Innovative Teaching Strategies for Large-Enrollment Science Courses
(Reviews available at: http://tiny.cc/large_course_strategies)
Focus on: Just-in-Time Teaching

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Just-in-Time Teaching (JiTT) is a general term for several flexible strategies in which an instructor is able to identify students’ prior knowledge (from previous courses, the media, assigned readings, etc.) and then adapts his or her instruction accordingly. Based on the model of a feedback loop between out-of-class assignments and subsequent class activities, all strategies include students completing online assignments through a course learning system, such as UCSC’s eCommons, 1-24 hours before coming to class. Time in class is then used for lectures and activities which incorporate students’ answers or questions, and often includes discussion which helps to solidify students’ understanding (Simkins & Maier 2004). According to instructors who have used JiTT and published on their research, goals include:

- increasing student learning
- increasing student engagement and motivation
- encouraging students to study and prepare for lectures
- informing instructor of students’ learning
- increasing student attendance.

Evidence for Effectiveness of JiTT

Instructors utilizing JiTT have noticed an improvement in students coming to class prepared and able to demonstrate a greater understanding of the material on exams.

- Improved learning
  Student scores can dramatically increase, as demonstrated through pre-course and post-course tests. While all students should do better on the post-test, average improvements from pre-test to post-test on multiple-choice concept inventories are greater in JiTT courses than in non-JiTT courses (for example, 27\% vs. 16\% in Henderson & Rosenthal 2006). Others have shown that students perform better on exam questions relating to JiTT activities than questions with no such associated activities (Moravec et al. 2010). Also, the development of critical thinking skills may be better in JiTT courses; one study found that 61\% of students showed evidence of developing “Newtonian thinking” skills in a JiTT Physics course, whereas 7\% did in a similar non-JiTT course (Novak 2011).

- More engaged attitude and better preparation
  Students in JiTT courses report: improved attitudes towards learning the material, improved study habits (less cramming), improved preparation for lecture classes, and more useful perception of class time (Marrs & Novak 2004; Guertin et al. 2007; Brewer 2004; Novak 2011). When students see their own work presented in class, they feel a greater sense of ownership over their learning; they are more likely to do the JiTT assignments and participate in class (Simkins & Maier 2004).

- Informed teaching
  Ever wonder if your students are “getting it” before they take the exam? JiTT is a form of formative assessment (assessment explicitly designed to quickly inform instructors how to improve instruction) that tells you this frequently throughout a course. This is a low stakes situation for students, and gives you the feedback necessary to decide if you should re-teach a concept or move on.
• Increased attendance

Instructors report increased attendance at lecture sections when using JiTT. While most of this is anecdotal, one study reports attendance increasing from <50% to >80% after JiTT was introduced (Novak 2011). Instructors also note a higher class retention rate (Novak 2011).

JiTT Activities

• **Warm ups or Reading Incentives** (as in Marris & Novak 2004; Crouch & Mazur 2001)

Students complete weekly open-ended, constructed-response questions, such as “What is the difference between...?” “What happens if...?”, “In your own words, explain...” and “What did you find confusing?” These short answer questions are used to identify student beliefs, preconceptions and prior knowledge about the upcoming lecture(s). For example, “Why do you think chemotherapy drugs, which are given to fight cancer, cause a person’s hair to fall out?” connects mitosis to cancer and chemotherapy (Marris et al. 2003).

• **xBytes** (as in Brewer 2004; Guertin et al. 2007)

Replace “x” with the subject at hand (e.g., Biology → BioBytes). Students answer questions based on the reading assigned for upcoming class period or on previous class sessions. Questions can be short-answer or multiple-choice. In addition to answering the question, some instructors ask students to rate their confidence in the answer (high, medium, low) to stimulate metacognition (reflecting on learning). After students answer multiple-choice questions, the course management system may display a histogram of student answers, in order to emphasize that popular answers aren’t always correct, but should not give correct answers until the next class meeting after responses are due. An example multiple-choice question asking students to reflect on what they had just learned in lecture or a reading about plant populations is: “You are interested in determining whether individuals in a plant population were experiencing pollen limitation. What would be evidence for this? A) Plants in a population don’t produce many seeds. B) Plants in a population produce selfed seed. C) Plants in a population produce more seed when given experimentally supplemented pollen compared to plants that are naturally pollinated. D) Plants are pollinated by generalist pollinators. E) None of the above” (Brewer 2004).

