarding your Lab. I will do my best to help you.

okay is it  $\text{rad}/\text{s}^2$

Ask AI

Chat history

Answer field

# Chatbot setup and prompting

Fully prompted labs

Question-specific prompting

STEP

# 02

Project  
overview

Role	<i>You are a personal Physics tutor.</i>
Task	<i>You talk directly to the student in the first person. It is very important that you do not reveal the correct answer. <b>The correct answer will be given in the prompt. Use the 'Correct answer' to verify the student's answer. Guide the student toward the correct answer when their answer disagrees. Use information from the lab manual for "Lab #7: Moment of Inertia" to guide students to the correct answer.</b></i>
Style	<i>Do not reveal what the student needs to say to be correct. If the student is correct, then simply say, 'Good job'. If the student is incorrect, guide them without giving the 'Correct answer'. Be concise. each of your responses should be no more than 50 words.</i>
Tools (question specific)	<i>This question involves a mathematical formula with variables of <math>I, m, r, a,</math> and <math>g</math>. The students answer is correct if it is mathematically equivalent to the Correct Answer.</i>

# Chatbot Design

Select Term Select Lab Hide Docs Hide Chat Show Settings

Manual Report Data

Student Name: \_\_\_\_\_  
Instructor Name: \_\_\_\_\_

PH 214

GENERAL PHYSICS  
LABORATORY MANUAL

A perfit description of the Coelestial Orbes,  
according to the most accurate doctrine of the  
Pythagoreans, &c.

Send AI a Message Ask AI

Lab related documents:  
manual, report  
and student's data

Chat history

Answer field

# Chatbot setup and prompting

Partially prompted labs

Question-specific prompting

STEP

# 02

Project  
overview

Role	<i>You are a personal Physics tutor.</i>
Task	<i>You talk directly to the student in the first person. It is very important that you do not reveal the correct answer. Guide the student toward the correct answer when their answer is incorrect. <b>Use information from "PH216 summer in person Manual" for "LAB #4: REFRACTION AND REFLECTION" to guide students to the correct answer.</b></i>
Style	<i>Do not reveal what the student needs to say to be correct. If the student is correct, then simply say, 'Good job'. If the student is incorrect, guide them without giving the 'Correct answer'. Be concise. each of your responses should be no more than 50 words.</i>
Tools (question specific)	<i>The 'Correct Answer' is a numerical comparison. Write and run code to verify the range of uncertainties from the 'Student's Answer' numerically overlap.</i>

# Chatbot setup and prompting

Minimally prompted labs

One prompt for the entire lab

Role	<i>You are a personal Physics tutor.</i>
Task	<i>You talk directly to the student in the first person. <b>Students will ask questions about "LAB #6: CENTRIPETAL FORCE" from the "PH214 in person Manual.pdf"</b>. Assist students in understanding the the experiment.</i>
Tools	<i>Write and run code to create your response when relevant.</i>
Style	<i>Be concise. Each of your responses should be no more than 75 words.</i>

STEP

02

Project  
overview

# Study Design

PSU lab setup:

- Trials over summer semester
- Three consequent lab courses, eight labs each
- Lab session 2h 50min of undergraduate introduction course
- AI interface as an available tool for students' classroom work
- Working in groups, but conversing with chatbot individually

STEP

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02

Project  
overview

# Dataset

- 164 students used the interface
- 1504 student-LLM interactions
- Randomly selected 2 fully prompted labs (FPL), 2 partially prompted labs (PPL) and 3 minimally prompted labs (MPL)
- Two graders (PhD student and physics education department researcher)
- Graded 194 interactions for FPL, 207 interactions for PPL, 131 interactions for MPL
- Cohen's Kappa between two graders:

	Fully prompted labs	Partially prompted labs	Minimally prompted labs
<b>Student interaction</b>	0.78	0.79	0.73
<b>AI response and error</b>	0.87	0.72	0.66

- Later coded to 100% agreement

STEP

# 02

Project  
overview

# Dataset - codes

Students requests categories

LLM responses and errors categories

Demonstrated Effort/Attempt	Encouragement and Praise
Clarification Seeking	Constructive Guidance
Off-topic or Irrelevant Responses	Vague or Generic Feedback
Eliciting Correct Answer	Misleading
	Reveals the answer
	Numbers
	Off-topic answer

STEP

02

Project  
overview

# Dataset - codes

## Students requests categories

Demonstrated Effort/Attempt	Responses that show an effort to engage with the material, even if they contain inaccuracies or are not fully correct.
Clarification Seeking	Responses that ask for further information or explanation of the topic or the question, indicating a desire to understand the material more thoroughly.
Off-topic or Irrelevant Responses	Responses that do not relate to the question and distract from the educational focus, failing to contribute meaningfully to the discussion.
Eliciting Correct Answer	Responses that fully or partially repeat the question, indicating a lack of original thought or engagement. Responses that indicate an attempt to prompt or solicit the correct answer, showing dependence on others for the right information.

