Hi all, Thanks for the great workshop! Please see my responses below to some of your questions from before the workshop. Feel free to see these responses as part of a discussion - you can follow up with me at jfraser@seas.harvard.edu. -James

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>What 1 or 2 questions do you have after reading the above articles and/or watching the video?</th>
<th>If you were to apply the pedagogies described in the above articles and video, to a large-enrollment course you have taught (or will be teaching), what do you think will be the largest obstacle to overcome?</th>
</tr>
</thead>
<tbody>
<tr>
<td>40716.56615</td>
<td>how do people learn?</td>
<td>still how to assess effectively whether students learned?</td>
</tr>
<tr>
<td>40716.56689</td>
<td>There are several standardized tests that measure conceptual learning in a variety of topics: FCI, BEMA, etc.</td>
<td>The use of clickers (technology) seems to help to get direct feedback from larger groups. I don’t think that flash cards will work effectively with large classes. The answer variety is here restricted to two maximal three different answers. I don’t think handing out more than two/three flash cards per student is practical. Therefore the largest obstacle to overcome would be the lack of modern equipped classrooms including a clicker system.</td>
</tr>
<tr>
<td>40716.59693</td>
<td>JiTT and PI in conjunction with a web based feedback seems to be a good way to address specific conceptual problems in the upcoming class. Are there any specific tools available to create such a web based feedback system?</td>
<td>Check out the ILT (link on Compadre). Re: flash cards. I still prefer clickers but was impressed with what Ed could achieve with them. That really blew me away!</td>
</tr>
<tr>
<td>40716.67193</td>
<td>How to organize a class/lecture so that there is as little material coverage loss as possible, compared to traditional lectures?</td>
<td>Motivating students.</td>
</tr>
<tr>
<td>40716.83007</td>
<td>What specific tips do you have for finding the correct balance between how much time you devote during class periods to PI techniques and how much time you devote to explaining problems in a more traditional lecture style?</td>
<td>In a large class, I feel like the time required to carefully read through all the free responses given on the JiTT quizzes, correctly identify weaknesses, and adjust what content will be emphasized in class the next morning, is extremely demanding.</td>
</tr>
</tbody>
</table>
| 40716.88953 | From my personal teaching experience, I found that the students’ learning effect strongly depends on students’ self-motivation. So far students who are highly motivated, they will learn no matter how good bad you teach. So how do you motivate students who have very low motivations, especially for students from a regional community college. | two possible obstacles:
1. From the college where I am from, it is very likely that most of the students in my class will not do the pre-class reading, this will make the pedagogies not that effective for my students.
2. Now we only teach astronomy in a large class setting. How can I come up with good questions in Astronomy? A majority of astronomy materials are about facts instead of understanding..... |
| 40717.26281 | What are some strategies for keeping (roughly) to a schedule when so much of class is interactive. I don’t want to cut short useful conversations among small groups, but how do you know when to cut off the small group discussion and have students re-submit their answer to the question? | Choosing appropriate questions! I’ve been doing this for a while in astronomy and have figured out which concepts need to be tested and how to phrase questions, but I have not done this in physics yet. |

