Introducing practical exercises in a mechanics course

Presentation

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Introduction. There is an increasing awareness that traditional teaching approaches in university physics, such as one-way communication in lectures, recitation session with algorithmic problem solving, and expository laboratory work, are not effective in influencing students' conceptual understanding of the topics (Knight, 2002). Therefore, physics teachers try to establish more student-active teaching approaches, where students engage in doing and talking physics with one another (Lemke, 1982). Furthermore, Knight recommends moving focus from mathematical abstractions to providing students with shared, concrete experiences of physical phenomena.Our experience is that many engineering students often do not have the practical experience of mechanics that we might assume when they come to our courses. For example, if a student does not have direct experience of using a wrench, this is not likely to be a useful starting point for an introduction of the torque concept. The present study is a case of introducing short practical exercises in a university-level course in mechanics, in order to provide students with personal experiences of physical phenomena in relation to the content. The overall aim of the study was to investigate the utility of practical exercises in university-level mechanics.

Methods. The study was conducted in a university course in mechanics for physics, engineering, and physics teacher students, in all about 120 participants. The response system Learning Catalytics (Schell, et al., 2013) is used in lectures in order to increase student interaction and provide prompt feedback. The course has historically had a theoretical focus on conceptual understanding and algebraic problem solving. We identified a need to ground the theory of mechanics in students' practical, embodied experiences (Amin, et al., 2015), by giving students the opportunity to interact with mechanical devices. Therefore, we developed four *practical exercises*, which students were asked to perform in random groups of 3-4 students during 10-15 minutes one after another during recitation sessions. In line with Knight's (2002) notion of experiential labs, students were asked to predict, observe and explain (POE, White & Gunstone, 1992) what happens in relation to a physical phenomenon qualitatively. The exercises involved:

- Experiencing the lower force of pulling up a 5 kg weight by a rope with a system of two pulleys, compared to a rope without pulleys (Figure 1a).
- Practically establishing the centre of mass of an object by holding the hands under the object and moving them toward one another (Figure 1d), after the lecturer has demonstrated that the two parts on either side of the centre of mass of a broom have different mass (Figure 1b).
- Observing the changing normal force by standing on a bathroom scale in a lift, as it starts, moves at constant velocity, and comes to a stop.
- The resulting pulling force on a dynamometer of a suspended weight and a horizontal force acting on the weight.

Data were collected by video observation of the majority of the groups' work with the practical exercises, audio recording of interviews with some of the teacher students on their impressions of the exercises after the course, results from multiple-choice questions on the exercises in the response system in lectures after the recitation sessions, and written course evaluations.

Results. The course evaluation and interviews with teacher students show that that the students in general enjoyed the practical exercises and found them useful in providing personal, physical experiences in relation to the theoretical course content. Of the four exercises, experiencing a system of pulleys and finding the centre of mass were seen as more engaging than the other two. Therefore our video analysis of students' work with the activities focused on the two exercises that were viewed as more engaging.In general, the students were excited by the physical observation that the force needed to pull up the weight by their hands with and without a system of pulleys felt so different. As an example, one of the students explained to her three group mates what she calls *“the law of pulleys”*, that a force pulling a pulley counter clockwise has to be counteracted by an equal clockwise force for equilibrium, when predicting the forces needed to pull up the weight. Her understanding of pulleys was enacted by her gestures (Figure 1c; Goodwin, 2003), in coordination with an oral explanation. In the activity of finding the centre of mass, many of the groups attended to the fact that when moving the hands towards the balancing point, typically only one hand at a time moves relative to the suspended object, which led to a discussion of the difference between static and dynamic friction between two surfaces.

Discussion and conclusions. Overall, we found the initiative of introducing practical exercises in a predominantly theoretical mechanics course worthwhile. The students were provided the opportunity to connect the content to personal, embodied experiences of the studied phenomena in line with what we had planned for. Apart from learning the content, some of the students experienced that this brief 10-15 minute interaction with subsequent discussion in random groups led to new communication patterns in the class overall, where they got to talk to students they did not know before. In this way, the exercises contributed to developing a learning community (Kim et al., 2014). Going forward, we intend to keep the format of practical exercises in the course, but replace the ones that were less engaging. During the Corona pandemic, the practical exercises were adapted to remote teaching, in which students were encouraged to make do with equipment they had available at home in a “do-it-yourself” fashion, but with less successful results than the original small-group interaction at campus.

Referenser

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