

The two flavors of Physics 121 and 122

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Since Spring 2014, engineering and physical-science majors at UR have had the option to take introductory physics in either of two ways:

- In the UR **lecture-workshop format**, involving about 5 hours per week of lectures and workshops, with students assessed by performance on homework, midterm and final exams. To the Registrar this flavor is known as PHY 121 and 122.
- In the **mastery/self-paced format**, with the course content divided into distinct **units**. Students progress through the course by demonstrating **mastery** in the units, one at a time and **at their own pace**; they are assessed by the number of units mastered, and by performance on a final exam. Students are scheduled for the same workshop duration as in lecture-workshop format, but they are *offered* more extensive opportunities, as the course workshop is open to all comers, 40 hours per week. The Registrar calls this flavor PHY 121P and 122P.

For convenience, we will refer to these flavors respectively as **LW** and **MSP** in the following.

Both flavors involve the same laboratory experience, in which students are assessed by performance on lab reports which count as a portion of the course grade.

Why do we offer Mastery/Self-Paced physics?

The format of MSP instruction we are using has been tested extensively for the last four decades in university classes, and has been demonstrated to be **significantly more effective** than the traditional lecture/recitation format, by controlled experiments based upon both final-exam performance and persistence, after the semester, of student command of the subject.

- These studies have shown that, on the average, students improve by **tens of percentile points**. For example, students who would be in the 50th percentile in a lecture-recitation class improve to 75th percentile, on the average, in the equivalent MSP class. On the average, C grades turn to B, B grades to A, in MSP courses.

Note that this is *on the average*. Your mileage may vary, of course.

- The reasons for these improvements seem to be the requirement of mastery in topics taught in the course's units; the fact that individual students can spend more time, or less time, than average in mastering the units; and the large amounts of easy access individual help provided to students by MSP instructors.
- **We have verified this improvement, by conducting controlled experiments on our own classes, and publishing our results ([Masi et al. 2015](#)).**

Those interested in the details will find references to the published studies below.

What's it like? What do students do, in Mastery/Self-Paced physics?

Here's an outline of how the course functions.

- The course material is divided into **units** – perhaps 13 per semester, for each of which the instructors provide a study guide, textbook-reading and video-viewing assignments, and homework problems to use to prepare for the unit's **quiz**.
- Students can study in the **workshop**, in small groups or individually, with instructors facilitating and coaching. The workshop, which is in the same room all semester long, is usually staffed long hours by faculty, graduate and undergraduate TAs. In 2014-2016 PHY 121P and 122P the workshop has been open 2-10 PM, M-F. Students are required to go to the workshop time-span for which they registered, but at their option they can go at any other time they want, for however long they want, to work on preparatory problems and to receive small-group and individual instruction.

There are **no regularly scheduled lectures** in PHY 121P or 122P. Students in these classes are, however, free to attend the lectures in PHY 121 and 122, at their option. Starting with the Fall 2014 version of PHY 122, the lectures have been recorded with a multi-camera system, edited, captioned, and posted on the BlackBoard sites for both flavors of the course, so one can view the lectures, from the current year, and past years, at leisure.

- When a student feels prepared to demonstrate **mastery** in a unit, s/he asks an instructor to take a quiz. Early in the semester this request involves a **pre-screening** process. If the instructor is persuaded that the student is ready, s/he issues a quiz – which will be new to the student, even if the student has previously taken a quiz on that unit – and sends her/him to the nearby **quiz room**.
- The student takes the quiz immediately. These tests are designed to be finished in 15-30 minutes, and are proctored, but in fact no time limit is enforced. No notes or electronic devices are allowed to be brought into the quiz room; calculators are provided.
- Upon completion, the instructor grades the quiz immediately, in the presence of the student. In PHY 121P and 122P it takes a score of at least 85% to demonstrate mastery. The instructors retain the quiz, pass or fail.
- If the student does not pass, the instructor – **using this as a prime teachable moment** – discusses the concepts behind the quiz problems with the student, guides the student in avoidance of the mistakes s/he just made, and recommends practice problems...
- ...whereupon the student retreats to the workshop and uses the advice just received to prepare for another attempt: a different quiz on the same unit.
- There is **no penalty for failing a quiz**.
- When a student passes a quiz, s/he moves on to the next unit: studying, solving problems, and preparing again to demonstrate mastery in that material.
- Students repeat this process for each unit, **moving at their own pace**, until either they have finished each unit or the end of the semester arrives. They all take a comprehensive final exam.

- Students who begin to fall behind a pace that would lead to passing all the units by the end of the semester will have to face increasing encouragement by -- and offers of additional help from -- the instructors.
- Students who finish all the units before the end of the semester are free until the final exam; such students will thus have lots of extra time to devote to end-of-the-semester work such as papers and design projects.