As a place to start, check out Eric’s book. I think telling students at the start of PI how long they will have is beneficial to them. Do not let it go to long, or it will drag. I would error on the side of cutting the discussion short for some students to make sure that you do not have a number of students sitting around waiting. Students will have time to discuss later (office hour, informally amongst themselves,).
| 40717.34632 | Is there a risk of losing coverage of material using the methods discussed by Dr. Mazur? My students have consistently asked that more problem-solving be done by me during lecture (probably in hopes that they will see very similar problems on tests). I fear that these methods, although extremely useful in teaching physics, will require cutting the amount of material covered significantly. If so, what do we cut and is that justified? | Probably maintaining order in the classroom during peer-discussion, and then getting the class back on track during instructor lecture. Going back and forth several times during a 55-min class seems logically difficult. |
| 40717.44948 | For coverage concern, see above. I have also always had students ask that "more problems be worked through" and think that your guess is right. For instance, when I provided more problems (with extra solutions) that students could work through on their own (or discuss with me during office hours), very very few of them used them. As for maintaining order, find what works with you. I use a mic even though I can be pretty loud. I also flash the lights to warn students to vote during very loud PI sessions. They tend to quiet down quickly when I show them the bar plot with their results. | |
| 40717.54792 | What happens after class? Are additional problems assigned as homework as usual? Who deals with questions students may have to solve more complicated or longer problems? Recitation and/or office hours time? | the pre-class reading assignments, although my hope would be that students would get used to doing this after trying it few times at the beginning of the course. |
| 40717.60419 | How do students perform in physics classes with "traditional methods" after taking a class with Peer Instruction? | |
| 40717.82 | How do students perform in physics classes with "traditional methods" after taking a class with Peer Instruction? How is problem solving incorporated into the course to prepare students for future classes that involve more advanced problems? | |
| 40717.87554 | Does it require the students some time until they realize that the PI-style lecture is not transferring knowledge, but that they need to get this from reading the book out of class? It seems to me that it might require students several weeks (and possibly even longer for some individuals) that this class differs from all the other classes they are used to. If so, how can one deal with it? I am wondering how one can implement the PI method effectively into recitations (which are led by TAs). Since the instructor usually brings in more experience and motivation than most TAs, it would be nice to have a way of using PI methods that requires less engagement of the teacher (in this case the TA), but nevertheless complements (rather than merely reiterates) what is done during the lecture. |
| 40717.87805 | The readings would usually involve example problems and students could ask that those be explored in class. The important thing would be to explore the concepts required for problem solving. This can include specific mathematical tools. I definitely think you need to address the particular conceptual challenges that your students have. Having them realize what their problems are and ask for assistance will make them much more receptive when you provide a "mini-lecture" on the concepts and techniques. | |
| 40717.89001 | How did students perform in physics classes with "traditional methods" after taking a class with Peer Instruction? | |
| 40717.91001 | The courses at my institution are at most 35 students so I do not know if they would be considered large-enrollment. I think the largest obstacle would be mathematics. Students at my school struggle with mathematics and not incorporating any problem solving in class would be trouble for the students that rely on seeing the mathematics done. The other struggle I would have is giving up the control in the classroom. This is obviously an important aspect, letting the students work through things, and it requires giving up some control in the classroom. |
| 40717.93601 | Does it require the students some time until they realize that the PI-style lecture is not transferring knowledge, but that they need to get this from reading the book out of class? It seems to me that it might require students several weeks (and possibly even longer for some individuals) that this class differs from all the other classes they are used to. If so, how can one deal with it? I am wondering how one can implement the PI method effectively into recitations (which are led by TAs). Since the instructor usually brings in more experience and motivation than most TAs, it would be nice to have a way of using PI methods that requires less engagement of the teacher (in this case the TA), but nevertheless complements (rather than merely reiterates) what is done during the lecture. |
| 40717.94801 | The courses at my institution are at most 35 students so I do not know if they would be considered large-enrollment. I think the largest obstacle would be mathematics. Students at my school struggle with mathematics and not incorporating any problem solving in class would be trouble for the students that rely on seeing the mathematics done. The other struggle I would have is giving up the control in the classroom. This is obviously an important aspect, letting the students work through things, and it requires giving up some control in the classroom. |
| 40717.96401 | How did students perform in physics classes with "traditional methods" after taking a class with Peer Instruction? | |
| 40717.98001 | How is problem solving incorporated into the course to prepare students for future classes that involve more advanced problems? | |
| 40717.A0101 | I can see how these techniques can be applied to introductory courses, but what about upper-division classes? | Student inertia. Students are used to the standard lecture model - it's what they're used to and it's comfortable. |
| 40717.A2101 | I have been using variations of the Peer Instruction method for two years in my classes. Although some students seem to gain better understanding of concepts in physics, many continue to show no improvement in their critical thinking skills. Slight modifications of a conceptual question or a different one clearly reveal that many students continue to lack the understanding basic concepts. Any tips on how to help these students? | I have found that the largest obstacle to overcome, regardless of the class size, is motivating students to do the work, to engage in active learning. I have spent a considerable amount of time explaining how important this is, as well as relating the topics to be studied with fields that students may find more relevant, always with minimal results. |
| 40717.A4101 | Does it require the students some time until they realize that the PI-style lecture is not transferring knowledge, but that they need to get this from reading the book out of class? It seems to me that it might require students several weeks (and possibly even longer for some individuals) that this class differs from all the other classes they are used to. If so, how can one deal with it? I am wondering how one can implement the PI method effectively into recitations (which are led by TAs). Since the instructor usually brings in more experience and motivation than most TAs, it would be nice to have a way of using PI methods that requires less engagement of the teacher (in this case the TA), but nevertheless complements (rather than merely reiterates) what is done during the lecture. |
| 40717.A6101 | Does it require the students some time until they realize that the PI-style lecture is not transferring knowledge, but that they need to get this from reading the book out of class? It seems to me that it might require students several weeks (and possibly even longer for some individuals) that this class differs from all the other classes they are used to. If so, how can one deal with it? I am wondering how one can implement the PI method effectively into recitations (which are led by TAs). Since the instructor usually brings in more experience and motivation than most TAs, it would be nice to have a way of using PI methods that requires less engagement of the teacher (in this case the TA), but nevertheless complements (rather than merely reiterates) what is done during the lecture. |
| 40717.A8101 | Does it require the students some time until they realize that the PI-style lecture is not transferring knowledge, but that they need to get this from reading the book out of class? It seems to me that it might require students several weeks (and possibly even longer for some individuals) that this class differs from all the other classes they are used to. If so, how can one deal with it? I am wondering how one can implement the PI method effectively into recitations (which are led by TAs). Since the instructor usually brings in more experience and motivation than most TAs, it would be nice to have a way of using PI methods that requires less engagement of the teacher (in this case the TA), but nevertheless complements (rather than merely reiterates) what is done during the lecture. |
| 40717.AA101 | Does it require the students some time until they realize that the PI-style lecture is not transferring knowledge, but that they need to get this from reading the book out of class? It seems to me that it might require students several weeks (and possibly even longer for some individuals) that this class differs from all the other classes they are used to. If so, how can one deal with it? I am wondering how one can implement the PI method effectively into recitations (which are led by TAs). Since the instructor usually brings in more experience and motivation than most TAs, it would be nice to have a way of using PI methods that requires less engagement of the teacher (in this case the TA), but nevertheless complements (rather than merely reiterates) what is done during the lecture. |

