

Using Just-in-Time Teaching Techniques in the Principles of Economics Course: A Preliminary Report

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Introduction

Over the past decade there has been growing concern that the teaching methods employed in college economics courses – especially in introductory courses – have been slow to incorporate innovative teaching pedagogies used successfully in other disciplines, potentially limiting both enrollment and student learning. National surveys by Becker and Watts (1995); Siegfried, Saunders, Stinar, and Zhang (1996); and Benzing and Christ (1997) point out that the typical economics instructor spends nearly 80% of class time lecturing, with little emphasis on collaborative learning projects, small-group discussions, or other active-learning teaching pedagogies. Becker (1997) notes that teaching practices in economics are not keeping up with those in other disciplines, especially in the use of active learning techniques that have been shown to be effective at increasing student learning. At the same time, while web-based educational technology is providing new and creative opportunities to enhance learning, Katz and Becker (1999) emphasize that economics is “lagging behind other disciplines in implementing (technology-based) instructional innovations that engage students more actively in the learning process.”

In response to these concerns about teaching and learning in economics, we are currently adapting an innovative teaching technique originally developed for physics education – Just-in-Time Teaching (JiTT) – for use in introductory economics courses. Broadly speaking, JiTT techniques combine the use of out-of-class web-based exercises with active-learning pedagogy in a traditional classroom setting that makes students active participants in the learning process. JiTT directly addresses the two critical issues raised by Katz and Becker with regard to economic education: the relative scarcity of active learning-based teaching methods and the lack of new technology-based instructional innovations. By exploiting the communication and instructional efficiencies provided by the web and web-based course management tools and directly linking out-of-class student academic work with classroom-based learning, JiTT promotes increased student participation in the learning process, provides students and faculty with prompt feedback on student learning, and encourages better student preparation for class.

JiTT pedagogy was originally developed in 1996 as part of the *WebPhysics* project led by physics faculty at the U.S. Air Force Academy and Davidson College with support from the National Science Foundation. In recent years the National Science Foundation has supported the expansion of JiTT pedagogy to chemistry, biology, and mathematics courses, in addition to our

development of JiTT techniques in economics.¹ Today, over 175 instructors at 73 institutions across the U.S., Canada, Europe, and Israel have adopted the JiTT strategy.

What follows is a preliminary report on our experiences with the development, implementation, and assessment of JiTT pedagogy in economics on three diverse campuses - Stanford University, a highly selective national university with nationally-ranked undergraduate and graduate programs; Glendale Community College, an urban community college serving a diverse student population; and North Carolina A&T State University, a mid-size historically black university - over the past two years. After describing the basic structure of JiTT pedagogy in the next section, we outline the benefits of JiTT techniques, both from an educational research perspective and from our own experience, before asking the question: does it work? To provide some tentative answers to this question we draw on our experiences using JiTT techniques in the principles of economics classroom, finishing with an overview of the lessons we have learned from our use of JiTT pedagogy and an assessment of its benefits in promoting student learning in economics.

What is JiTT?

As the original developers of JiTT describe it in their book, *Just-in-Time Teaching: Blending Active Learning with Web Technology* (G. Novak, E. Patterson, A. Gavrin, and W. Christian; 1999), “Just-in-Time Teaching is a teaching and learning strategy comprised of two elements: classroom activities that promote active learning and web-based resources that are used to enhance the classroom component.”² The two work together to promote a “feedback loop” that (1) encourages outside-of-class preparation by students, (2) provides prompt feedback on students’ conceptual understanding of course material, and (3) informs “just-in-time” modifications of class activities and discussion.

The JiTT strategy is straightforward. Between classes, students complete carefully constructed exercises – covering material that has not yet been covered – and submit them electronically using course management software such as Blackboard or WebCT, a web-based form, or simple email, by a preassigned time a few hours before class. These JiTT exercises, or “JiTTs” as we refer to them, are short assignments typically focusing on material that will be

¹ Two of the authors, Mark Maier and Scott Simkins, are developing JiTT techniques in economics with the support of NSF grant DUE-0088303, “Developing and Implementing Just-in-Time-Teaching (JiTT) Techniques in the Principles of Economics Course.”

