Video Tutorials on Selected Topics in the Introductory-Level Dynamics

Abstract. The lack of effective problem-solving skills is one of the stumbling blocks to students' success in the introductory physics courses [1]. The video tutorials described in this paper were envisioned as a supplementary on-demand resource that students could access 24/7 and study at their own pace. The authors focused on selected topics of Dynamics: such as Normal Force, Static and Dynamic Friction. These topics are known to be especially challenging for introductory level students. The resources developed for this project were used in the authors' own courses as well as other physics instructors at their university.

1 Project Motivation

Many students in introductory-level physics courses often cannot apply theoretical knowledge to problem-solving [1]. They often lack both conceptual understanding and math knowledge needed to plan and construct correct solutions. Learning effective problem-solving skills is even more difficult in large-enrollment classes [2], which are typical in STEM-based and premedical programs across North America. Quality open resources for physics based on the advances of Physics Education Research (PER) are still relatively scarce, while the need for such resources is great. A study commissioned by HEQCO to investigate the impact of active–learning strategies on students learning (conducted by the team lead by one of the authors of this paper in 2012-2013) revealed that students have particular interest in materials aimed at the development of problem-solving skills [3]. According to the survey, the students favor the format of short videos that demonstrate effective problem-solving strategies, and which model the expert problem-solving process. The students need the materials that can be accessed on demand, 24/7, at students' convenience. These materials can be used as pre-lecture assignments for a flipped classroom as well as for post-lecture reinforcement in a traditional lecture setting.

2 The Content Creation and Sharing

The tutorials were prepared in the form of dynamic Power Point slides. Since the tutorials targeted the topics in Dynamics, one of the essential goals was to provide the students with a tool to build Free Body Diagrams (FDBs) which are fundamental to successful problem-solving. Therefore, the basic animations illustrating FBDs development were added to the Power Point presentations. In addition, the animated screen display is supplemented with a brief text explanation. The presentations were narrated by the former student who took the course before. The presentations were then screen-captured by Camtasia, with an added voice over. For the current set of tutorials, the authors chose the topics of Normal Force, and the Static and Kinetic friction which present certain difficulties for many novice students. For example, the common misconception is that the normal force is always equal to the weight of the object. The tutorial created leads the students through the series of examples of how the normal force can be altered by applying an additional force having the component that is perpendicular to a

contact surface, or by placing the object on an inclined surface. Another example is the typical misconception about static friction is that the force's magnitude is always equal to the product of the normal force and the coefficient of static friction.

The completed materials were shared with the instructors teaching introductory level physics courses at the authors' university. They are used already to teach 600+ students in introductory physics for science programs, with an additional potential reach of about 1,400+ students if used in engineering programs as well.

3 The Results and Conclusions

It is expected that the improved problem-solving skills achieved in the introductory courses has a lasting impact positive impact for the remainder of the students' University education. To receive objective feedback for the potential improvement of the materials, in the course offered for Science Programs students, the evaluations included targeted questions that assessed the learning outcomes for the topics addressed by the video tutorials. The results were compared with the baseline provided by the somewhat similar questions that were used in past years. Since the comparison year did not have the baseline questions for some of the subtopics, it was not possible to conclusively quantify the improvement due to the video tutorials.

The feedback from an informal voluntary students' survey indicated that overall, the students found the tutorials useful. In particular, the students believed that the tutorials focused on the essentials; learning from following the animated tutorials was more time-effective than from reading the static textbook sections; the mini-lessons are easy to follow; the animations in the tutorials are helpful for the visualizing the concepts. The students appreciate the ability to learn at their own pace: they can pause and re-watch the material as many times as needed. Several students indicated that they would like to see new videos targeting other challenging concepts.

This project is a work in progress. More video tutorials will be added. For the existing materials, more rigorous evaluation of their impact on students learning is being planned.

References

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