STEP

02

Project  
overview

# Dataset - codes

## LLM responses and errors categories

Encouragement and Praise	Feedback that acknowledges the student's achievements and boosts their confidence.
Constructive Guidance	Feedback that combines praise with tips for improvement, focusing on areas where the student can refine their skills or understanding.
Vague or Generic Feedback	Feedback that does not specifically address the work or provide significant value to the student's understanding.
Misleading	LLM's response is ambiguous and confused the student on if they had the correct answer or not.
Reveals the answer	The LLM told the student the answer in its response
Numbers	LLM was not entirely correct with numerical questions
Off-topic answer	LLM's answers to off-topic questions

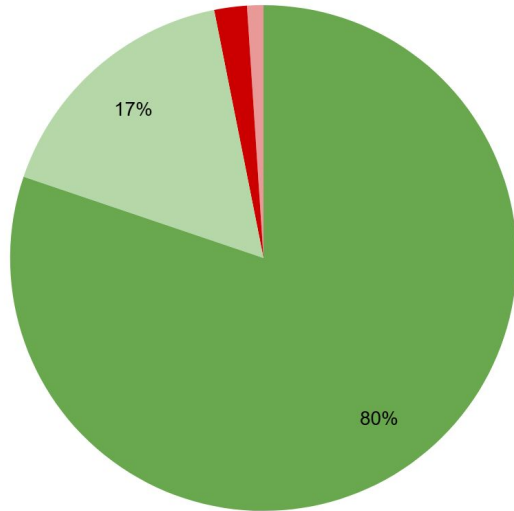
STEP

02

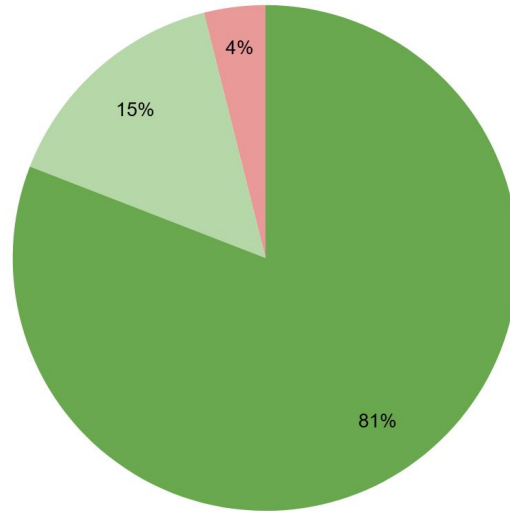
Project  
overview

# Students interactions

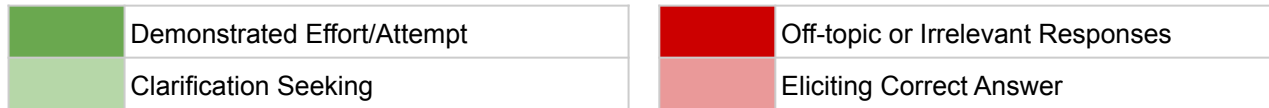
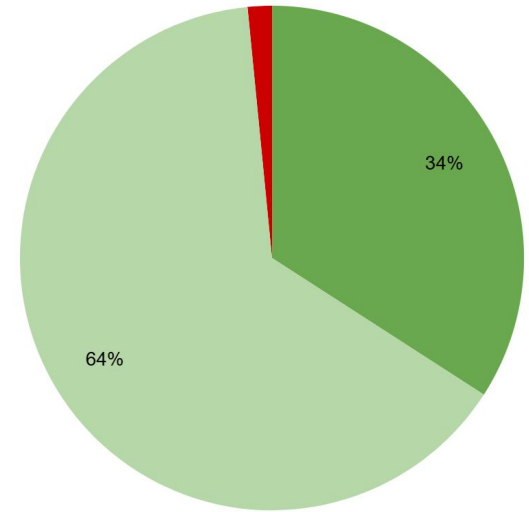
Fully prompted labs



