Teaching AI Literacy in Quantitative Experimentation Courses

Dr. William W Tsai, Cal Poly Maritime Academy

Dr. William W. Tsai is an associate professor in the Mechanical Engineering Department at Cal Poly Maritime Academy. His research background is fluid mechanics and heat transfer. In engineering education, he is involved in the incorporation of information literacy into the engineering curriculum. He is also involved in his program's assessment, ABET accreditation activities, and the Institution-Wide Assessment Council. Before Cal Maritime, Dr. Tsai was a Member of the Technical Staff in the Fluid Mechanics Group at The Aerospace Corporation. Dr. Tsai earned his Ph.D., M.S., and B.S. at the University of California, Berkeley in Mechanical Engineering.

Ms. Amber Janssen, Cal Poly Maritime Academy

Amber Janssen is an Associate Librarian at Cal Poly Maritime Academy. Her research has focused on information literacy for undergraduate engineering students, information behaviors of engineers, and more recently AI literacy for undergraduate students.

Laurie Borchard, California State University Maritime Academy

Laurie Borchard has an MLIS in Library and Information Science with over twelve years of professional experience working in libraries. She has nine years of experience working in academic libraries providing information literacy instruction to undergraduate students in both online and in-person environments. Her research has focused on open educational resources (OER), information literacy instruction, and student success initiatives in academic libraries. At Cal Maritime, she works closely with faculty in various departments including engineering, oceanography, political science and the humanities.

Work in Progress: Teaching AI Literacy in Quantitative Experimentation Courses

Abstract

The use of generative artificial intelligence (GenAI) is becoming more prevalent amongst students. Employers increasingly expect graduates to be competent in using GenAI at work. However, the level of competence and understanding of these tools can vary widely based on the experiences of a given student. Since GenAI is now a publicly available tool, it is important that students receive training on the appropriate use, ethical implications, and limitations before using this tool in coursework. To inform these efforts, the authors developed an AI literacy framework designed for quantitative experimentation courses. This framework, presented at ASEE in 2025, guided the development of the instructional methods described in this paper.

In the fall of 2025, Mechanical Engineering and Library faculty piloted a series of learning modules focused on AI literacy in quantitative experimentation. These modules consisted of instructional materials, assignments, and assessments. The learning outcomes focused on teaching students about the uses, ethical implications, and limitations of AI as it applies to aspects of experimental instruction. For this project, learning modules were built to teach students about how to use GenAI in laboratory classes for: i) literature review and ii) data post-processing and plotting. The modules included pre-work (short videos with knowledge checks), a teacher-led demonstration, followed by directed practice. Students were given an initial self-assessment. After the instruction, student artifacts were collected, including ChatGPT conversations, short reflective responses on the process of interacting with GenAI, and final assignments. In addition, the faculty of the courses were interviewed to measure student engagement with AI following the discussion. The materials were developed with enough flexibility to be adapted for other laboratory courses across varying disciplines. This was demonstrated through the piloting of modules in two lower-division physics and eight upper-division engineering laboratory sections. The methodology and some initial qualitative findings are presented. The lessons learned from this work will inform the creation of instructional materials to support adoption in laboratory-based courses across disciplines.

Introduction

With the increased availability of generative artificial intelligence (GenAI) tools to the general public, students in undergraduate programs are increasingly being exposed to these tools. However, guidance and instruction on how to use these tools ethically and effectively are still inconsistent and relatively new. This project aims to provide instructional approaches and assessment tools for incorporating AI literacy into undergraduate courses in quantitative experimentation. The research team is comprised of a Mechanical Engineering professor and two librarians at Cal Poly Maritime Academy. The initial phase of this project began in early 2025 to determine a framework and competencies for AI literacy. This initial work was reported on in a previous ASEE paper[1]. In the Fall semester of 2025, this project moved into the next phase of piloting lesson plans in engineering and physics laboratory courses at Cal Poly Maritime Academy. Topics covered in the pilot courses included literature reviews for lab and project reports, data post-processing, and plotting. This paper will discuss the implementation of the AI literacy plans in the pilot courses and the initial findings from faculty and researchers on AI literacy instruction. Future publications will analyze student perceptions and assignments. All

lesson plans and assessment tools will also be released in an Open Educational Resource (OER) format.

