This chapter gives an overview and implementation guidelines of Just-in-Time Teaching, an interactive engagement pedagogy used across the disciplines and across the academy, now in its 14th year. The pedagogy has proven effective in improving classroom climate, student motivation and fostering deeper learning.

Just-in-Time Teaching

Gregor Novak

Tell me and I forget. Teach me and I remember. Involve me and I learn.

-Chinese Proverb as quoted by Benjamin Franklin

At Indiana University David Pace teaches a course titled *Visions of the Future: A History*. To get productive participatory class time with engaged students he asks students to ponder a preparatory question and respond to him electronically shortly before coming to class. For example:

*Imagine that you were preparing to write an essay in response to this question:*

"The development of new types of futures in the late 19th and early 20th century science fiction represented a major break with the kinds of visions of the future that had dominated Western culture since the triumph of Christianity in the Roman Empire. The grand moral perspectives that had characterized older Western futures were replaced by adolescent fantasies that had no higher purpose than attracting an audience."

A. Describe in your own words what this question is asking you to do.

B. From the three choices below identify the position you would take, if you were actually answering the question.

1. The quotation is essentially correct, and I would present evidence to convince my readers of that fact.
2. The quotation is essentially incorrect, and I would present evidence to convince my readers of that fact.

3. The quotation is partially correct and partially incorrect, and I would present evidence to convince my readers of that fact.

C. Very briefly present three bits of evidence that you would use to support your position and explain after each how it would make your case more plausible.

David Pace practices JiTT, Just-in-Time Teaching, a pedagogical technique used across the academy (Simkins & Maier 2009.) Note the main features of the Pace’s JiTT pre-class warmup.

- Students are presented with a slightly provocative and memorable statement that is open to a considerable amount of interpretation.
- The first task is for each student to rephrase the question in his or her own words. The responses will tell the instructor how students interpret the assignment.
- Students must take a stand and justify it. They must examine prior knowledge, consult the course resources, and perhaps discuss the issue with classmates.

All this intellectual activity happens before any formal instruction.

JiTT Basics

The heart of JiTT pedagogy is web-based pre-instruction assignments called warmups, with some colorful local variations such a GeoBytes in a geology class (Guertin 2007). Students take a stab at responding, and go to class with genuine interest and desire to find out the answers. The questions are a bit vague, open to interpretation and, when fully explored, require fairly complex answers. Typically, students approach these questions with somewhat limited prior knowledge. Their responses form the stub on which they eventually build a more complete understanding, possibly approaching that of an expert on the subject. Students submit responses online just a few hours before class time, giving the instructor just enough time to incorporate the insights gained from them into the upcoming lesson. Exactly how the classroom time is used depends on a variety of issues such as type of course, class size, classroom facilities, and student and instructor personalities.
Instructors and students become a teaching-learning team, ready to begin the lesson with an awareness of the mental status of the class, making the learning experience as relevant as possible to a particular class at a particular time. What happens in the classroom consists of a mix of pre-planned activities and creative improvisation suggested by student responses and guided by students’ in-class reactions to thoughts and opinions in those responses.

Over the JiTT’s 14-year evolution practitioners have enriched the practice borrowing eclectically from many current learning theories and instructional techniques (Bransford 2000). Particularly relevant are research into the ways students learn by weaving new knowledge into existing knowledge (Scott 1991) and work that concerns itself with students’ motivational beliefs and with the effects classroom contextual factors on learning (Beghetto, 2004).

JiTT is a web-based pedagogy, but it definitely is not distance learning or computer-aided instruction. All JiTT instruction occurs in a classroom with human instructors. The web materials, added as a pedagogical resource, act as a communication and organizing tool. Because most of the learning occurs outside the classroom, JiTT practitioners view their pedagogical strategy as feedback loops between teaching and learning and between in-class and out-of-class experiences.

The student-student, student-teacher interactions, and time-on-task, the top three critical factors contributing to success in college, identified in Alexander Astin’s (1997) 30-year study, are enhanced immensely by technology. Timely web assignments prepare students and the instructor for subsequent in-class interaction, give students some control over their learning, and enrich the in-class meeting.

**Implementing JiTT Successfully**

*The most profound effect comes in changing the way the instructors think about their own teaching, and more important, the learning of their students.*

Simkins and Maier (2009, p. 135)

A JiTT–based course differs from a traditional lecture-based course in two significant aspects. First, having completed the web-assignment, students enter the classroom with a good start into the learning process.
The instructor, having read the responses, also has a good sense of the state of the class. This preparatory process makes the unknown unknowns into known unknowns, to paraphrase Donald Rumsfeld.