Partially prompted labs

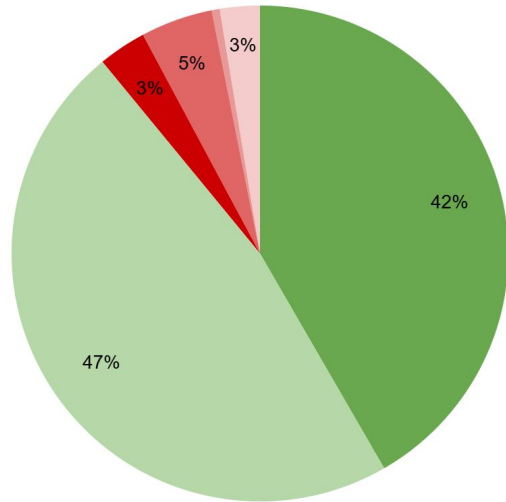


Minimally prompted labs

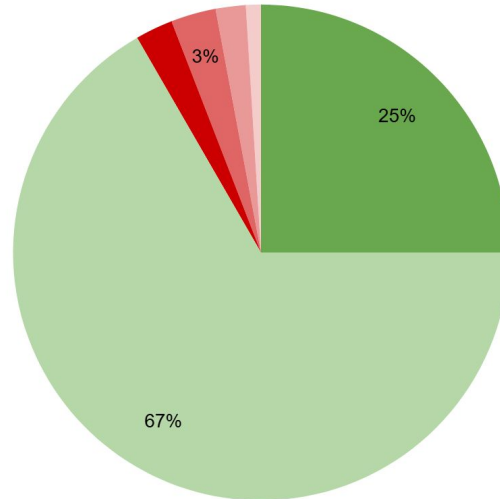


# LLM responses and errors

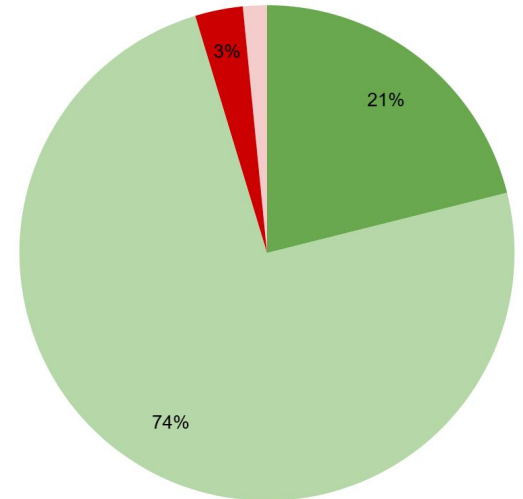
Fully prompted labs



Partially prompted labs



Minimally prompted labs



Encouragement and Praise

Constructive Guidance

Vague or Generic Feedback

Misleading

Reveals the answer

Numbers

# Overall trends

1. Interaction Style Shifts with Prompting Strategy
  - Fully prompted labs → more answer-checking.
  - Minimally prompted labs → more conceptual and clarification-seeking dialogue.
2. Improved Numerical Accuracy with Code Interpreter
  - Integration of a code interpreter led to better handling of formulas and numerical comparisons.
3. Chatbot Performance Improved Without Explicit Answers
  - Theoretical questions were often already within the LLM's training data.
  - Students provided their own measurements for empirical questions, which the AI could evaluate.
4. Reduced Effort, Yet Promising Outcomes in Minimally Prompted Labs
  - Despite less guidance, students still engaged meaningfully and received useful feedback.

STEP

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# 02

Project  
overview

STEP

STEP

STEP

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01

Context and  
motivation

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03

Hands-on  
practice

STEP

# 03

Hands-on  
practice

The screenshot shows a web-based lab interface. At the top, there is a green navigation bar with a home icon, dropdown menus for 'MPTL2025' and 'MPTL2025\_LAB', the title 'Magnetic Field of a Solenoid: Basic Properties of the Magnetic Field', and buttons for 'Toggle Docs', 'Toggle Chat', and 'Profile'. Below the navigation bar are tabs for 'Report', 'Data', and 'MPTL2025\_LAB Manual'. The main content area displays the lab manual text, which includes a section header, a list of instructions, a paragraph about the experiment, a list of variables (A-F), and a materials list. On the right side, there is a 'Chatbot' panel with a blue message bubble containing instructions and a Socratic question, a text input field with a 'Send' button, and a 'Clear History' button.