Background

The authors' previous research established an AI Literacy framework that specifies key competencies and learning outcomes, which informed the design of the instructional modules. Drawing on Bloom's taxonomy, the framework organized AI literacy into four broad domains: (1) Know and Understand AI (basic functions of AI and the ability to recognize AI), (2) Use and Apply AI (using AI tools effectively across contexts), (3) Evaluate and Create AI (critically evaluate AI outputs and collaborate with AI) and (4) AI Ethics (human role in AI and ethical and environmental impacts).[2] Long and Magerko provide a comprehensive set of 17 AI literacy competencies; nine were selected that aligned with our topics for instruction. [3]

1. Recognize AI – distinguish between technological artifacts that use and do not use AI.
2. Understanding Intelligence – critically analyze and discuss features that make an entity "intelligent," including discussing differences between human, animal, and machine intelligence.
3. AI's Strengths & Weaknesses – identify problem types that AI excels at and problems that are more challenging for AI. Use this information to determine when it is appropriate to use AI and when to leverage human skills.
4. Machine Learning Steps – understand the steps involved in machine learning and the practices and challenges that each step entails.
5. Human Role in AI – recognize that humans play an important role in programming, choosing models, and fine-tuning systems.
6. Data Literacy – understand basic data literacy concepts.
7. Learning from Data – recognize that computers often learn from data (including one's own data).
8. Critically Interpreting Data – understand that data cannot be taken at face value and requires interpretation. Describe how the training examples provided in an initial dataset can affect the results of an algorithm.
9. Ethics – Identify and describe different perspectives on the key ethical issues surrounding AI (i.e., privacy, misinformation, ethical decision making, diversity, bias, transparency, and accountability).

These competencies set the foundation for developing learning outcomes, instruction lesson plans, and assessment tools. These competencies were mapped to every lesson plan, instructional material, assignment, and assessment tool/question. Table 1 provides an example of this mapping.

TABLE 1. AI Literacy Competency Alignment

	Prework	Literature Review Assignment	Using AI Tools to Process Data
1. Recognize AI	X		
2. Understand Intelligence	X	X	X
3. AI's Strengths & Weaknesses	X	X	X
4. Machine Learning Steps			X
5. Human Role in AI	X	X	X
6. Data Literacy		X	
7. Learning from Data	X		
8. Critically Interpreting Data			X
9. Ethics	X	X	

Methods

This project was submitted to the California State University, Maritime Academy IRB and was determined to be exempt. The instruction was implemented with the following structure. The authors spoke to classes prior to any instruction and provided a consent form allowing their data to be used. Students were advised that the AI instruction would be a part of the course regardless of whether they consented or not, although none of the work directly associated with the research would impact their grade. Students who consented to participate then completed a pre-survey using a unique QR code for each course section. One week later, all students were assigned an asynchronous "pre-work" instructional module to complete before our in-person instruction. During each instructional session, the instructor provided a brief demonstration or mini-lecture on targeted concepts, followed by directed practice. The authors collected GenAI conversation transcripts and written responses to lesson-specific reflection prompts for participating students. Finally, at the end of the semester, participating students completed the post-survey.

For all of the instructional modules, students were expected to use ChatGPT. The authors had considered other GenAI tools such as Claude, Julius, and Gemini. Ultimately, the decision came down to availability and student access. For this institution, all students and faculty have access to ChatGPT, making it easily accessible during and after instruction. However, this choice may vary by institution. With this in mind, the authors have developed instructional materials that are not platform-specific and could be used in one of the other GenAI tools with little modification.

Prework

One week prior to the in-person instruction, students were assigned a Canvas module to be completed before the first in-person instruction. The pre-work introduced foundational concepts in AI and AI ethics. This module consisted of two short videos and one article, followed by ungraded quizzes that served as knowledge checks and are not a part of our formal assessment. The video Generative AI in a Nutshell [4] and The Guardian's visual explainer [5] provide an introduction to how GenAI works, its limitations, and tips for using it effectively. Whereas, Sasha Luccioni's Ted Talk [6] describes the ethical impacts and risks of using AI. The learning outcomes for the prework are:

- Define “generative AI”
- Define “prompt engineering”
- Understand how GenAI works
- Identify strengths and weakness of GenAI
- Understand the human role in AI

The purpose of the Canvas module was to establish a baseline understanding across students with varying prior knowledge. This allowed for more in-class time devoted to active learning. In class, instruction was built on the pre-work through instructor-led demonstrations, followed by directed practice.