² JiTT techniques are described extensively in their book and at the accompanying JiTT website: <http://webphysics.iupui.edu/jitt/jitt.html>.

covered in the next class. Once submitted, instructors then review students' JiTT responses an hour or two prior to class and use the responses to organize and modify the upcoming classroom session – hence the “just-in-time” label. Excerpts from students' submissions are presented during the class as the basis for discussion, replacing the traditional lecture, and are used to develop follow-up exercises that groups of students work on in class.

Thus, the in-class component of the course is informed by and complements students' out-of-class JiTT assignments, producing a positive feedback loop that enhances student learning. Because students see their own work presented in class, they develop a heightened sense of ownership of their learning; thus, they are more likely to complete the JiTT exercises and actively participate in the ensuing classroom discussion and activities. As a result, students come to class better prepared and gain more from each class session. In addition, students receive immediate feedback on their understanding of the concepts covered in the JiTT exercises, providing a “teachable moment” that is absent with traditional homework assignments or quizzes, which provide feedback only with a lag. At the same time, instructors also receive valuable feedback that helps to make in-class teaching and learning more effective. Because the JiTT exercises are completed between classes, instructors can uncover students' misunderstandings of economic concepts *prior to* class and design classroom activities to overcome these misunderstandings while the concepts are still fresh in students' minds.

Benefits of JiTT: The Educational Framework

Our development of JiTT pedagogy in economics is influenced by a long tradition of educational research on effective teaching and learning, in particular Chickering and Gamson's well-known and widely cited *Seven Principles for Good Practice in Undergraduate Education* (1987, 1991)³. Chickering and Gamson's *Seven Principles*, listed below, provide a widely-accepted benchmark of “best practices” for college teaching distilled from decades of research on undergraduate education.⁴ According to Chickering and Gamson, good practice in undergraduate education

³ Similar principles are promoted by Astin (1993), who identifies a number of factors that enhance student learning, including increased quantity and quality of student-student interaction, student-faculty interaction, and student study outside of class, and Angelo (1993), whose fourteen principles for improving higher learning include: focusing on active learning; meaningfully connecting new and prior knowledge; identifying and unlearning erroneous previous knowledge; organizing subject matter in meaningful ways; using abundant and timely feedback; and using real-world examples to transfer learning.

⁴ In recent years, the *Seven Principles* have also been used to guide the effective use of instructional technology to maximize enhance student learning (Chickering and Ehrmann, 1996).

- Encourages student-faculty contact.
- Encourages cooperation among students.
- Encourages active learning.
- Gives prompt feedback.
- Emphasizes time on task.
- Communicates high expectations.
- Respects diverse talents and ways of learning.

JiTT pedagogy provides a natural framework for promoting Chickering and Gamson's *Seven Principles*. As noted earlier, JiTT techniques are designed to encourage active student participation in the learning process, focus student attention on important course-related concepts, and provide useful feedback on student learning while there is time to meaningfully affect that learning. Specifically, JiTT pedagogy

- Makes students and faculty co-creators in the knowledge generation process; students' responses to JiTT exercises are the basis for in-class discussion and activities.
- Encourages students to actively interact with assigned readings, economic data, and web-based resources, using them to solve unfamiliar problems. Follow-up activities in class focus on group-based exercises that encourage students to share ideas and problem-solve with other students.
- Promotes effective use of student study time and in-class instruction. By providing a structured introduction to new material, JiTT exercises help students focus on the most important concepts, while out-of-class preparation and focused in-class activities directly related to the JiTT exercises help to make effective use of in-class instruction time.
- Provides prompt feedback on student learning, helping both faculty and students to identify and understand learning gaps, misconceptions, and misunderstandings. The use of web technology offers labor-saving tools for collecting and sharing information, in particular JiTT responses, allowing students to "see" whether they are correctly understanding the economic concepts being covered and allowing instructors to promptly intervene in the learning process when necessary through the use of complementary in-class exercises.
- Reinforces the message that learning takes place when students come prepared to class. Increased learning from in-class activities reinforces the benefits of completing JiTT exercises and leads to sustained student engagement in the learning process.
- Provides a "scaffold" to help students with diverse learning styles; most JiTT exercises emphasize concrete application of economic concepts and encourage students to discuss economic concepts in their own words or by relating those concepts to experiences from their own lives. These linkages between newly introduced economic concepts and previous knowledge increase the potential for creating deeper, long-term learning.