It is great that you have been applying these ideas already! Motivation is a challenge - one idea is to make sure assessment is aligned with your objectives. For example, make sure students see that reading directly benefits them on tests (questions that draw on the readings but NOT on topics covered in lecture). As for improving critical thinking skills, that is essential! Lecture time can only go so far - students need to practice on their own. Recitations, office hours, staffed help centers, or if these are not possible for you, in-class time for students to work through context rich problems in small teams, might be helpful strategies.
1. Is there a way to use these methods to teach derivations? Whenever I'm writing a derivation on the blackboard, I feel that no one is learning anything, yet I think it is important to understand how equations are derived.

I think the most difficult thing for me would be planning the class period with enough flexibility to be able to adjust on the fly based on student responses, and also to manage class time well enough to cover the essential points.

40718.37381

2. How do the JITT pre-class questions work for an early morning class? Does it work to have the questions due the day before?

With practice you can get very quick at moving back and forth between peer instruction and professor led discussion. Students love to see the histogram of results. I would usually not ask the same question that was used for the reading assignment in lecture, unless students got it mostly wrong. If that was the case, I would use some "easier" concept questions to build up to the more challenging question. Controlling seating positions is possibly beneficial, but in most cases, very disruptive. I have never done it.

40718.47799

3. Is there a way to use these methods to teach derivations? Whenever I'm writing a derivation on the blackboard, I feel that no one is learning anything, yet I think it is important to understand how equations are derived.

I agree, I think that passive students "observing" a derivation do not learn. Definitely derivations should be in the reading, and through conceptests and peer instruction, you can break down a challenging derivation into parts and focus on the steps students are having trouble with. As for JITT for an early-morning class, it is up to you when you make the "deadline". Some students will do the reading assignment early - I tend to use these responses more since I can review them and think about them when I am not rushed.

40718.37959

4. How do you encourage students to actively discuss the question if you are going to ask it again.

With practice you can get very quick at moving back and forth between peer instruction and professor led discussion. Students love to see the histogram of results. I would usually not ask the same question that was used for the reading assignment in lecture, unless students got it mostly wrong. If that was the case, I would use some "easier" concept questions to build up to the more challenging question. Controlling seating positions is possibly beneficial, but in most cases, very disruptive. I have never done it.

40718.47799

5. Do you really think that solving problems in class is not important?

It depends on what you mean by "solving problems in class". Many many studies show that very little learning happens when students passively observe an expert working through a problem. Have you ever turned to your class after laying out a beautiful problem solution, and asked them "are there any questions?" and gotten no response or perhaps a few questions from the same small subset of students. If you can turn the class room experience so that students are actively engaged in problem solving, then I think your students will be much better off. Don't fool yourself that "classroom discussions" make the experience active - the majority of students sit passively and observe in these situations.

40718.51992

6. Are the tools suggested in Just-in-Time teaching such as Interactive Learning Toolkit sold to students? That is, is it for profit?

Are the tools suggested in Just-in-Time teaching such as Interactive Learning Toolkit sold to students? That is, is it for profit?

40718.52554

7. Are the techniques of "Farewell Lecture" equally practical in a class of two hundred students as in a class of 15 students?

The ILT is free and you can sign up for access for you and your class. Definitely the techniques described work for smaller classes as well as large ones. Definitely finding the right mix is an important balancing act. That said, any mix that engages most of your students and has them participating as active contributors rather than passive observers, is a good mix!

8. How do I develop useful pre-class questions? I typically pick some easier questions out of the back of the chapter but the students still really struggle with them.

The students have stated that they want me to do a lot of problem solving, even though half of my current class is already dedicated to that. I feel like the students would still have that comment with this layout.

