Innovative and Creative Undergraduate Teaching

Grant Application

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Project title: Phield Based Physics

Department: Physics

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Rationale

Physics can be found everywhere in the world around us. Physics teachers of all levels continually emphasize this to their students. With modern technology it is now possible for students to interact with and analyze authentic, real world data. Most handheld devices such as IPads have accelerometers, video software is available to capture and mark object motion frame by frame, and there are a number of other simple probes that can be used along with these devices to record a wide range of information such as pressure, temperature, etc. This can be used to literally put the data collection decisions and tools themselves right in the hands of the students. Students can conduct "Phield Based Physics". For example, they could video any object as it fell or moved through the air, use the IPad itself to record acceleration of the device, analyze sound waves, etc.

This proposal is for funding to redevelop half (6 out of 12) of the laboratories for the first semester of the full year introductory physics series, to have students conduct "real world" measurements rather than performing traditional labs in a lab room. Although not every activity may require the use of technology, IPad use will greatly expand the range of data that students are able to collect outside of a traditional lab setting. Students will work in collaborative groups of two or three students and conduct activities around the science lab building, both inside and outside, extracting physics from general situations. The focus will be on students applying physics concepts to the world around them and giving them ownership of their investigations. This is a very different approach to the current labs that strongly focus on following step by step directions to verify and become familiar with physics concepts in a prescribed lab environment with specialized lab equipment.

Excluding general education classes, the physics introductory courses have the largest enrollments in the Physics Department. In fall 2014 these new labs will be implemented for the first semester of the trigonometry based physics series (PHYS 2010). At present the trig and calculus classes (PHYS 2010 and PHYS 2210) conduct the same set of labs and it is likely that in future years these new labs will be used in the calculus class as well. The combined enrollment of PHYS 2010 and 2210 each academic year is approximately 350 students, and includes majors from a number of different colleges that require these classes as part of their programs.

By the end of the spring 2014 semester an outline for the physics content of the six new labs will be established. During the summer semester new equipment (IPads, and accompanying software and probes) will be purchased, testing of equipment and procedures will be conducted, and lab instructions will be written for the six new labs. In the fall semester the lab manual for PHYS 2010 will be comprised of six current (old) lab reports and the six newly developed ones, roughly alternating each week. Students will conduct half of their labs in the physics lab rooms, using specialized equipment designed to make physics concepts more tangible for students. The other half of the labs they will use equipment such as IPads to study physics in more real world situations rather than the contrived lab environment.

At this time enrollment in PHYS 2010 and 2210 is limited by the number of students that can be accommodated in lab sections. For example, this semester the department has nine lab sections for these classes with a maximum of 18 students per lab section. Eight of our nine lab sections are either at or exceed capacity with up to 21 students in a lab section, which is not ideal. Both time constraints on the lab rooms and available faculty hours make it difficult to schedule additional lab sections. In addition to the pedagogical advantage that Phield Based Physics has in providing students with experiential learning, it also opens the possibility of accommodating up to twice as many students in the available introductory physics lab rooms in the future. Students could alternate conducting a lab in the lab room and conducting a Phield Based Physics lab, allowing for two groups of students to share the same lab space. As the physics labs are already at capacity and WSU enrollment is expected to continue to rise, this is a solution worth investigating.

Specific project details, including learning objectives, assessment and budget, are detailed in the sections that follow.

Description of the Innovation

New learning objectives that differ from current physics labs:

- Increase students' appreciation for the importance of physics for understanding our world. Students will see that general real world situations contain many of the physics principles they are learning in their introductory class.
- Improve students understanding of basic physics concepts such as velocity, acceleration, forces, energy, etc. By conducting experiments of their own and interacting with the data, students will improve their physics intuition and knowledge of these concepts.

- Students will learn how technology can be used to collect real time data from their surroundings. They will collect data, analyze it and make decisions to improve their procedures.
- Students will actively participate in the process of conducting science. Rather than following a predetermined set of instructions, students will have more flexibility and personal input into the experiments they are performing.

In addition these labs will still meet all of the learning objectives of the current introductory labs, such as students developing team work skills, physics intuition, verifying physics concepts, learning to analyze data through graphs and other techniques, etc.