JiTT pedagogy effectively supports each of Chickering and Gamson's foundational educational principles and provides the basis for creating a stimulating learning environment that increases student involvement in the learning process and enhances student learning.

Benefits of JiTT: Our Experience

Our classroom experience with JiTT in economics suggests that the practical benefits of JiTT can be organized around four general themes that are closely related to Chickering and Gamson's *Seven Principles*: (1) students are more likely to be prepared for class; (2) the use of student responses in class creates a positive feedback loop that promotes further learning; (3) JiTT exercises make instructors more aware of student thinking processes; and (4) in-class activities complement student responses, providing important "just-in-time" reinforcement of important concepts.

(1) Students Are More Likely To Be Prepared For Class

Encouraging students to prepare for class is, of course, not a new idea. Strategies such as "pop" quizzes and short papers collected at the start of class have been shown to improve student preparation and subsequent performance in college courses (see, for example, Ruscio (xxxx), Connor-Greene (xxxx), and Cross and Angelo (1994)). JiTT exercises, to the extent that they are assigned regularly and completed by students, are expected to yield similar results. An added benefit of JiTTs, however, is that are completed out of class, freeing up valuable in-class instruction time for interactive lectures, hands-on activities, or collaborative problem-solving exercises. JiTTs make it possible to focus students' attention on specific course concepts, with the knowledge that their responses help frame the structure of the upcoming class. JiTT pedagogy also gives students greater ownership of the knowledge creation process, providing additional incentives to complete each JiTT exercise.

By using a course management program such as Blackboard or WebCT, it is relatively easy to manage frequent JiTT submissions (for example, every class or once a week) by students. Because JiTTs are relatively short, requiring no more than a paragraph to answer, they can be assigned in relatively large sections without overwhelming the instructor. We have been using them in classes of about 30-40 students without undue effort. We typically assign JiTT exercises once per week throughout the semester.

But do students actually do the JiTT exercises? Because the JiTTs account for a nontrivial part of the semester grade (a minimum of 5%, say), student submission rates are quite high, averaging near 90% in our courses. Because of this, we believe that student preparation for class is significantly higher than before we instituted just-in-time activities; our anecdotal evidence supports this hypothesis. Students, too, believe that JiTT exercises help them to keep up and

come to class prepared to participate, as the following end-of-semester teaching evaluation comments indicate:

- The JiTT assignments prepared me for class. It allowed me to read ahead so that I would fully understand what would be covered in class the next period.
- The exercises allowed you to become familiar with the material so that you would be able to participate in class discussions.
- ... I was familiar with discussed information and that enabled me to understand the concepts better.

(2) The Use Of Student Responses In Class Creates a Positive Feedback Loop that Promotes Further Learning

As noted above, student responses to JiTT exercises, or a subset of those responses, are shown (anonymously) in class – using a digital projector and PC or a simple overhead – and used as the basis for in-class discussion and follow-up activities. Using students’ responses as an organizing tool for classroom activities creates a positive feedback loop that connects students’ out-of-class web-based work with classroom instruction. As a consequence, students are better able to see the connection between what they are being asked to do outside of class and what is being covered in class, leading to greater student motivation for learning, increased time on task, and improved understanding of course concepts. According to students,

- JiTT assignments made me work hard to find the answer but understand the chapter.
- The assignments kept me up to date with the material covered in class. They really made me think outside the classroom of things I’d normally not bother with.