40718.55221
Re: working through examples for students. No matter how much you do this, students will ask for more! As someone else noted here, what they are really asking for is solutions similar to the ones that are on the assignment. They can then just solve the homework by pattern recognition and mimicry. So when students make this request, I say no and explain the reason for it: let's focus on the concepts in class, so that they are ready to attack the problems. Problems for the reading assignments should be challenging, and I like the fact that you say your students "struggle" with them. That is good! They will be ready to discuss in class! The preclass reading is only the first stage of learning so don't worry if your students are having problems with them. It is a problem if students find them so difficult that they do not even try. We grade on best effort. As for students convincing each other of the "wrong answer" or perhaps convincing each other of the right answer but for the wrong reason - make sure to provide closure to every conceptest so that students can hear what you say is the right answer and what your reasoning is for it.

This is a challenge - reading assignments that make them think about the reading are very important. Also remember that in many topics from first year, students have considerable background (even from everyday life) and so will have lots to discuss.

What are the key elements of ensuring effective peer instruction?

Devising good questions

I would like to hear more about the typical complaints students have and how you have addressed them.

You talk a lot about using your methods in the intro physics classroom. Do you have any pointers for upper level undergraduate physics classes?

- getting a buy-in from the students, especially from pre-meds who are worried about their MCAT prep and anything that could potentially be different from what they think is "right"
- the number of different questions/points of confusion, not being able to address all, and, as a result, many students feeling like they don't matter

Active engagement in lecture allows students to gain better conceptual understanding that they retain! This will be particularly valuable to your premeds! A possible complaint from students is that they want the teacher to be teaching them. I assure students that I like nothing better than lecturing - that it is really easy for me to do BUT I have learned (and many studies show) that lecturing is a severely lacking approach if STUDENT LEARNING is the goal. The only way for them to learn is for them to do the work. I as the instructor am going to help them as best as I can by focussing on the problem areas to help them where they need helping!

How many times do you have to teach the same class to achieve balanced material and comprehension? Any experience from other instructors who tried this method?

Harvard students are not exactly average...

Frankly, applying a radically new approach to teaching a large undergraduate class is a "high-risk" activity a for non-tenured faculty. Students may not appreciate it (for a variety of reasons) which will result in poor ratings for the instructor.

Students do not need to "understand" the prelecture reading - it is really there to "prime the pump" for learning. You do need specific tasks to ensure that the majority of students do it. The most successful implementation we have found is to ask students two concept tests and have them explain their reasoning, and also ask them what is the most important topic they are still having problems with. When students realize that their reading assignment questions are determining what gets taught in class, they start to appreciate them as being useful. This approach has been successful at a variety of institutions from two-year colleges to Ivy league.

Is it possible to mix the traditional way of teaching with the peer instruction, which means that in the test in addition to the multiple choice conceptual questions, you would also have problems that test the conceptual understanding and not require much math?

A lot of class time is still spent in "mini-lecture" but the difference with PI is that it is to respond to particular problems motivated by the students. In my experience, numbers and math can be part of conceptest, but be careful. If the question is asking students to "plug and chug", it will not generate good discussion.

How do you get students to talk to one another during peer instruction if the students are hesitant to participate, or already think that they know the answer? How do you get students to move their seat in the classroom occasionally, so they get to participate with other students?

The biggest obstacle that I've found in my first year of teaching physics/astronomy is that creating lectures are, of course, easier than incorporating something new. Finding time to thoroughly read the JITT answers and adjust my presentations have been difficult. So, how can this teaching method be streamlined from an instructor's point of view?
First of, time is a major concern!  I suggest focussing your effort on what has been shown to help and minimize time spent on other activities.  Take a good luck at everything you are doing with your course and be suspect of anything you do since “it is expected” or “standard”.  Of course, certain items like calculating final grades and submitting them are essential.  One major time investment I have often seen is that instructors are not happy with their text book so attempt to create lecture notes to supplant it or replace it.  I have seen this backfire (unfortunate students complaining about typos in the lecture notes).  No textbook is perfect.  JITT reading assignments allow you to determine what your students problems are which might be very different from what you think are the problems.  For a large class, you can sample responses to find out common concerns.  The ILT ensures comments from students who have not been responded to much come to the “top of the line” so that way you will have input from everyone in your class over time.  Having students move seats is really hard.  This year, we had an enormous lecture hall so we instead of trying to get students to move seats so they would be closer to each other, we “roped off” the back two-thirds and requires students to sit in the front 10 rows.  It worked well.

40719.19649
no question.

40719.59721
Is it practical to incorporate multi-step problems into this approach?

40719.62031
Have I been a complete failure as a physics teacher for the past year?

40719.70998
Can “Peer instruction” be used for introductory course of Modern Physics, which contains of relativity and quantum physics?

