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Work In Progress: Improving student preparedness in undergraduate laboratories: are pre-lab quizzes an effective tool for encouraging students to use preparatory material before laboratory classes?

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Introduction

Pre-lab quizzes have long been popular exercises assigned to students in preparation for laboratory classes. In 1983 already, Kolodny and Bayly [1] discussed early implementations of pre-lab quizzes on computers. They used computers with the hope that they would be more ``fun'' and create less anxiety than traditional paper-based quizzes. Their goal at the time was to create an incentive for students to read lab material before class because "although a major component of student success and satisfaction is preparation for each experiment, it was apparent that most students came to lab unprepared". More than 40 years later, the instructors of the Energy Systems Laboratories at our institution are still observing that many students come to lab unprepared, even though they are required to take online pre-lab quizzes before class.

In general, studies across STEM disciplines find that pre-lab quizzes and other preparatory activities have a positive impact on students' preparedness [1,2] and engagement [3]. Several authors [4-5] also found that pre-lab activities helped reduce the cognitive load during lab time, which resulted in improved learning.

Nevertheless, in their recent snapshot of pre-lab practices in the UK, Navarro et al. [2] reported issues with what they called "tick-box completionism" where there is a misalignment between the students' goals (getting done with the activity as quickly as possible) and the instructors' (verifying that students engage with preparatory material) [6]. This lack of student engagement shows the difficulty of creating pre-lab activities and quizzes that are engaging and designing incentives that are effective.

This paper presents work in progress towards assessing how students utilize preparatory course material in the Energy Systems Laboratories at our institution, and whether pre-lab quizzes are an effective incentive to motivate students to prepare for their lab classes.

Course organization

The undergraduate laboratories in Energy Systems are taken by approximately 250-300 senior mechanical engineering students every year. The laboratories include six experiments using large-scale equipment: steam turbine, gas turbine, air compressor, flow measurement bench, drag measurements in wind tunnel, and compressible flow in converging-diverging nozzle. Students run the experiments in groups of three or four. They collect and process data, and they analyze them using dedicated software and their knowledge of thermodynamics, heat transfer, and fluid dynamics. Finally, they present their results in a written report or an oral presentation.

Students work in groups of three or four. The class is divided into multiple sections and there are typically eight groups (32 students) and two instructors per section. The laboratories meet for two 2h-long class periods per week. Groups perform the experiments in a round-robin format. Each experiment takes four class periods to complete. Ideally, the first class period is dedicated to collecting data and the second period to importing data into software and post-processing. During the third period, students finalize post-processing and start their analysis. They present their work to the instructors orally or through a written report on the fourth class period. A significant amount of work is performed outside of class and there are Friday office hours for students to get additional help with post-processing and analysis. On most days, there are four groups in the early stages of their experiment (collecting data or post-processing) and four groups in the late stages (analyzing data or reporting) in each section.

All the course material is accessible to students through the course webpage in the Learning Management System (LMS). A lab manual is available as a pdf file for each experiment. It contains background information about the experimental setup and reviews theoretical concepts necessary to analyze the experimental data. For example, for the steam turbine experiment, the background section reviews the Rankine cycle; principles of impulse turbines; energy and entropy balances on the various components of the cycles; definitions of performance indicators (efficiency, steam rate, …); and a review of heat-exchanger modelling. The background information is followed by a detailed description of the experimental setup. Finally, the manual provides a step-by-step operating procedure, a list of calculations to perform and plots to generate, and a list of questions to answer and discuss in the report.

In addition, lecture videos are available that review the theoretical background and provide further details about key concepts. The videos are about 10-15min long, and there are one or two per experiment. Both experiment manuals and lecture videos are available throughout the semester so students can access them at any time, before, during, or after each lab.

To make the best use of in-class time, it is crucial that students familiarize themselves with the experiments before coming to the labs. The instructors rely on pre-lab quizzes to incentivize students to read the manual and/or watch the lecture videos ahead of time. Students are required to complete pre-lab quizzes individually online, on the LMS. These quizzes are due at the beginning of the first class period for each experiment, which occurs at different times during the semester for different groups. Together, the six pre-lab quizzes account for 10% of the final grade. Each quiz consists of five questions, which can be multiple choice or numerical. The questions were designed to draw the students' attention to key sections of the manual and videos or to concepts that, based on the instructors' experience, are often overlooked by students. All the answers can be found in the manual or in the videos. For example, the pre-lab quiz questions for the "drag over a cylinder" experiment are:

1. For a cylinder in cross flow, "friction drag" is the most significant contributor to the drag force: True/False.

2. Select all the statements that are true:
    a. If all the other conditions are the same, a laminar boundary layer around the cylinder will display a wake that is more narrow than that of a turbulent boundary layer
    b. If all the other conditions are the same, a turbulent boundary layer around the cylinder will separate earlier than a laminar boundary layer.
    c. The drag coefficient is typically lower for a turbulent boundary layer than for a laminar boundary layer
    d. The inviscid flow is a limiting case that provides a maximum value for the drag coefficient.
3. The table in Figure 1.5 can be used to find the drag coefficient for a cylinder in crossflow when the boundary layer is laminar: True/False
4. Using the table in Figure 1.5, what value of the drag coefficient do you expect for the small cylinder used in the experiment? Assume the Reynolds number is approximately 10000. (Read the manual carefully)
5. You should attempt calculation 1 before going to class. To calculate the average air flow velocity in the tunnel from the pressure drop across the inlet converging section, you may (select all that apply):
    a. Assume the flow is incompressible
    b. Use Equation 1.28
    c. Combine Bernoulli and conservation of mass

Research questions

Despite the implementation of pre-lab quizzes, the instructors find that many students come to lab unprepared. The proposed research will aim at checking the instructors' perception against data from the LMS and assessing the effectiveness of pre-lab quizzes.