Students see their own work presented in class as part of a positive, formative process where JiTT responses serve as the starting point for further exploration and analysis, rather than as simply another assignment to be turned in for a grade. As noted by the original JiTT developers, “These questions, when fully discussed, often have complex answers. The students are expected to develop the answer as far as they can on their own. We finish the job in the classroom.”⁵ Because JiTTs serve as an introduction to a new economic topic or concept, students must read the textbook or assigned reading to effectively complete the exercise. The objective of JiTTs is to increase student understanding of economic concepts, but some mistakes are expected. In fact, these mistakes often provide the foundation for the upcoming class’s discussion. While JiTT responses are graded, the focus is more heavily weighted on student effort and less on complete understanding of the economic concept being analyzed. In-class discussion and activities help to solidify students’ understanding and provide real-time feedback on how well they understand the

⁵ From a draft of a National Science Foundation NSDL grant proposal provided by Evelyn Patterson.

material that is being covered in class, feedback that they can use to modify their own learning “just-in-time.” As one student put it,

- I (also) liked the fact that the JiTT assignments were used along with class discussion. Even if you got the JiTT wrong you were still able to learn through the discussion.

(3) JiTT Exercises Make Instructors More Aware Of Student Thought Processes

Although experienced instructors can anticipate common student errors in learning new concepts and take them into account in classroom teaching, students’ JiTT responses allow us to better understand students’ thinking processes, improving both teaching and learning. In some cases JiTT responses illustrate student misconceptions or misunderstandings that can be addressed through in-class discussion and/or activities, while in other cases students provide rich illustrations of economic concepts that relate closely to their lives, helping students build new knowledge by linking new concepts to previously learned ideas or experiences. As an example of the former, consider the following two examples of JiTT questions and student responses.

***Example 1:** JiTT Question: Describe the role of the price of a good in moving a competitive market to equilibrium if there is currently a shortage in this market. To fully answer this question, consider the following two questions: (1) What will happen to the price of the good in this case? Why? (2) How does the change in the price of a good provide an incentive for demanders and suppliers to change their behavior in this situation, thus bringing the market to equilibrium? Explain.*

The (unedited) student responses below were selected for presentation in class and grouped according to response type (as shown) in order to generate a discussion on the incentive role of prices in moving competitive markets back to equilibrium from a shortage condition.

Prices Fall (a minority view)

The price of goods with a competitive market in its equilibrium during a shortage will slowly decrease in its market. Reason is because they would not be able to produce their supplies as well as they did with competition.

In moving a competitive market to equilibrium, if there is currently a shortage in the market, the price of the good in this case will decrease because the market is making more profit as it move upward toward the equilibrium price.

Whenever a good is sold at a low price, the demand for that good is higher than the supply, there will be a shortage in the market. The price of the good will decrease because of the shortage in the market. This is because the quantity demanded decreases therefore the price of the good would decrease.

Curves Shift?(cause of shortage)

The shortage of a good would if viewed on a supply and demand model, would cause the supply curve to shift to the left.

The Supply curve has shifted to the left of the equilibrium supply/demand point.

Move to Equilibrium

In order for demanders and suppliers to bring the market to equilibrium they would have to increase the demand so that the curve and shift increase the equilibrium quantity.

The price of the good is now higher because there is not enough of the good supplied to keep the price where it was before the shortage. Because the price has changed less of the good will be bought by demanders. Suppliers of the good will try to put more of the good into the market and some suppliers who can supply this good may enter the market and increase the supply of the good. The end result should be for the supply curve to shift back to the right and the market to be back at equilibrium.

This JiTT was given early in the semester during the initial coverage of supply and demand. The student responses illustrate a number of misunderstandings about the workings of competitive markets and our models of those markets and provide a good jumping-off point for class discussion and real-world examples of markets in action. Note that the same material could be covered in a traditional, passive lecture format, but in the case above students play a central role in the knowledge creation process. The responses are written in their own words and reflect their own thinking, however flawed, providing an engaging entry-point into the learning process.