40719.72086
Re: time.  Please see above.

40719.74573
1. How does a professor compensate for external issues that influence a student's comprehension?  For example, suppose a student has a fairly good basic understanding of a concept in physics, but lacks basic fundamental skills/knowledge in mathematics that contribute to solving a problem correctly?

2. What is the best approach to determining an appropriate amount of material to cover during the semester while delivering deep on certain topics?

3. What grading model is used for class participation and attendance?

40719.79041
You have many important points.  Congratulations on your successes with nontraditional teaching approaches!  I hope the discussions in the NFW (and info on compare) helped you identify more JITT resources.  I do not have data about changes to student evaluations.  I will say that my personal experience is that if students believe you care for their progress, if you close the feedback loop to show students that interactive approach is working for them (showing increase in correctness gains, matching assessment on exams with in class and out of class learning), your evaluations will improve.  At the pre-tenure stage, I would not suggest trying to convince senior faculty that their approach is wrong.  I think most senior faculty would agree that a small group seminar is the best learning opportunity for students.  Through PI, you are attempting to create a “seminar-like” experience for students (students come prepared to class, all students are expecting to contribute, ...) even in a large enrollment class.

40719.20204
In my physics department, I am the only person who has been using PI techniques and clickers (based on Mazur's approach) in a calcu based E & M course.  [The other introductory courses are taught based on the traditional combination of one-way lectures + labs.]  At the personal level, I enjoy using the clickers greatly and found them to be very effective for establishing communication with students and learning about their psychology.  It was relatively easy to introduce and use them throughout the academic year.  At the end of the semester, I measured the pretest-posttest gain using a standard test (BEMAI) and obtained the value of 30%, pretty much as I was expected.  I had more difficulty with reducing the amount of required material or introducing a textbook that was designed according to recommendations of physics education. Potential changes in the curriculum can be a hard sell with the senior faculty. Our students are expected to learn how to solve physics problems, but PI leaves less time for teaching them how to do that during the lectures. I introduced additional help sessions dedicated to problem-solving, but this has generated negative feedback in students evaluations.

40719.20204
1. Where can I find JITT resources for intro physics courses, in addition to a small number of examples shown on the JITT webpage?

2. If interactive lectures do not discuss problem-solving with students, how do students learn how to solve them?

3. Mazur points out that students' evaluations of the instructor is a poor indicator of learning outcomes in the class.  Still, many school administrators take students' evaluations into consideration when deciding on faculty promotions.  What happens with evaluations of a typical instructor who switches from a traditional to interactive technique? Do they improve or become worse?

40719.21022
Relatively speaking, I think this will require more time.

40719.22086
For a calculus based course the conceptual questions gives students wrong perception of expectations on the exams.  Also, limited time in recitation does not allow for a lot of conceptual problems, since harder multi-step problems need to be addressed.

40719.40719
The largest obstacle to overcome would be spending the time to make the effort to change my teaching methods.

40719.41022
I wonder if students do not have a feeling that this kind of teaching is better for high school than for university?

40719.41722
My biggest concern would be that as an inexperienced teacher I would not be able to check a large number of homework and then prepare well for class.

40719.43022
I can understand your concern - I expect you have been working hard to teach well, but have used a traditional approach.  That effort will be very useful to you in an “interactive” approach.  Mini-lectures that you give in response to specific student problems will probably be directly taken from your current lecture notes.  To reduce the amount of time required, make extensive use of the materials available to you!  The end result is going to be a lot more fun than talking at a large group of students with minimal interaction.

40719.45022
I believe the hardest issues to overcome will be convincing students that this technique is beneficial to their understanding especially when they are accustomed to a professor regurgitating information in a textbook.  Another difficulty will be found in balancing allotted enough time for peer instruction and covering a suitable amount of material.

40719.46022
If students do not have a grasp of the basic concepts, is it right to jump into multi-step problems?  I think my mistake in the past was assuming that if students could do multi-step problems, they had the basic conceptual understanding.  This was a bad assumption. I would argue that basic conceptual understanding will make practice with multistep problems more effective.
1. How do you motivate your students to actually read the assigned material before the lecture, not just look for specific sections/paragraphs that seem to contain information they can use to answer the assigned questions? I can mention here a number of things here. 1. One big problem is student's inertia and laziness. In order for this technique to work students must be motivated and do all assigned reading on time. This might be difficult.

2. Another thing is that in order for this teaching methods to be effective you need to have your weak student learning from the strong ones. But this is very often the case (at least this is what I often see in my classes) that weak students tend to group together in the classroom. How to overcome that?

3. If the class size if large (about 100 students) then it is very difficult to effectively guide student's discussions.

4. And of course, these discussions are very time consuming. It is might be challenging to balance this time and the amount of the material covered during the course.

