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Center for Education and Research
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Towards A Flipped Classroom for Introductory Physics

We propose to develop and organize online curricular materials which be used to implement a new program of "flip teaching" within the main calculus-based introductory physics sequence here at CWRU.

PHYS 121 is a large lecture-based course on introductory Newtonian Mechanics that serves many undergraduates at CWRU for degree programs in the sciences, mathematics, and engineering. During the 2013-2014 academic year, for example, over 300 students per semester enrolled in PHYS 121. The course is usually taught in a large lecture hall such as Strosacker Auditorium. Although PHYS 121 includes a hands-on laboratory component, most of the students' class time is spent in the lecture hall.

The department of physics has a strong track record of innovation and effort toward improving the level of engagement and active learning within our large introductory lecture courses. For example, during the 1990s, members of our group lead pioneering efforts to develop and implement the use of "clicker" technology in large lecture courses. More recently, we have adopted a "Cyclic Syllabus" wherein course materials are presented during the whole semester in a manner more consistent with what we now know about the Learning Cycle. Our approach has been to apply both new technologies and new results in education research so as to improve the student learning experience while at the same time retaining those essential aspects of our existing courses that remain effective for achieving our overall pedagogical goals.

One of the more intriguing and compelling innovations we are now considering for physics courses is the implementation of the method known as "class flipping". In a traditional course, new materials are generally first presented to students during a classroom lecture by the instructor, and then the students continue their study outside of the classroom through assigned homework. In contrast, for the flipped classroom, students are first introduced to the materials outside of class, and then subsequently are encouraged to explore the same topics on a deeper level during classroom time. In the traditional class, the instructor lectures to the students who passively absorb the material. In the flipped classroom, students actively engage the material.

The method of class flipping represents a new approach to addressing the very old problem of motivating students to arrive well-prepared for class. Good instructors in physics always strongly recommend that students read the assigned textbook materials *before* attending lecture, since they know that students who have completed the assigned reading beforehand will get much more out of the classroom experience. In practice, however, few students are sufficiently motivated to complete the assigned reading before class, and efforts to motivate just-in-time reading are often met with resistance.

In the "flipped" classroom, we can overcome student resistance to preparing for lectures by presenting introductory materials in the form of online video or multimedia presentations. Here

the goal is to make the first introduction to specific topics in the course as accessible, interesting, entertaining, and otherwise painless as possible, so that the students are well-motivated to encounter the materials before class. By flipping at least some of the introductory materials from presentation in-class to presentation before-class, time is made available during the class hour itself for more student-engaging activities. The instructor can spend less class time lecturing and more class time working in-class problems, presenting clicker problems, setting up group-work exercises, and conducting illuminating demonstrations.

Our plan for flip teaching is informed by our past experience in developing and implementing innovations such as the use of clickers. We will take an incremental approach, introducing new curricular materials in a gradual way, so that their effectiveness can be assessed in real-time, and so that we can retain important and effective pedagogical aspects of the course as presently implemented with minimum organizational disruption. Here we propose to develop a "core package" of coordinated online materials, to be used for a first-pass effort to introduce methods of flip teaching in PHYS 121. In our view, the minimum threshold for such a package corresponds to approximately 30 online video clips, each specifically selected for particular course topics so that students will view on average two clips per week before lectures. Video clips will range from 5 to 15 minutes duration each, and will be presented to the students in a simple, publicly accessible location on the internet. Each clip will be assigned to introduce some new central physics concept to the student and/or to present an intriguing or surprising aspect of the topic in a way that might not normally be considered during a standard in-class lecture. Given that introductory mechanics is a widely taught subject, we already know that we can expect to find appropriate and effective "third party" video materials in the public domain can can be effectively used for a reasonably large fraction of the topics presented in PHYS 121. However, given the specific character that is unique to our own implementation of the course, we also expect to supplement third-party materials with our own home-made video segments which will be designed, developed, and produced by students and faculty in the physics department. Also, as we already do with clickers, we will implement a simple online method to to record student participation through the awarding of small numbers of "bonus points" based on responses to simple online surveys.

For this project, we are asking the Nord Grant Program for supporting funds to cover the costs of summer salary for two undergraduate physics majors who will work during the months of July and August 2014 to develop, prepare, and organize the materials for first use during the Fall 2014 PHYS 121 course. Each of the two undergraduates will work for six week of Summer 2014. The students will work closely with the faculty supervisor on a daily basis. The end product of the student work will consist of three components that are essential to our plan to introduce methods of flip teaching in PHYS 121:

- First, summer students will search for and identify existing third-party online resources available in the public domain that would be well-matched for assignment to major conceptual topics listed week-by-week for the semester.
- Second, summer students will work with the faculty supervisor to develop in-house video clips for those topics where effective third-party materials are not already available.
- Third, summer students will work with the faculty to develop a set of short-answer multiple-choice questions that will be implemented through online surveys to verify student participation for each video clip before class.

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Budget:

The budget for this project consistent of summer salary support for two undergraduate students (CWRU physics majors) each working 40 hours per week for six weeks at a department standard rate of $10.50 per hour (no fringe), during the period July 1 through August 18, 2014. The total amount is $5,040.

The product that will be generated will be a coherent set of at least 30 video clips. Each video clip will be associated with a specific in-class lecture topic, along with existing clicker questions and lecture demonstration materials. Video clips will include a mix of materials collected from the public domain together with materials developed in-house by faculty and student in the physics department.

The product will also include set of simple multiple choice questions for each video clip along with an online survey mechanism for providing bonus point to encourage student participation.

All products, including curricular materials and software developed as part of this project will be made freely available for use by any faculty for use in any courses taught at CWRU.