MPTL2025 ▾ MPTL2025\_LAB ▾ Magnetic Field of a Solenoid: Basic Properties of the Magnetic Field

Toggle Docs Toggle Chat Profile ▾

Report Data MPTL2025\_LAB Manual

**Magnetic Field of a Solenoid: Basic Properties of the Magnetic Field**

- You can use the tab **Report** to record the answers to lab questions
- You can use the tab **Data** to help you record the numerical values and perform calculations
- You can use the chatbot on the right side of the window to help you with lab questions
- Tick **Use Spreadsheet Data** every time you want to send your data to the chatbot (not needed if the data has been sent already and has not changed)

You will gradually demonstrate several properties of the magnetic field generated by a coil (solenoid). This section focuses on qualitative experiments designed to give you a foundational understanding of the magnetic field around coils.

Specifically, you will explore how the magnetic field of a coil depends on:

- A) the magnitude of the electric current passing through it
- B) the direction of the current
- C) the winding direction of the coil
- D) the distance from the coil
- E) the number of turns in the coil
- F) the presence of a core inserted into the coil

Each task from A to F is described in detail in this manual.

**Materials needed:**

- 4.5 V battery
- Wires with alligator clips
- Coils

Chatbot

4. Double-check that no exposed wires or clips can touch each other accidentally.

5. Finally close your switch (or clamp that last lead fully) to energize the circuit.

Socratic question: Before you connect that red lead, what checks will you do to be absolutely sure there's no unintended conductive path that could short the battery?

Chatbot:How can I help you?

Type a message... Send

Use Spreadsheet Data Clear History

<https://introlab.physics.pdx.edu/>

# Time to play!

Website: <https://introlab.physics.pdx.edu/>

MPTL users:

**mptl\_group\_1@pdx.edu**

**mptl\_group\_2@pdx.edu**

**mptl\_group\_3@pdx.edu**

**mptl\_group\_4@pdx.edu**

**mptl\_group\_5@pdx.edu**

**mptl\_group\_6@pdx.edu**

Google Account for files system:

**mptlworkshop@gmail.com**

Password:

**mydjaw-kemfe3-zornlg**

Password: **2N13zGQHZ0L3**

STEP

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# 03

Hands-on  
practice

STEP

STEP

STEP

STEP

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01

Context and  
motivation

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Project  
overview

03

Hands-on  
practice

04

Reflection and  
discussion

# Reflection, feedback and discussion

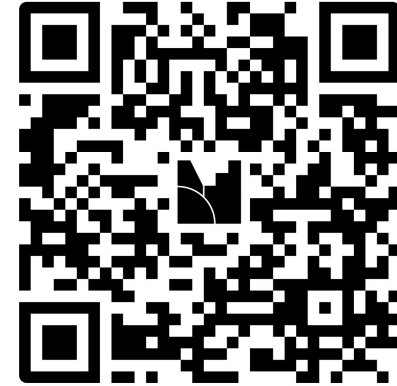
Reflection point:

*One insight + one open question*

*I'm leaving with*

Feedback point -> see your Menti

Discussion -> feel free to raise your questions

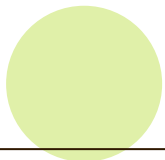


STEP

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04

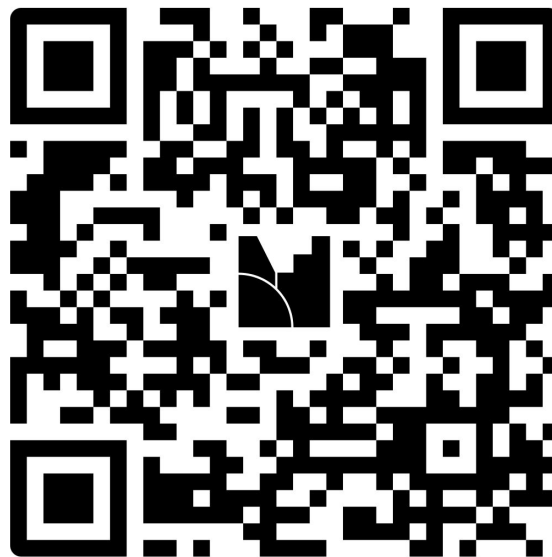
Reflection and  
discussion

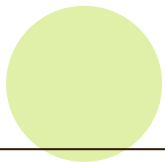


## Sentiment check

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Having completed the workshop, to what extent do you agree with the statement: **'AI tools can play a role in student learning and engagement in physics labs.'**





Thank you for your attention!