Second, starting the lesson this way invites students to assume some of the ownership of the process. Because student responses to a well-posed JiTT question will be presented for the live classroom discussion, at least a part of the interactive lesson will feature students’ own wording.

There is much flexibility in constructing and using JiTT assignments. The variety across the disciplines is mutually enriching (Simkins & Maier, 2009). However, all implementations of JiTT satisfy two criteria:

1. Faculty thoughtfully construct assignments based on validated education research and
2. Student responses constitute an integral part of the lesson not merely an add-on.

JiTT encourages all students in the course to participate in and reflect on the learning and teaching process; appreciate perspectives other than their own; apply concepts as they learn them; and connect these to other parts of the course, other courses, and the wider world. JiTT encourages instructors to show interest in the useful mistakes students make and offer corrective support; model how to learn from mistakes; allow multiple attempts at learning tasks without severe penalties; give credit for making progress in learning course content not just for completed work; and foster a community for mutual help, which involves students and the instructor in a team effort.

**Developing a JiTT Lesson.** Preparing a lesson for any JiTT-based course typically follows five steps. In general, JiTT teachers should:

1. Think about the lesson content and the lesson type. Is it an introduction to a new topic or a continuation? Is the primary purpose of the lesson to explore conceptual issues or to develop and practice procedural skills? Does it involve laboratory or field work? Is it a comprehensive review?
2. Identify the lesson parts. Does the topic involve a single concept, multiple concepts? Is a review necessary? Will it include demonstrations or hands-on activities? How are the parts to be sequenced? How much time is to be devoted to each part?
3. List the new concepts (words, definitions, examples.) If mathematics is involved, list the prerequisite skills and equations.
4. Design a set of questions that probe for the understanding or misunderstanding of the concepts. If the lesson is part of a sequence, design questions that require application of knowledge acquired in previous lessons. Ideally, the question set is broad enough to enable construction of the lesson content from student responses. Anticipate the responses. When the submissions are in hand, look for well articulated versions of the arguments you anticipated as well for surprise responses.

5. Using the anticipated responses as a guide, outline the lesson flow, but be flexible enough for surprises.

A good JiTT question is broad enough to elicit individual idiosynchratic student responses to enrich the classroom discussion. It requires an answer that cannot easily be looked up and it encourages students to examine their prior knowledge and experience. The question demands that students formulate their responses, including the underlying concepts, in their own words and is ambiguous enough to require that they supply some additional information not explicitly given in the question. (This feature enriches the subsequent classroom discussion. Grappling with the pre-class questions prepares students for a discussion of a complex, possibly controversial topic.)

JiTT questions can be constructed to help students deal with jargon and academic language. Formal academic language can be a serious barrier to deeper learning (Snow, 2010). In many subjects, dry definitions of technical terms and complex concepts leave students disinterested at best and often perplexed and confused. For example, consider the following question:

\[ \text{Please explain in your own words what a focal point is, without referring to any particular device. (from Andy Gavrin)} \]

Pre-instruction questions may also explicitly encourage reflection and metacognition. For example:

\[ \text{Explain in simple terms how you solved warm-up #1. In particular, what questions did you ask yourself and what conclusions did you draw from the answers? (from Bob Blake, Texas Tech University)} \]

In addition to the disciplinary education research literature there are many theory-based resources that are useful when preparing a JiTT lesson. For example, Bransford et al.’s (2000) well-known treatise, *How People Learn: Brain, Mind, Experience, and School* provides a good starting point. Also helpful is the literature related to Bloom’s taxonomy and learning styles issues. For example, you may wish to consult
After Student Submissions Have Been Collected. The variety of interesting student responses typically falls into a fairly well-defined set of categories. I have found the following guidelines useful for incorporating student responses into my lectures:

1. Select representative examples for class discussion and weave them into the lesson. Make sure that all the students get their day in class by using each student’s response at least once.

2. Don’t ignore the free form comments. Every assignment should provide space for student comments, which very often yield valuable pedagogical insight into student thinking.

3. Revise the lesson flow now that you have the actual responses. The fact that the wording actually comes from students makes the lesson fresh and interesting to the students.

4. Go to class and be ready to improvise if necessary. The locution used in class will now come directly from student responses and will vary from class to class. The lesson flow is influenced by the feedback from the live class. Each class session is unique because the students in each class are unique.