Literature Search Lesson Plan
Some of the participating courses included a literature-search instructional module. In these courses, instruction addressed how to use and evaluate ChatGPT to identify high-quality information sources relevant to students’ projects. This approach was implemented in five upper-division mechanical engineering lab sections. The learning outcomes for this lesson plan were that, upon completion, students would demonstrate the ability to:

- Identify and locate relevant resources
- Apply effective prompt engineering to receive relevant results
- Critically evaluate ChatGPT outputs

The instruction began with a short overview of prompt engineering, including tips on how to develop an appropriate prompt to get better results. As a group, the instructor and students brainstormed elements of the prompt that would be most helpful for getting the best results. In groups of two, students were instructed to develop a prompt, to find relevant sources for their project, and then evaluate the chat responses, as well as the information sources. One person was instructed to take notes during the process, while the other did the prompting. Not only did students evaluate the chat, but they also had to find the full text of the information sources suggested by ChatGPT and evaluate those sources for relevancy and accuracy. They were encouraged to update their prompt, ask follow-up questions, and think of this as a conversation.

They were given a series of questions that helped guide them through this activity. The artifacts collected were their ChatGPT conversations and answers to the following questions:

1. Ask for 3-4 sources that will inform their experiment
    a. What kinds of sources did it give you (journals, books, websites, etc.)
    b. Did you adjust or update your prompt? - Why and how are the results different?
2. Find the full-text outside of AI
    a. Were you able to locate the sources?
    b. Did it match the description provided by ChatGPT
    c. Were links provided by ChatGPT
    d. Where did you find the full text (library, Google Scholar)
3. Evaluate the relevance and credibility of these sources
    a. Were they relevant to your prompt?
    b. Are they appropriate for a lab report?
    c. Is there something you think is missing?

4. Compare this use of AI to the plotting assignment. What are the similarities and differences? In the future, would you use AI for plotting and finding sources?

Data Post Processing and Plotting Lesson Plans

All of the participating courses included a data post-processing instructional module. In these courses, instruction covered how to use ChatGPT to generate plots and other data products from experimental data, as well as how to critically evaluate the output. The learning outcomes for this lesson plan were that, upon completion, students would demonstrate the ability to:

- Demonstrate the ability to use GenAI tools to generate spreadsheets and plots from collected data [4, 5]
- Evaluate the quantitative output from GenAI tools
- Recognize the code underlying the output generated by GenAI tools

Since the students had completed the pre-work module prior to this lesson, all of the students had some basic knowledge of AI tools and how they work. The module does require that students have or would be collecting quantitative data in their laboratory session, and that they would be required to post-process their data. In all of the courses, the students had prior experience with converting their data into post-processing products such as plots and tables.

The instruction began with prompts written as short phrases to illustrate the importance of context. One of the most effective prompts for the demonstration was simply asking for a plot, specifying only which values go on the axes. In doing so, the AI tool did not always get the correct values, even though they are listed in the headers. In ChatGPT v. 5.0, the x-axis often defaults to the row number. This became a useful instructional moment, as students may not instantly recognize it as incorrect until asked to check for certain details. After discussing the issue, students were then prompted to generate a prompt with additional context, including background information, data ranges, plot labels, and curve fits. Students were invited to further work with the data set to generate their own plots, then use the text prompt to perform calculations, such as finding the best-fit curve equations and applying them to manipulate the data. To close the lesson out, students were asked about data products they would expect beyond the plot. The ability to use ChatGPT to generate output Python codes, simple Excel files (containing only the values), and Excel files that include the equations used. Overall, the underlying theme in this module could be summarized as prompt engineering for quantitative analysis, where students learn how to utilize GenAI to create output from a data set, and also understand the need to critically think about the outputs.