Mastery/Self-Paced physics FAQs

- *Are PHY 121P and PHY 122P online courses? I didn't come here to take online courses!*

No they aren't, and we wouldn't ask our students to take one. In many ways MSP classes are the *opposite* of online classes, as they offer practically as many hours per week of face-to-face, individual attention as one could want. PHY 121P and 122P have websites (under BlackBoard) on which will be found many course resources, but these are not MOOCs and this is not the University of Phoenix.

- *If I lack self motivation wouldn't this class be harder?*

Self-motivation is crucial to success in *all* classes, not just mastery/self-paced ones. If you mean "won't this class be harder on me since I won't be forced by the lectures to stay on pace?", we would say No. If you attend the Workshop frequently the instructors will bug you, and help you, to keep up.

- *Mastery/self-paced instruction sounds a lot like "flipped classroom" teaching. Is it?*

It looks "flipped" primarily in the lack of lectures and the role of the instructors as guides and coaches in problem-solving sessions. The mastery and self-paced aspects are not native to the Flipped Classroom.

- *You mean to tell me that you would allow students to pass such classes without passing all of the units?*

Yes we would. And, as the studies show, such students *still* do better on the final than the students in the Traditional course, because in MSP courses students master what they pass.

- *What if a student exhausts the bank of quizzes for a unit?*

This is very rare, due to the personal guidance provided when a quiz is flunked. But the instructors would just make up additional quizzes.

- *Why is pre-screening necessary before I can get a quiz? That seems like an extra test before the real test.*

Pre-screening is not an extra test; it's what we call our protocol for a student to show the instructor that s/he has actually done the homework and is prepared to demonstrate mastery in that unit. Without such a protocol, many students are tempted to start taking mastery quizzes before they have mastered the material, trying to learn as they take multiple quizzes, and thus gaming the system in which there's no penalty for flunking a quiz. Studies have shown that the MSP method is much more effective when mastery is actually achieved by students doing their homework and discussing the material with their instructors and fellow students in the Workshop, and when the quizzes are just the *demonstration* of that mastery.

- Which faculty are teaching the two flavors of physics? Does the mastery/self-paced course get a professor?

In Spring 2016, PHY 121 will be taught by Prof. Yongli Gao, and PHY 121P by Prof. Steve Manly. Each will be assisted by a large team of graduate-student teaching assistants and undergraduate teaching interns. PHY 121P students will see Prof. Manly in the Workshop, and also are welcome in Prof. Gao's lectures, but are not required to go to the latter. Prof. Gao's lectures, and those by Prof. John Howell as recorded and captioned in Spring 2015, will be available in video form on PHY 121P's BlackBoard.

- Where can I find these controlled studies, and the data which show that mastery and self-paced instruction work?

To get you started, here is a paper in which are discussed 72 controlled studies of college classes taught simultaneously in our MSP format and the traditional lecture-recitation format:

C.C. Kulik, J.A. Kulik & R.L. Bangert-Drowns 1990, *Effectiveness of mastery learning programs: a meta-analysis*, [Rev Educ Res 60, 265](#).

"Our" particular form of mastery/self-paced instruction is called the Personalized System of Instruction (PSI), and is even better known in educational circles as the Keller Plan. Here is the article which describes the original course design and experimental studies:

F.S. Keller 1968, *Good-bye, teacher...*, [J Appl Behav Anal 1, 79](#).

And here is an article on the same method, as employed in primary schools (not universities!), from the *New York Times* last year:

T. Rosenberg 2013, *In 'Flipped' Classrooms, a Method for Mastery*, http://opinionator.blogs.nytimes.com/2013/10/23/in-flipped-classrooms-a-method-for-mastery/?_r=0

And we have done our own controlled experiments too. The results of our study of Spring 2014's PHY 121 and 121P were published recently in the refereed Proceedings of the American Society of Engineering Education (ASEE):

B. Masi, D.M. Watson, A. Bodek, D.A. Khaitan & E. Garcell, *Comparison of mastery learning and traditional lecture-exam models in a large enrollment physics course*. [Proc. ASEE 2015 \(ISBN 978-0-692-50180-1\)](#).

This is the largest controlled experiment we know of in the mastery-learning literature. The two classes were very nearly the same size, 163 and 165 at the end of the semester. They were statistically indistinguishable in terms of student math and science preparation, previous math/science achievements and [Basic Math Assessment](#) scores. They were given the same workshop materials and a common final exam. Thus any differences in the final-exam outcome can be ascribed to different effectiveness of the LW and MSP methods. These results are consistent with the previous literature and show that students, on the average, do significantly better in MSP. For example, the **students of PHY 121P scored 0.4 standard deviations higher** on the common final exam than the PHY 121 student. As a result the median letter grade in PHY 121P (A-) was quite a bit higher than in PHY 121.