Student classroom participation will be enhanced if students come to class with informed opinions that they are eager to share and defend. (e.g., Pace’s question above). Good questions create a “need to know” in students, and should be sufficiently captivating so that even unmotivated students may become interested in the answers. For example:

Allison is driving with her parents when they get in a serious car accident. At the emergency room, her doctor tells Allison that her mother, Carla, is fine, but her father Bob has lost a lot of blood and will need a blood transfusion. Allison volunteers to donate blood, and you tell her that her blood type is AB. Bob is type O. (a) Can Allison donate blood to Bob? Why or why not? (b) Allison, who is a biology student, begins to wonder if she is adopted. What would you tell her and why? (from Kathy Marrs, IUPUI)

Adapting JiTT to One’s Teaching Style
JiTT has to be adapted to one’s teaching style, not just adopted. It has become clear that there is no such thing as canonical JiTT, no one-size-fits-all. Just as we demand that students construct their own version of the subject matter, interactive engagement pedagogies demand that teachers construct their own brand of teaching tactics. Faculty reactions from JiTT classrooms range from euphoria to despair, largely dependent on whether JiTT was approached as a set of recipes, or adapted to match the instructor’s teaching style and nature of the course.

When first attempting to implement JiTT, teachers should be prepared for a trial and error period while they adapt existing JiTT materials and create new JiTT materials. Teachers should also be sensitive to students’ ideas, attitudes, and state of knowledge, and constantly monitor their students’ learning progress. Of course, teachers should also have a good grasp of their material and have a repertory of conceptual pathways to deliver and explain that material such that they can both appreciate and respond to students’ ideas. Finally, an effective JiTT teacher also has to be able to develop creative tasks that support students’ learning within a classroom climate in which they may participate freely without the experience degenerating into frustrating chaos.

**JiTT Demands on Students**

When teachers first introduce their students to JiTT, students may find it difficult to work in the small, daily installments required by the drumbeat of the warmups. Thus, it is important that some enforcement mechanism be in place. Teachers have to hold students responsible for on-time delivery of meaningful responses. At least a part of the pre-class assignment should include a free-form written response. Teachers should give credit for thoughtful, thorough responses, well reasoned from stated prior knowledge and assumptions, even if the responses are wrong. Teachers should encourage students to indicate the thought processes that led them to the response, as in Pace’s example above.

It also is important to help students to see that “wrong” answers are not evidence of failure on their part but are stepping stones in the exploratory learning process. In fact, in the best JiTT classes there are no “wrong” answers to the warmup questions. What teachers expect of students, and reward, is evidence of thinking. Each discipline will experience its own version of this issue. For example, in the
sciences, many students hold the positivist view that science is a compendium of incontrovertible facts, and thus they may be reluctant to consider their own or other students’ perspectives in developing their answers to the warmup questions or in discussing these questions in class. Scott (1991) suggested that deeper and more permanent learning occurs when teachers create a learning environment, teaching strategies, and learning tasks that foster conceptual change rather than piecemeal accretion of new information. To that end, JiTT teachers ask students to examine and evaluate their own points of view and those of other students.

**Can JiTT Make a Difference in Student Learning?**

Assessment in Just-in-Time Teaching connotes many ideas. JiTT assignments are themselves a form of assessment. They continuously provide a sightline into the students’ progress towards deeper learning. However, in addition to monitoring cognitive gains, it is necessary to pay attention to the affective aspects of students’ involvement in the course. Successful implementation of the JiTT strategy depends critically on the teacher and students’ total buy-in. If students see the on-line assignments merely as an add-on to the course, to be completed perfunctorily in the shortest time possible and then discussed briefly at the beginning of class, before the “real” lecture, they will resent the extra work and will not get any additional benefit from JiTT. Teachers using JiTT report a spectrum of results, ranging from significant affective and cognitive gains to very negative student reactions, disillusionment, and sometimes a regression in learning gains (Camp as cited in Simkins & Maier, 2009).

**Cognitive Gains.** Successfully implementing Jitt leads to cognitive gains, ranging from moderate to quite significant. For example, in the first semester introductory physics course the standard assessment instrument is the Force Concept Inventory test (FCI). Identical multiple-choice questions are administered on the first and last days of class. The improvement, if any, is measured in terms of the “Hake gain” defined as \( \frac{\text{posttest\%} - \text{pretest\%}}{100 - \text{pretest}} \) (Hake, 1998.) Typical scores in traditional courses are in the teens. JiTT practitioners report gains in the 40% to 70% range (Hake, 1998). The gains are even stronger when JiTT is paired with other interactive engagement techniques such as peer instruction or collaborative learning (Crouch, 2001).
Another interesting result comes from a five-semester study at North Georgia College & State University (Formica, 2010) This study analyzed responses from Force Concept Inventory (FCI) questions (the distractors as well as the correct answers) for evidence of students reaching the transition threshold from “common sense thinking to Newtonian thinking,” a well-defined notion in physics education (Arons 1979.) Sixty-one percent of the students in the JiTT class reached the threshold, compared to only seven percent in the traditionally taught class.