Example 2: *Explain why the aggregate demand curve shows a negative relationship between inflation and real GDP (output). That is, why does the amount of goods and services demanded in the economy fall as the inflation rate increases?*

This example focuses on the relationship between inflation and real GDP that is the foundation for modern explications of the basic aggregate demand/aggregate supply model (see, for example, principles-level economics textbooks by Taylor and Frank/Bernanke). Central to this relationship is the notion that the Federal Reserve reacts to inflation rates via a monetary policy rule, changing interest rates to keep inflation near its target level. The change in interest rates, in turn, affects aggregate spending and output, providing the linkage between inflation rates and output embodied in the aggregate demand curve presented in the textbooks listed above. The following (unedited) student responses used in class (with the listed discussion question) illustrate a variety of responses and challenge students to think more deeply about this complex and abstract relationship.

Which answer is best? Why?

- *Inflation is the increase in the overall price level over a given time. This means that when inflation occurs goods and services cost more. Therefore, when prices are higher people are less willing to spend the money to buy them.*
- *First of all I think that you have to understand why the aggregate demand curve slopes down. First of all, there is a negative relationship between interest rate and real GDP. Second of all, there is a positive relationship between inflation and interest rate. And third of all, these two relationships imply that there is a negative relationship between real GDP and inflation, and that relationship is the aggregate demand curve.*
- *One method of reasoning behind the aggregate demand curve involves the following. First, the Fed would raise interest rate to counter-act higher inflation rates. Higher interest rates would lead to less investment spending, a decline in net exports and a fall in consumption. Investment would decline because the higher interest rates would make it more expensive to purchase capital. The cost of domestic goods would increase and foreign goods would decrease. Therefore, net exports would decrease. On the opposite end of the spectrum, when the Fed lowers interest rates, investments, net exports, and consumption all rise. When interest rates, net exports, and consumption rises, real GDP rises also. This proves that when inflation rises, real GDP decreases, and visa versa.*

The responses inform the instructor about students' current understanding of new material and provide an opportunity to have students critique their own thought processes. Providing contrasting examples of student responses, even when more than one is technically correct, helps students understand what it means to fully explain a particular point. Comparisons of student-generated work change the dynamic of the classroom environment and put students in the center of the learning process. As a consequence, students are more involved in classroom discussion and are more willing to engage in out-of-class reading and follow-up exercises.

The following examples help to illustrate the usefulness of JiTT exercises in providing real-life examples of economic concepts drawn directly from students' lives. The variety and richness of these examples enlivens the classroom and incorporates students more fully into the learning process. Student examples illuminate economic concepts in ways that go beyond what even the most creative instructors can develop and help students link new, abstract concepts to their own real-world experiences.

Example 3: *Provide an example of diminishing marginal returns based on your own experience.*

Here is a sampling of (unedited) student responses that were used in class:

- *At a certain point or certain age, a person can no longer improve their time for running a mile.*
- *For the Rose parade many people volunteer their labor and time to work on the floats. As more people volunteer, the less space and floats there is to work on.*
- *An example of diminishing marginal returns I thought of was adding more detergent to my laundry. The input would be the detergent, and the output would be how clean my*

clothes come out in x number of washes. Using more than the required (a cup) of detergent for one basket of my laundry would only leave my clothes soapy. Therefore, I'd have to let it spin in the washer more than once, which will negatively affect my output. Not only would it take more time to finish my laundry, more wash cycles would result my clothes to fade and make it look worn-out.

In another example, students were asked early in the course to describe a cause-effect model based on their own experiences and explain how they would graph the resulting relationship. The resulting responses, represented below, provided rich examples for classroom discussion.

Example 4: *Develop a verbal model to explain the relationship between two variables that describe the behavior of an activity related to your own personal experience (e.g. time spent studying and grade on upcoming exam - but don't use this example). Also, how would you illustrate your model graphically? What would the graph look like? Explain.*

Student Responses (unedited):

I have been working in a restaurant-eatery for a few months now and I have been noticing that when the employees smile a lot to customers, the most likely they are to get big tips. The smiler we are, the more money we get. Graphically I would put on the Y-axis the amount of tips left by customers and on the X-axis I would put the "average of smile" form the workers. The bigger this number is , the upper the line goes, at least for a while. After, even if the numbers of smile is still going up, the amount of tips left does not increase as much.