At this point, if the students already had data collected, they were asked to use the prompt engineering lessons from this instruction and apply them to that data. Depending on the nature of the work remaining, the presenter either stayed with the instructor to help support the session or left the class to allow them to do their data collection and processing. If the students had not yet collected data, data processing using ChatGPT was done later. In addition to data processing, the presenter asked students to provide two artifacts for assessment. One artifact was a transcript of the conversation the students had with ChatGPT to generate the plot, and the other artifact was a student reflection of the instruction experience, where they were asked the following questions:

1. Explain your thought process as you developed the prompts to process your data further.

2. What challenges did you encounter while trying to post-process your data? Did you find ways to solve or work around those challenges?
3. What do you see as the gaps and/or limitations of using generative AI tools for data processing?
4. Do you think you will use generative AI tools to help in your data post-processing going forward? Why or why not?

All students were asked to submit their responses, although only the artifacts from those who consented to participate will be used.

Assessment Instruments

During the initial phases of the project, the authors completed a review of assessment methods for AI literacy [1]. These previously published instruments were adapted to create a survey that could be used before and after AI literacy instruction. In addition, the authors chose to collect student assignments as authentic evidence of student learning.

Survey

A survey was developed to measure student perceptions and competencies related to AI. Existing survey tools were reviewed to identify questions that would match the framework and competencies that this project sought to address [7], [8], [9], [10], [11]. All survey questions from the literature that matched the competencies for this project were identified. The authors then reviewed the questions for redundancy and clarity. Finally, the remaining questions were further reduced to keep the survey short. The survey was then piloted with the faculty whose courses would be participating in the project. Their feedback revealed questions that lacked clarity or that were not closely aligned with the learning outcomes.

Before instruction began, participating students were given the survey to determine pre-existing perceptions about AI and measure pre-existing competencies in AI literacy. After the AI literacy instruction, students again took the survey to measure if there has been any change in perceptions or competencies. Survey questions and results will be shared in a future publication.

Student Assignments

In addition to the pre- and post-surveys, assignments associated with the AI literacy instruction were collected for the participating students so that a rubric could be used to measure student learning. This assessment method is often used for assessing competencies and literacies because of the level of detail that can be obtained in examining what students have and have not learned [12], [13]. These assignments included the ChatGPT transcripts generated during the AI literacy instruction sessions, self-reflections written by students during the AI literacy instruction sessions, and the resulting lab report or course assignment that was in progress at the time the AI literacy instruction occurred. The rubric used for assessment and results will be shared in a future publication.

Preliminary Results

At the time of publication, the quantitative analysis of the survey data and assessment of student work were in progress. However, preliminary findings based on the authors' experiences with the instruction and the course faculty were presented to provide insights into the students' experience and to help shape improvements to the instruction.

Participants

Participants for this study were drawn from multiple courses, each with multiple laboratory sections. In Fall 2025, 66 students participated in the work across 4 courses: i) a lower division Physics course in Mechanics (13 students), ii) a junior level engineering course in instrumentation (13 students), iii) a senior level engineering technology course in instrumentation (23 students), and iv) a senior level capstone engineering laboratory course (17 students). Regardless of whether students consented or not, all students actively engaged in the instruction module by following along with the instruction and actively working through the activities that followed.

Faculty Interviews

At the end of the Fall 2025 semester, participating faculty were interviewed to gather feedback on the AI literacy instruction. The authors developed a series of questions to get an understanding of the faculty experience, the feedback they gathered from their students, the impact on student work submitted, and the suggestions to improve the instruction, which are included in Appendix A. The goal of the questions was to qualitatively understand faculty members' perspectives on the session's relevance and impact.

Across the interviews, common themes emerged. Faculty perception of the instruction modules was that it was beneficial and helped illustrate the application and limitations of generative AI tools. For the data post-processing instruction, the faculty appreciated that the instruction included having students work with the dataset from the class, which made the material relevant and relatable to students. This observation was reinforced by faculty conversations with students and listening to the interactions between students. All of the faculty agreed that, if provided the material, they were confident that they could provide the instruction. The faculty also responded that ChatGPT was an appropriate tool for this exercise, although they all noted limited experience with generative AI tools for quantitative data processing.

While the content was designed to incorporate course materials, a suggestion from several of the faculty interviewed was to improve the integration of the student assignments with the course itself. The faculty did try to incorporate the submission of chats and reflections as parts of their assignments in different ways. However, since students had to opt in to the participation in the research, it was not possible to incorporate the assignments into the grade. The faculty believed that this may have hurt participation in terms of assignment and artifact collection. This recommendation would be useful for future research work, although it should not be an issue if an instructor implements the assignments as a required part of the course.