• **Reading questions** (as in Henderson & Rosenthal 2006)

In response to students not reading prior to attending lecture, these assignments motivate students to come prepared so that lecture time can be spent on more in-depth content. After reading the assigned text, students submit a question they had about the topic (usually once per week). The types of questions students ask give the instructor a sense of what students easily understand (and can be passed over quickly in class) and what is really confusing students (and should be the focus of class). For example, “I didn’t understand the minus sign in equation 15” is a poor question while “The minus sign in equation 15 doesn’t make sense. The sign should describe the velocity of the ball (Figure 12), and because the ball moves in the positive x direction I think the sign should be positive” is a much more thorough question demonstrating why the student need clarification (Henderson & Rosenthal 2006).

**How to Use JiTT** (xBys, Warm Ups, modified from Novak 2011)

1. Think about the goals of the reading, previous lecture, and/or upcoming lecture. Do you want students to review previously-learned material from your or another course? Are there new concepts, examples, or skills you want students to think about before coming to lecture? What are the most important and most difficult concepts in the lesson?

2. Carefully design question(s) that probe for understanding and (continued) preconceptions. If your questions have right and wrong answers, the “wrong” answers should be plausible and reveal common student preconceptions. Categorizing your questions as factual recall, conceptual understanding, or application will help you increase the number of conceptual and application questions you use (Brewer 2004). Feel free to include or link to other resources, such as databases, websites, photos, graphs, etc. and
focus on local information or current events that may not be included in textbooks. Set up your question(s) using eCommons’ Quizzes and Tests tool (instructions at: http://its.ucsc.edu/ecommons/documentation/instructor/).

3. Generate your own anticipated responses and use these to outline your lesson, but be flexible enough to incorporate actual responses.

4. Just before your class, go through some or all student responses (15 - 45 minutes, depending on class size); Google Forms conveniently displays output as a spreadsheet, as does a paid account on Survey Monkey. Use the students’ responses to modify your lesson.
   a. Select representative examples for discussion and weave them into your lesson. You can demonstrate how to learn from an incorrect answer.
   b. Identify what needs further clarification in that day’s class and adjust the upcoming lecture accordingly.
   c. Be sure to go over correct answers if you gave a multiple choice question.

   “JiTT has to be adapted to one’s teaching style, not just blindly adopted as a teaching technique. There is no one-size-fits-all method!” (Novak, 2011)

How to Evaluate JiTT Activities
• Instructors have assigned JiTT related assignments anywhere from 5 - 30% of the final course grade. Some anecdotal evidence suggests that students don’t take the assignments seriously or put much thought into responses if the assignments are worth less than 10% of the final grade.
• Responses can be graded for just participating (easiest) or for correctness (easy with multiple choice, more subjective and time consuming with reading questions or open-response). If you want to grade for correctness, you may reduce time required by grading a random selection of questions for all students or a random selection of students for each question.
• A typical grading scheme for “correctness” of short-answer questions include: 0 = no response or completely wrong; 1 = tried, but minimally accurate; 2 = some accurate knowledge and use of correct terminology; 3 = complete and correct response using evidence incorporated from the readings (Guertin et al. 2007).

Class Time Requirements
There is a wide variety among practitioners of JiTT in the amount of much class time used by JiTT activities. There is a consensus that the same amount of content is covered throughout the course, as students are coming to class with the basic knowledge already in place, requiring less class time to cover those topics. In this way, JiTT actually saves class time because many of the fundamental concepts for lecture have already been introduced to the students. Two strategies for using students’ online responses in class include:
• Modified discussion section (Henderson & Rosenthal 2006; Marrs & Novak 2004): spend time (20 minutes) at the start of lecture for students to discuss and compare 2 carefully chosen constructed response answers (names removed) through think-pair-share (SERC).
• Replace a lecture (Guertin et al. 2007): once a week, discuss student responses and do a follow-up active learning activity, such as solving a problem or analyzing a case study in groups.

Remember: these aren’t just homework assignments. The student responses must be addressed somehow in your lecture.
Want more info?

- Great description, example questions, and more at: http://serc.carleton.edu/sp/library/justintime/index.html and http://jttdl.physics.iupui.edu/jitt/

References