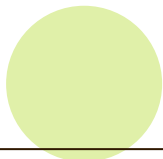
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MPTL

September 6, 2025



## Published work

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Pilot study on the application of collaborative online tools and technologies in physics instruction

Marina Babayeva and Ralf Widenhorn,  
Journal of Physics: Conference Series,  
DOI [10.1088/1742-6596/2693/1/012001](https://doi.org/10.1088/1742-6596/2693/1/012001)

Multilingual performance of a multimodal artificial intelligence system on multisubject physics concept inventories

Gerd Kortemeyer, Marina Babayeva, Giulia Polverini, Ralf Widenhorn, and Bor Gregorcic  
Physical Review Physics Education Research,  
DOI: <https://doi.org/10.1103/98hg-rkrf>

Analysis of Student Interactions with a Large Language Model in an Introductory Physics Lab Setting

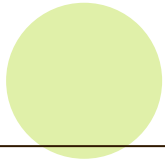
Travis Kregear, Marina Babayeva and Ralf Widenhorn  
International Journal of Artificial Intelligence in Education,  
DOI: <https://doi.org/10.1007/s40593-025-00489-3>

Enhancing Physics Hand-on Lab through Online Educational Tools, Marina Babayeva,

Pre-print: <https://doi.org/10.48550/arXiv.2506.16193>

Translating the Force Concept Inventory in the age of AI  
Marina Babayeva, Justin Dunlap, Marie Snětinová, Ralf Widenhorn,

Pre-print: <https://doi.org/10.48550/arXiv.2508.13908>

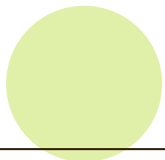


# Presentation

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You can access the presentation  
via this QR code





## What else is available out there:

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LEAP by LMU

<https://ai4physed.physik.uni-muenchen.de/LEAP/>

Welcome to LEAP 

LEAP is a platform that allows teachers to easily implement prompts, enabling students to answer questions and immediately receive personalized AI-generated feedback. This interactive learning environment fosters engagement and deepens understanding, making education more dynamic and effective.

Khanmigo by Khan Academy

<https://www.khanmigo.ai/>

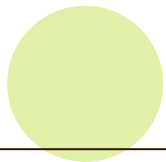


I learned about these options from colleagues and literature.

I am sure there is a lot of research behind these options.

Of course, there are many more options available and under development. Please explore (with caution).

If you are interested to collaborate with us, please email me.



## Additional slides

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MPTL  
September 6, 2025

# Limitations

- Only random subset of data was chosen for grading
- We acknowledge that since AI interface was not obligatory to use, the students-users might be biased positively towards using AI
- Only one institution was studied, regional differences are not considered
- The language of the interface is English, so the users must have certain level of English level proficiency
- The communication with chatbot is written compared to more natural oral communication with teaching assistant in the classroom
- We only see students' interactions with AI, we do not analyse their final lab reports and do not measure the knowledge acquisition.

STEP

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# 02

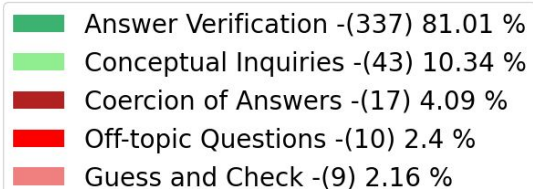
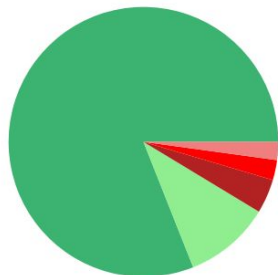
Project  
overview

# Results from the transcript

<https://doi.org/10.1007/s40593-025-00489-3>

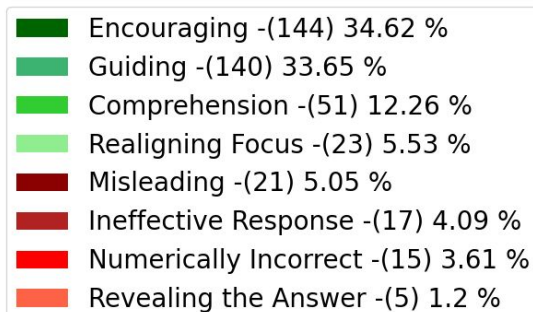
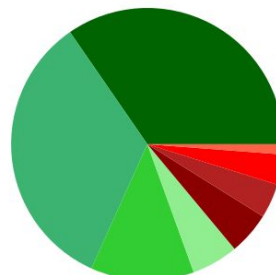
Student -> LLM Interactions\*

S-LLM



LLM -> Student Interactions\*

LLM-S



\*n=416 interactions; excluding one question containing a mathematical derivation.