Online Laboratory – Equipped with Procedural understanding Perspective

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Abstract. During the pandemic, educational institutions implemented online laboratory sessions, adapting formats based on available resources. Our approach diverges from traditional instruction-centric models, focusing on fostering procedural understanding. Through interactive webpages, we aim to engage students in critical thinking and problem-solving. Our online laboratory empowers students to make decisions regarding instrument selection, data collection, and analysis. Visit https://sites.hbcse.tifr.res.in/shirish/index.php/vigyan-vidushi/ for access. We believe that these online resources, born out of necessity during the pandemic, possess significant potential to enhance students' procedural understanding and prepare them for real-world laboratory experiences.

Introduction

During the pandemic, schools and colleges adopted the option of online laboratory. Depending on the available resources, the format of online laboratory changed. Some colleges used simulations. Based on these simulations students were asked to perform tasks and collect the data. Some used photographs and videos of experiments. These photographs and videos were generated in the college laboratories and then students were asked to generate data using them. Some colleges sent the low-cost or easy-to-transport apparatus to students along with the instruction sheet. Using these instruction sheets students assembled the apparatus and performed the experiments. Later they were asked to share their data with the faculty and carry out discussions based on their data analysis. In all these efforts, the rules of the experimental game are clearly laid down for the students. They are informed about the measurement tools to be used. They are given instructions about the procedures to be adopted, the data to be collected, and in some cases, even the range of data to be collected. This hardly leaves any scope to check their knowledge of procedural understanding.

What is procedural understanding?

Procedural understanding is pivotal in experimental physics, whether one is conducting experiments as a student or designing them as a developer. It involves comprehending the rationale behind each step, asking "Why" to understand the logic. Key aspects include identifying variables, determining variable ranges, selecting instruments and measurement procedures, plotting appropriate graphs, managing uncertainties, and maintaining precision in results. Emphasizing procedural understanding[1][2] cultivates independent decision-making skills and enables effective experimental planning. This approach empowers individuals to take charge of experiments confidently, fostering both learning and innovation in scientific endeavours.

The online laboratory webpages

The development of our online laboratory differs from the traditional instruction-driven perspective. We developed webpages with the aim to introduce different aspects of procedural understanding in which detailed description and images for the apparatus and setup of the

experiments are given. The student is expected to analyze the video or images and generate the data for variables in the experiment. The following experiments are provided to the students: (1) Determination of the wavelength of laser using diffraction due to one-dimensional grating, (2) Determination of the angular speed of ceiling fan and (3) Studying repulsive force between two cylindrical magnets.

In the first task, students were provided with photographs of diffraction pattern due to one-dimensional diffraction grating. The grating element was chosen in such a way that small angle approximation (which students assume in a traditional laboratory) would not hold true. By making suitable measurements with 1% uncertainty, they were asked to determine the wavelength of the laser. In the second task, slow-motion videos of a fan rotating at different speeds were provided. Students were asked to design their procedure for determining the angular speed of a fan assuming 1% uncertainty in measurement. In the third task, photographs as well as a video of magnet-magnet repulsion assembly were provided. Students were asked to collect the data for the distance between the magnets and the corresponding force of repulsion.

Sample

These experiments were given to students as a pre-assignment for two online camps. The first camp was with 53 student-participants of Indian olympiad program who are typically in their XI/XII standard (pre-university). The second camp was with 56 women students enrolled in post-graduate course in physics. Sufficient time was provided to all the students. They were given a Google form to submit their prominent findings, data, and calculations.

Discussion

Detailed discussions about the experiments and students' responses were conducted after their submissions. We observed that students were still in their traditional laboratory environment while attempting the online laboratories. In the first experiment, most of them used small angle approximation without considering that the distances of maxima and the distance between the screen and the grating are comparable. Most of the students used the 30 cm scales provided in the photographs for distance measurement which led to inaccurate data collection. Moreover, most of them did not realize the possibility of using better measurement techniques like magnification of photographs for measurement with 1% uncertainty. This was also observed in the measurement of distances between magnets in experiment 3. In the angular speed of fan experiment, majority of students did not make use of the video to conveniently choose the start and end point of fan blade rotation. Instead, they counted 10 rotations as they do in a traditional laboratory setting. We observed that these difficulties were present in both groups indicating a lack of procedural understanding in laboratory programs at different levels. During the conference, the intricacies of these findings will be discussed with the gathering. We believe that these online laboratory webpages, though emerged during the pandemic, have good potential to make students realize and internalize different aspects of procedural understanding before entering the actual college laboratory.

References

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