One of the faculty had suggested that the instruction modules provided should be a part of a short general AI familiarization course provided to all students at the start of the term. These instructional modules were seen as a blueprint for a broader series of instruction with the goal of creating a common understanding and basic competency in GenAI usage. This would allow instructors to provide more specific and course-related GenAI into their instruction since students would start with the same skill level. Although this suggestion was outside the authors' scope of work, it highlighted the need for GenAI instructional materials.

Challenges

An issue that arose during some instruction sessions was the functionality of ChatGPT during the instruction. Generally, one issue that arose was the processing time for a prompt. For ChatGPT, users have access to models with varying levels of complexity and, therefore, varying processing times. For the most advanced models, queries could take on the order of tens of minutes to process, which was too slow for the instruction. From this experience, the authors modified instruction to limit students to using the tool's basic form, enabling quicker prompt responses.

For the post-processing instruction, there were some occasions when the instructor's ChatGPT instance would not accept any uploaded files or images, restricting the ability to provide the initial dataset for processing. Another error that occurred was the inability to generate figures, specifically plots, during demonstrations. Advice from other colleagues led to the preparation of backup materials for these contingencies. Screen captures of prior conversations with ChatGPT in preparation for the instruction, which still allowed students to see the desired output and follow along with the lesson.

The above challenges reinforced the importance of testing the prompt exercises immediately before instruction. This practice commonly occurs when instruction demonstrates software use. For AI instruction, the authors reimplemented this practice to ensure the lesson plans remain relevant, given the rapidly changing nature of AI tools, and to capture variation in prompt responses. For example, prompt testing was used prior to each post-processing lesson to ensure that the demonstration of the incorrect plot would function as planned. Saving the instances provided the backup necessary to cover the issues previously described, making sure that the method preserved the images.

Another challenge that arose with this project was student participation in the study, which greatly varied by course and even by section. Prior to being assigned the pre-work, the authors spoke to the class about the project and provided students with the consent forms. However, participation in the study varied greatly, with 23 out of 28 students (82%), while another class had 17 out of 28 students (60%). To better understand the factors influencing participation, the authors asked the class about concerns about participating. Responses from the conversation included reluctance to use AI due to concerns about academic integrity, privacy in GenAI conversations, and environmental and societal impacts. These concerns should be considered important for any faculty member looking to implement instructional materials, as they may need to account for students' reluctance to use the tools.

Another area identified as worth further examination was the development of additional methods to demonstrate students' critical thinking. The authors made sure that all lessons included having students carefully evaluate the GenAI outputs from the conversation. During instruction, the authors could assess whether students were thinking critically about the results through interactions such as follow-up questions. If students were taking the accuracy of the outputs for granted, the instructors could address this. However, depending on the class size, there may not have been enough time to engage every student in this discussion. Although more detailed conclusions can be drawn from the analysis of student work samples, the authors also believed that further development of the lesson plans should include additional checks to ensure that students think critically about GenAI outputs.

Conclusion

This work-in-progress paper describes the activities that occurred during the summer and fall of 2025. The work presented captures the implementation of instructional modules in quantitative courses in physics and engineering. The positive faculty feedback suggests that the work provided a net benefit, although ultimately, quantitative data from student artifacts will be used to determine efficacy and inform improvements to the instructional materials. Future work includes analyzing the pre- and post-surveys and applying a rubric to the student assignments collected. The authors will also implement other instructional materials in development in a course in the spring semester. The ultimate goal is to create an OER for faculty looking to incorporate GenAI into their courses.

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References

[1] L. Borchard, A. Janssen, and W. W. Tsai, "Creating Artificial Intelligence (AI) Literacy Learning Outcomes for a Quantitative Experimentation Laboratory Course," presented at the 2025 ASEE Annual Conference & Exposition, Jun. 2025. Accessed: Jan. 16, 2026. [Online]. Available: https://peer.asee.org/creating-artificial-intelligence-ai-literacy-learning-outcomes-for-a-quantitative-experimentation-laboratory-course

[2] D. T. K. Ng, J. K. L. Leung, K. W. S. Chu, and M. S. Qiao, "AI Literacy: Definition, Teaching, Evaluation and Ethical Issues," in *Proceedings of the Association for Information Science and Technology*, 2021, pp. 504–509.