Preliminary Evidence

"The National Science Foundation funded a study on the status, contributions, and future direction of discipline-based education research (DBER) in physics, biological sciences, geosciences, and chemistry…DBER is based on a 30-month study built on two workshops held in 2008 to explore evidence on promising practices in undergraduate science, technology, engineering, and mathematics (STEM) education…DBER combines knowledge of teaching and learning with deep knowledge of discipline-specific science content. It describes the discipline-specific difficulties learners face and the specialized intellectual and instructional resources that can facilitate student understanding." (http://www.nap.edu/catalog.php?record_id=13362)

In the section related to Physics Laboratories (DBER collection, pg. 130-131) a criticism of traditional physics lab manuals as not reflecting what scientists actually do is described. Scientists do not follow detailed directions to a predetermined outcome. Scientists design and conduct experiments, including making decisions about how to collect and report their data. Research has found that physics laboratories that are designed to allow students to be more involved in the experiment design result in students' having an increased ability to "design experiments, collect and analyze data, and engage in more authentic scientific communication" (DBER collection, pg. 31) as well as having a more positive attitude towards introductory physics labs.

Field work has been a central part of most Geoscience curricula for more than a century. Research shows that these field experiences can "positively affect the attitudes, career choices, and lower- and higher-order cognitive skills of student…, improve introductory students' understanding of the concepts…, and contribute to the development of teamwork, decision-making, autonomy, and interpersonal skills". (DBER collection, pg. 135)

Implementation

In fall 2014 the Phield Based Physics labs will be implemented in the first semester of the trigonometry based physics series (PHYS 2010). The enrollment for this class in the fall semester is typically 120 students. It is likely that this will be expanded to include the first semester of the calculus based physics

series (PHYS 2210) in future years. The combined enrollment for these two classes during each academic year is approximately 350 students.

Assessment

Informal formative assessment will be conducted during the actual lab periods to assess students learning, understanding and approach to the activities.

More formal assessment will consist of written lab reports and a practical lab exam that will be completed individually. The lab reports and lab final will consist of questions that assess basics physics knowledge, data acquisition techniques and understanding of the scientific inquiry process.

To get a measure of students' attitudes/understandings of the applicability of physics to real life and the process of doing and learning physics, we'll use the Maryland Physics Expectations Survey (MPEX): http://www.physics.umd.edu/perg/expects/ .

To determine improvement in students meeting the learning objectives of the introductory physics lab classes we will compare final exams and MPEX surveys for the trig based physics class (PHYS 2010) and the calculus based physics class (PHYS 2210) at the end of the fall semester. The calculus based class will be conducting labs in their traditional format.

Sustainability

Once new labs have been developed they can continue to be used in future semesters as part of our regular lab program. The Physics Department uses student lab fees to purchase equipment updates and replacement due to damage during regular use.

Similar labs could be developed for the second semester introductory physics lab courses through either a future grant or faculty sabbatical.

Budget

10 IPad Mini	10 x $400 =	$4000
10 PASPORT Airlink 2, Pasco	10 x $160 =	$1600
Capstone Site License, Pasco		$400
20 sensors, Pasco	20 x $200 =	$4000
Faculty supplemental pay 90 hours	90 x $43.525/h =	$3917.25
Faculty summer benefits	32% of $3917.25 =	$1253.52
Total		*$15 170.77*

Introductory physics labs typically have about 20 students per section. Although in the lab setting groups of three can work fairly well, it is preferable to have groups of two for the Phield Based Physics labs so that all students can be involved in the decisions, data collection and analysis processes. Thus we would have ten pairs of students per section. The IPad Mini will be used as the primary data analysis and storage tool. The PASPORT AirLink 2 (made by Pasco Scientific) is a bluetooth interface that is used to connect numerous Pasco sensory probes to handheld devices such as an IPad Mini. Pasco has a wide range of sensors that can be used to collect different data on motion, forces, sound, temperature, pressure, etc. Based on the final content of the labs we will purchase five each of four different probes, making a total of twenty. Probes range in price from $80 to $350, with $200 being a good approximation of the average price per probe. Capstone is the Pasco software that can be used on IPads or PCs to facilitate data collection and analysis.

90 hours of faculty supplemental pay, and associated benefits is requested for work conducted during the summer. This is 15 hours or work for each of the six new labs. It is fairly certain that the number of faculty hours devoted to this project will greatly exceed 90 hours.