If students see that their input from the readings is really changing your lecture, and feel that their needs are been well served by this process, they will increase their effort in the readings. It also helps to test material that was in the readings but NOT covered in class (since students did not identify it as a problem area). I suggest doing this early in the term, in an early test or midterm. Be very careful in making assumptions about how you learned in class, and how your students learn. Ed is right - they are unicorns! If you are worried that your textbook is really lacking in a specific area, ask a reading assignment question on the topic. This will help students realize that it is a problem for them. Start off your discussion in class with a recap of their response ("only 30% of you got this right, so we really need to deal with this problem"). Give a mini-lecture about the problem or even start with a concepttest to remind students about this problem, and then mini-lecture. Get them to interact. They will learn much better if they have already identified it as a problem for themselves. With PI, do I work through a proof or multi-step derivation in class: no. Should you explore the "hard parts" of an important proof in lecture - definitely!

Students do have different time pressures but I think something like PI provides them with organization for the goal of achieving deep learning. This takes time! I also think your second question is really important since I think PI is all about making use of time better. Since you are covering only topics that students' raise as a concern, you are really providing targeted teaching where students need it! I do not have grad students in my class during PI, but I certainly roam the room looking for quiet students.

1) How do you handle the situation of only a small number of students coming to class prepared?

2) What separates a good PI question from a bad one? I have two questions regarding the logistics and implementation of JITT. First, the example provided did not go into enough detail regarding the nature (and range) of questions asked. Are these essentially the same as ConceptTests, only with the multiple-choice aspect removed? Or are these generated uniquely each semester for the current batch of students? (Or both?)

Second, I am still shaky about the implementation of JITT. The reading indicates that the answers from the JITT are reviewed 12 hours prior to class (or starting 12 hours prior and leading up to class). With a class of ~200 students and ~3 JITT questions/students, how much time does it take to review the resulting ~600 answers? Is JITT done for each class period? I think the most challenging aspect of the implementation will be to review all the answers from the JITT assignments in order provide a tailored learning experience for the students. However, an extremely close second-most-challenging aspect for me will be the creation of JITT and PI questions that are both challenging and instructive.

RA questions can be reused from year to year. Use what resources you have to make them. I think they should require more thinking than a concepttest, and include a free response for students to "explain" their answer. The most valuable question is the third question which is always the same "What did you find most confusing? If you did not find anything confusing, why did you find the most interesting? Please explain." In terms of time management, using the ILT I can sample student responses, and it will bring to the top of the column students who have had less response from me. That way students are routinely have interaction with me (but not every class).

How much time do students take to complete the JITT pre-class assignments? It is important to stress that you do not expect students to "understand" everything in the reading assignment. The point is for them to identify one or two things they would like help on (in lecture). PI with JITT requires students to spend more time before each class, but hopefully less time is required for doing assignments and preparing for tests.

Selling this pedagogy to the students seems critical both in terms of keeping enthusiasm up during class and in terms of their satisfaction with the class and with me as the instructor.
How do you choose what questions to cover in the classroom?

I have a comment, not a question. Two of the ideas that Professor Mazur mentioned were very helpful to me. One is that he takes notes for students’ wrong answers for the source of making good questions. The other is the open-book tests that he decided to incorporate in his assessments. Both of them requires time and effort on the instructor’s side, but it helps student understanding.

I have a comment, not a question. Two of the ideas that Professor Mazur mentioned were very helpful to me. One is that he takes notes for students’ wrong answers for the source of making good questions. The other is the open-book tests that he decided to incorporate in his assessments. Both of them requires time and effort on the instructor’s side, but it helps student understanding.

I have a comment, not a question. Two of the ideas that Professor Mazur mentioned were very helpful to me. One is that he takes notes for students’ wrong answers for the source of making good questions. The other is the open-book tests that he decided to incorporate in his assessments. Both of them requires time and effort on the instructor’s side, but it helps student understanding.

I have a comment, not a question. Two of the ideas that Professor Mazur mentioned were very helpful to me. One is that he takes notes for students’ wrong answers for the source of making good questions. The other is the open-book tests that he decided to incorporate in his assessments. Both of them requires time and effort on the instructor’s side, but it helps student understanding.

I have a comment, not a question. Two of the ideas that Professor Mazur mentioned were very helpful to me. One is that he takes notes for students’ wrong answers for the source of making good questions. The other is the open-book tests that he decided to incorporate in his assessments. Both of them requires time and effort on the instructor’s side, but it helps student understanding.

I have a comment, not a question. Two of the ideas that Professor Mazur mentioned were very helpful to me. One is that he takes notes for students’ wrong answers for the source of making good questions. The other is the open-book tests that he decided to incorporate in his assessments. Both of them requires time and effort on the instructor’s side, but it helps student understanding.