[3] D. Long and B. Magerko, "What is AI Literacy? Competencies and Design Considerations," in *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, Honolulu HI USA: ACM, Apr. 2020, pp. 1–16. doi: 10.1145/3313831.3376727.

[4] Henrik Kniberg, *Generative AI in a Nutshell - how to survive and thrive in the age of AI*, (Jan. 20, 2024). Accessed: Jan. 20, 2026. [Online Video]. Available: https://www.youtube.com/watch?v=2IK3DFHRFfw

[5] "How AI chatbots like ChatGPT or Bard work – visual explainer | Technology | The Guardian." Accessed: Jan. 20, 2026. [Online]. Available: https://www.theguardian.com/technology/ng-interactive/2023/nov/01/how-ai-chatbots-like-chatgpt-or-bard-work-visual-explainer

[6] S. Luccioni, *Sasha Luccioni: AI is dangerous, but not for the reasons you think*, (1698763613). Accessed: Jan. 20, 2026. [Online Video]. Available: https://www.ted.com/talks/sasha_luccioni_ai_is_dangerous_but_not_for_the_reasons_you_think

[7] D. T. K. Ng, W. Wu, J. K. L. Leung, T. K. F. Chiu, and S. K. W. Chu, "Design and validation of the AI literacy questionnaire: The affective, behavioural, cognitive and ethical approach," *Br. J. Educ. Technol.*, vol. 55, no. 3, pp. 1082–1104, 2024, doi: 10.1111/bjet.13411.

[8] A. Carolus, M. J. Koch, S. Straka, M. E. Latoschik, and C. Wienrich, "MAILS - Meta AI literacy scale: Development and testing of an AI literacy questionnaire based on well-founded competency models and psychological change- and meta-competencies," *Comput. Hum. Behav. Artif. Hum.*, vol. 1, no. 2, p. 100014, Aug. 2023, doi: 10.1016/j.chbah.2023.100014.

[9] B. Wang, P.-L. P. Rau, and T. Yuan, "Measuring user competence in using artificial intelligence: validity and reliability of artificial intelligence literacy scale," *Behav. Inf. Technol.*, vol. 42, no. 9, pp. 1324–1337, Jul. 2023, doi: 10.1080/0144929X.2022.2072768.

[10] C. W. Yuan, H. S. Tsai, and Y.-T. Chen, “Charting Competence: A Holistic Scale for Measuring Proficiency in Artificial Intelligence Literacy,” *J. Educ. Comput. Res.*, vol. 62, no. 7, pp. 1675–1704, 2024, doi: 10.1177/07356331241261206.
[11] M. C. Laupichler, A. Aster, N. Haverkamp, and T. Raupach, “Development of the “Scale for the assessment of non-experts’ AI literacy” – An exploratory factor analysis,” *Comput. Hum. Behav. Rep.*, vol. 12, p. 100338, Dec. 2023, doi: 10.1016/j.chbr.2023.100338.
[12] M. Oakleaf, “Dangers and Opportunities: A Conceptual Map of Information Literacy Assessment Approaches,” *Portal Libr. Acad.*, vol. 8, no. 3, pp. 233–253, 2008.
[13] B. M. Moskal, “Scoring Rubrics: What, When and How?,” *Pract. Assess. Res. Eval.*, vol. 7, no. 3, Mar. 2000.

Appendix A
Faculty Interview questions

1. What parts of the AI literacy instruction do you think worked well? And why?
2. What parts of the AI literacy instruction do you think could be improved? And how?
3. What were your experiences and perceptions of student use of AI before this project?
4. After observing the AI literacy instruction, have your perceptions changed?
5. Did you notice a difference in the quality of student work? Lab reports before AI lesson plans vs. after lesson plans
6. Do you think ChatGPT was the right tool for these lesson plans?
7. Do you feel like you could implement this lesson plan on your own in the future?
8. Are there any other thoughts you would like to share with us to improve our AI literacy instruction?

Possible Follow ups

- Do you feel like you could implement this lesson plan on your own in the future?
- Did you notice a difference in the quality of student work? Lab reports before AI lesson plans vs. after lesson plans
- Do you think ChatGPT was the right tool for these lesson plans?