Marrs reported similar gains on pre-post assessment in biology, using the Hake rubric (Marrs as cited in Simkins & Maier, 2009). With traditional lecture-based pedagogy the gain was 16.7% in a class using JiTT or collaborative learning the gain jumped to 52.3% with JiTT and to 63.6% with collaborative learning.

Since the introduction of JiTT at the US Air Force Academy, the final exam questions in the introductory physics sequence have shifted significantly towards conceptual probing for deeper understanding. Analyzing carefully kept records from the pre-JiTT early 1990s until the present, one finds that despite the increasingly more challenging questions, the scores have held steady and even improved in some semesters. Here there are too many variables in play to make this case into a rigorous piece of evidence, but most physics teachers looking at these data would likely be impressed by the depth of thinking required by the Air Force cadets in JiTT courses.

Classroom Climate, Motivation, and Attitude. When we introduced JiTT in Introductory Physics at IUPUI in 1996, course attendance jumped from under 50% to over 80%. Instructors in other disciplines have reported similar results. Better attendance inevitably leads to fewer students dropping the class and an overall rise in grades. In JiTT Physics and in Biology courses at IUPUI the D/F/W numbers plunged from 40% to under 25%.

Warmups can make a difference in student study skills. Students in Marrs’ biology class credit JiTT to a significant decrease in cramming for tests. She asked her students “Did you put off studying for Biotech 540 and as a result 'cram' for Biotech 540 tests?” to her graduate students, and 34% answered yes.
However, 62% of the class answered in affirmative to the question “Do you 'cram' for other courses that you have this semester?”

Gavrin reported that 80% of the students in his JiTT class responded “yes” to “Do the JiTT exercises help you to be well prepared for lecture?” versus 21% affirmative to the same question in “other classes.” He found a 58% vs 18% split on “staying focused,” a 59% vs 18% split on “feeling like an active participant,” and a 71% vs 21% split on “finding classroom time useful” (Gavrin as cited in Simkins & Maier, 2009).

Student comments on the free-form climate question, included in most JiTT assignments show a similar trend. Students complain about the assignments being “time consuming” but they usually recognize the benefits, for example, a student in Gavrin’s JiTT class commented, “…they are a pain, but they help me prepare.” (Gavrin as cited in Simikins & Maier, p. 127, 2009)

**Conclusion**

When trying to assess the efficacy of any pedagogical strategy, it is important to appreciate that the choice and implementation of a particular teaching method will affect student and faculty attitudes and motivation as well as learning outcomes. In her use of JiTT, Laura Guertin has noticed strongly positive reactions from her students:

I see my students working weekly through open-ended questions that require higher-order cognitive skills. I see students working together in class, gaining additional practice with quantitative, communication, and management skills. I see my students using the vocabulary of the discipline as they work through JiTT exercises and discuss JiTT responses in class. I see students connecting ideas across the course and across their lives (quoted in Simkins & Maier, 2009, p. 111).

We have much anecdotal evidence that, in the best of cases, after adopting student-centered teaching approaches such as JiTT, many faculty change their teaching philosophies, sometimes in significant ways. Faculty members who once viewed their role as being “conveyors of knowledge” shift to
becoming “facilitators of student learning.” This developmental shift increases the efficacy of their subsequent teaching, and ultimately increases the levels of “deep learning” experienced by their students.

However, as is the case with all innovations in teaching and learning, further questions remain to be answered by scholarly work. For example, with respect to JiTT, the following questions come to mind: How do we define what “working” actually means when we ask if JiTT is working? What factors determine how much “resistance” students will show when first introduced to JiTT? What types of JiTT questions/problems are most effective in helping students master the material at a deeper level? What skills do students develop in JiTT courses that they do not develop, or develop not as well, in non-JiTT courses? Do students retain knowledge longer in JiTT courses compared to non-JiTT courses? Undoubtedly, answers to these questions will lead to a better understanding of how JiTT impacts student learning, and just as importantly, faculty teaching effectiveness.

References


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