That is going to be problematic. What would be really interesting would be an analysis of why it failed. I have experience with two courses where PI or a variant of it “failed” and I as an outside observer can point to certain problems in both cases. In one, the obvious hesitations on the part of the instructor to reduce their role of lecturer led to a lot of lecturing and students began to wonder about the value of PI. It was a downward spiral. Another case, initial reluctance on the part of the students to doing the prereading led the instructor to attempt to teach all the material, which encouraged students to NOT do the reading. Perhaps in your dialogue with fellow faculty members you might want to jointly discuss research results that showing interactive teaching, when done correctly, makes dramatic improvements to teaching. You would think this approach would bear fruit except it is easy to “criticism” PER (“Our students are different.” “That approach will not work here.” “That was tried and didn’t work.”...). Perhaps the best way is to have students complete something like pre and post PCI. When an instructor sees a gain of only 20% on such easy material, it is hard for them to maintain that their traditional teaching is optimum.

The technique of JIT and PI as described in the articles and video is very much aimed at large enrollment introductory physics service courses. While this does typically represent the bulk of the “students” taught, it is not always representative of the classes that the bulk of the “teachers” are teaching. In major or even graduate classes (average of 20 student) the practice of lecturing is just as widespread, and JIT and PI probably have to be adapted to be effective in those contexts. Students are (I think) by then past the conceptual stage, and the goals of the advanced courses are often exactly the learning of problem solving depending on the students’ conceptual understanding, and assuming 5 concept tests with between 2 and 7 minutes depending on the outcome, leads to a third more (or less) time available per 1:30 hour lecture. Although I assume that this will average out over a semester, it still has the possibility of completely messing up the schedule of the course.

With JITT and PI, you cannot cover all the material in lecture - this would backfire dramatically. Let the reading assignments “cover” all the material, and spend class time on the particularly important concepts. I am not sure if I agree that students in major or graduate classes should not be concerned with underlying concepts. If I grab my Milonni and Eberly “Lasers” text (from sr level course), I see many important concepts like dispersion, polarizability, etc. that are important to understand to be able to understand the field of optics and lasers.

I’m interested in the ILT software: how difficult/tedious is it to implement and use? I currently use Blackboard and the iclicker software, and find that they work, but not efficiently. I feel like I spend so much time setting up and deploying tests, etc.

Getting students to talk to me and to each other effectively.

Check out the ILT software online - it is easy to sign up. It is optimized for PI and JITT so at least you will be better off than Blackboard/Moodle/etc. I think getting students to talk to each other effectively is extremely important. One very basic problem is time on task: you can set certain expectations that all students will be contributing early and then during PI, move around the class to reinforce those expectations.

My main concern is how to implement such teaching strategies in upper division and graduate courses, where the students may feel that forced assignments for every lecture is paternistic. I used flash cards in my last class and found them to be a bit awkward. I definitely preferred using the clickers, but once again a graduate class I think that the students would revolt if I asked them to pay $40 for a clicker.

As illustrated in my questions above, I think that the biggest issue that I worry about is how receptive the students will be to the change in pedagogy.

I think the way Ed used flash cards in the NFW showed how a master can use them very effectively. As for clickers - at least students can resell them at the end of term.

- Can you use it with any (or most) standard textbook? Students tend to get upset if you teach stuff not covered in the textbook. Calculations...?

- Seems like JITT and PI focuses most on conceptual understanding. How do students develop quantitative skills, apart from just getting familiar with the type of teaching and knowing how to find the right material in the question bank, I think the hardest part will be to find the time between the students submission time (midnight?) and lecture time (could be 8 or 9 am) to go through the answers and have time to prepare the topics where the students struggle the most and pick the best clicker questions. But I guess that would become easier the more times you’ve done it...
It is easier with practice. Also, you can start sampling student responses before the deadline. I think that with JiTT you would have to be very careful of teaching material beyond the textbook (since the reading assignments define the topics covered). Perhaps you could do this with additional readings that you could provide in pdf format so students would have access to them before the class. WRT student time: if they see the time preparing as an investment to reduce the time required to do the problem sets and prepare for tests, your students will grow to demand JiTT. As for quantitative/calculation/multistep problems, which are very important, the best way for students to learn these skills is by practice. You do need to help them create the right conditions for success. Part of this is ensuring that they have appropriate conceptual understanding before they start doing the homework. I think that often my students would just attack the homework problems without reading the text, without "learning" the topics covered in lecture. They would employ strategies that got them to the desired end: find a similar problem and solution and mimic it, or ask a friend to explain to them how to do the problem. By helping them learn the underlying concepts, they are much better prepared for the assignments.

40720.82554

I'm curious: how does JiTT and PI apply to graduate level classes? I can see how some aspects carry over easily, but it's not clear to me whether tedious but necessary derivations, for example, are meant to be just pushed into reading assignments?