The two research questions are:

- RQ1: Are students using preparatory material (manuals, videos) before coming to labs?
- RQ2: Are online pre-lab quizzes an effective incentive for students to prepare before coming to labs?

Methodology

The study relies mainly on data extracted from the LMS as well as a student survey. We are currently waiting for IRB approval to use the data and implement the student survey.

The author will work with data analysts at their university to collect student activity data from the Energy Systems Laboratory LMS in the Spring 2026 semester. The enrollment for this semester is approximately 200 students. The collected data is summarized in Table 1. It includes

pre-lab quiz scores, and overall final score for the course. It also includes time stamps of when lab manuals and videos were accessed for the first time, when quizzes were started and time taken to complete a quiz.

Table 1 - Data collected from the LMS.

Student data	**Events data for each experiment**
Student Identifier (anonymous) Final score Scores for each quiz Due date for each quiz	Time quiz started Time taken to complete quiz Time of first access to lab manual Time of first access to lecture video Time of first access to webpage

Each data point is associated with an anonymous student identifier, which allows to calculate correlations between timed events and scores. For example, we can use the data to verify if there is a correlation between time taken to complete the quiz and quiz score. Table 2 shows a list of tests that will be performed with the data and how they may contribute to answering the research questions.

Table 2 - Summary of tests to be performed with LMS data and questions they will try to answer

Test	**Question addressed by test**
RQ1: Are students using preparatory material before coming to labs?	
Class percentage accessing content (manual, video, webpage)	Are students using course material at all?
Class percentage accessing content (manual, video, webpage) before the start of lab	Are students using course material before lab?
Distribution of how early before the deadline quiz is completed and content accessed	When do students access course material and complete pre-lab quizzes?
RQ2: Are pre-lab quizzes an effective incentive?	
Distribution of time taken to complete quiz	How long does it take to complete the quiz?
Class percentage completing quiz in less than X min, with X to be determined	What fraction of the class is completing quiz in an impossibly short amount of time, suggesting cheating?
Correlation between time taken to complete quiz and quiz score	Does the time spent working on the quiz correlate with quiz score?
Correlation between time taken to complete quiz and final score	Does the time spent working on the quiz correlate with the final score?

Correlation between how early quiz is completed and quiz score	Does the time when quiz was taken correlate with quiz score?
Correlation between how early quiz is completed and final score	Does the time when quiz was taken correlate with quiz score?
Correlation between when content is accessed and quiz score	Is there a correlation between when content is accessed (before or after labs) and quiz score?
Correlation between when content is accessed and final score	Is there a correlation between when content is accessed (before or after labs) and quiz score?

Students will also be asked to answer a survey regarding their use of pre-lab quizzes and their perception of how well they are prepared before coming to labs. The goal of the survey questions will be first to offer a point of comparison with the LMS data and assess the students' perceptions about their own preparedness before labs. The survey will also aim at obtaining feedback about the perceived adequacy of the manuals and lecture videos and inform us whether these materials could be modified to improve their use by students.

Future work

The results of this study will provide the instructors with information about how students use pre-lab quizzes and how they prepare for experiments in the laboratory. Based on this assessment and best practices described in the literature, the instructors will discuss potential changes to the course material, pre-lab quizzes, or other course activities to improve student preparedness for laboratory work. After implementation, the impact of these changes will be assessed using a similar data collection and analysis framework as presented here.

References

[1] N.H. Kolodny and R. Bayly, "Enhancing the laboratory experience in introductory chemistry with Apple-based pre-lab quizzes", Journal of Chemical Education, 60 (10), pp. 896-897, 1983.

[2] C. Navarro, B. E. Arenas, M. F. Haddow, A. J. Kirkham, and P. I. T. Thomson, "A Snapshot of UK Prelab Practices and Instructor Perceptions of their Purpose and Effective Design", Journal of Chemical Education, 102 (9), pp. 3893-3900, 2025.

[3] A. J. Cann, "Increasing Student Engagement with Practical Classes Through Online Pre-Lab Quizzes" Journal of Biological Education, 50(1), pp. 101–112, 2016.

[4] Rathnayaka, C. M., Ganapathi, J., Kickbusch, S., Dawes, L., & Brown, R. "Preparative pre-laboratory online resources for effectively managing cognitive load of engineering students." European Journal of Engineering Education, 49(1), pp.113–138, 2024.

[5] H.Y. Agustian and M. K. Seery, “Reasserting the role of pre-laboratory activities in chemistry education: a proposed framework for their design”, Chem. Educ. Res. Pract., 18, pp. 518-532, 2017.

[6] B.K. DeKorver and M.H. Towns, “General Chemistry Students’ Goals for Chemistry Laboratory Coursework”, J. Chem. Educ., 92 (12), pp. 2031–2037, 2015.