40720.85211

1. When I have tried to hold breakout sessions with students in my classes (not in nearly as organized a pattern as Dr. Mazur now uses), I feel like the class devolves and no learning takes place. It is chaotic, but not a good kind of chaos. Students will start to talk about sports or will fight together. I do realize that I need to do a better job of helping the students to see the connection between the breakout session and their learning (and performance on an exam). One part of my question then is, how do a do a better job of making that connection? The second part is, how does peer instruction alter if the students you have are not Harvard students. There is a difference between a class where virtually every student in it was a top student in high school, and a class with all ranges of students, some who really don't care what grade they get as long as they don't fail.

40720.85784

Great questions. I do not have good data to answer them. We are far off from every student in a science curriculum having JiTT/PI courses. I see my additional structuring of their time as a way to help them manage their time more effectively (and drop-out rates are lower). Frankly, I am not trying to steal time away from other courses, but have students invest time early in the term and all through the term, then just during midterm weeks and finals. As for upper year courses, the evidence is slowly coming out showing improved conceptual learning in higher level courses taught with interactive teaching techniques. As for resources: a text book that you split up into reading assignments, reading assignment questions, and a selection of concept tests that you have at your disposal ready to go. Avoid making your own if time is an issue for you (and of course it is!)

40720.859392

I think it is important that students are held accountable for being productive in peer instruction. With clickers, they know you have a record of whether they were right or wrong. With flash cards, they are forced to commit to an answer (that you see). I have used breakout sessions where students need to submit a one line answer with their names on it that I then mark quickly (out of 3). It needs to have a clear goal that students need to respond to. It can't just be an "opportunity for students to improve their learning". Also, be very careful about giving too much time. It is better for students to feel rushed rather than that they have lots of time. More successful PI instructors wander the room and interact with students to make sure they are on track, but also to show that they care about what is being discussed. Finally, you might want to consider assigning groups.

40720.93661

I have found MUCH more discussion with students immediately after class with PI. Some students come to argue with me about the answers to the concept tests, because they thought they understood this stuff, but they got it wrong. They try to impose JiTT on a single section of a class with multiple sections is not something I would do. It takes a bit of time for students to see the benefit of JiTT and it would be too easy for them to back out early (switch sections). That said, even in such a case, you should employ interactive engagement techniques as much as possible, that involve all the students.

40720.89392

Is there any evidence that instructors with generally bad student evaluations gets significantly improved scores from students and more confidence that learning was finally happening after applying pedagogical methods described here?

40720.89392

Sorry I do not know of such data. I agree that heterogeneity of the classroom is a challenge. That said, but employing a "parallel" teaching structure like involved with PI (many conversations going on at once), learning is improved for most students.
Positive feedback to help students see that the process is working for them will help keep students motivated. As a strategy to dealing with JITT responses, sample a few of the early responders ahead of the deadline to get a sense of where the discussion is headed. You will never be able to read all 350 but if you can sample them in such a way that you directly respond to every student in a regular fashion, the students will keep doing the assignments.

<table>
<thead>
<tr>
<th>40721.15804</th>
</tr>
</thead>
<tbody>
<tr>
<td>I'd like to know more about the ILT software -- in particular I like the idea that cell phones/laptops etc can be used to poll students in class. Last semester I used the iclicker system for that purpose, but reducing the gadgetry that I and the students have to have in class is certainly appealing. My only concern is that while I can ask students to purchase an iclicker for this class (they tend to use it for multiple classes anyway), I cannot ask them to purchase a laptop or a smartphone. Is this a difficulty you encountered? Students being able to use their neighbor's laptop to answer a question seems like the only option.</td>
</tr>
<tr>
<td>Last semester I thought a large enrollment class (~260) for the first time. I had tried to generate some peer/class discussion around concept questions. I found that the biggest difficulty for me was generating good questions. They would typically either be too hard or too easy. Hence only a minority of them generated any decent discussion. Test banks (as mentioned in this article for example) are of course a great help here. Having students answer a few questions ahead of class (JITT), would certainly help me in writing/selecting the questions for discussion in class.</td>
</tr>
<tr>
<td>The ILT is not a classroom response system. It is best for managing JITT assignments, distributing lectures, etc. There are several products already on the market that make use of iPhones, etc. but I am not sure if your student population all has the appropriate technology. That said, here at Harvard in a class of about 90 students only 2 or 3 did not have a device. We had on hand some touchscreen units that were lent out (in exchange for student's id card) to students who did not have appropriate hardware. I think web enabled cell phone usage will become ubiquitous within our student population but I am not sure if it is there now. About concept level of difficult, I agree with you. I really like Eric’s collection in his Pi book (in pdf format on the CD). I will mention that I have often used questions that I considered &quot;too easy&quot; but found them very useful.</td>
</tr>
</tbody>
</table>