I work at a camera store, I have attended several workshops about cameras and sale techniques. Because of these workshops my sales has increased; therefore my commission will increase along with my knowledge. Graphically: I would use a line graph with two variables. Variable one (axis x) would be how many workshops I attended and variable two (axis y) would be the amount of commission I will receive. Therefore this would be positively related variables. The graph will be upward-slopping lines that will show how one variable increases the other variable increases. The more workshops I attend the more money I will make.

My day is just not long enough to accomplish everything that I want to accomplish. There is an opportunity cost for everything that I do. I have noticed that if I do not spend any time with my girlfriend that our relationship suffers. My girlfriend is not happy if everyday I do not at least call her (15 minutes). If I see her (1 hour) she continues to be even more happier. However after an hour while her enjoyment contiunues to grow, it is at a slower rate. After 3 hours, her enjoyment stops growing and begins to decrease. This model has allowed me to maximize her enjoyment without increasing my opportunity costs. For example I have to eat so I have lunch with her 1 hour. The increasing opportunity cost of having to spend more time with my girlfriend for her to get the same amount of enjoyment occurs at the one hour mark and increases at the two hour mark. As we get closer to three hours I know that the rate at which the increasing opportunity costs grows until at the three hour mark her enjoyment actually decreases. Yes with Economic Models even personal issues can be studied and handled much more effectively. From now on I will spend only one hour a day with my girlfriend and spend the other two hours studing Economics.

As you can see, these responses provide an opportunity to discuss assumptions, the relationship between verbal explanations and graphs, and economic concepts in a context-sensitive setting. Again, similar concepts could be presented using a passive lecture approach, but we think the benefits of using student-generated examples and explanations as the starting point for classroom discussion are obvious. Students are more engaged in the learning process when they see their work being used in class.

(4) In-Class Activities Complement Student Responses, Providing Important “Just-In-Time” Reinforcement Of Important Concepts

JiTt enhances student learning even more when student responses are followed up with in-class activities that challenge students to think more deeply about the concepts being covered. The activities are ideally group-based and may incorporate actual student responses or extend the concepts covered in the JiTT using new examples, problems, or exercises. In many cases, these may be textbook specific, forcing students to interact not only with other students but also the textbook.

The examples below provide just a few types of in-class exercises that we have used to directly supplement JiTT exercises.

- In one case, students were asked to use the U.S. Federal Reserve Board web site <http://www.federalreserve.gov/bios/> to prepare a list of characteristics of those appointed to the Board of Governors. As an introduction to the conduct of monetary policy, students shared their findings in small groups.
- In another JiTT exercise, students analyzed examples of fiscal policy recommendations at the Republican and Democratic Party official web sites. (<http://www.rnc.org/> and <http://www.democrats.org/index.html>). Representative student answers were photocopied (without identifying the student) and used for analysis by small groups based on a rubric: Did the student identify a fiscal policy? Did the student accurately identify the strengths and weaknesses of the fiscal policy proposal?
- In yet another example, student responses to a JiTT question were structured in a multiple-choice question format. As a small-group activity, students were asked to select the best answer and explain why they selected their chosen answer, using economic analysis. The specific exercise is listed below.

An increase in the demand for a good or service will lead to an increase in price in competitive markets. Explain why.

- a. An increase in the demand for a good or service will lead to an increase in price in competitive markets because the demand curve shifts to the right, which causes the intersection of the supply and demand curves to shift to a greater quantity and a higher price.*
- b. Consumers have no choice but to either pay the higher price or not purchase the good or service.*
- c. As the demand for a good or service increases, the supply of that good or service increases. This will also cause the price of the good or service to increase.*
- d. Besides technological improvement, another reason for a rise in prices is also shortages.*
- e. When a business knows that there is a high demand for their product or service, they are able to charge higher prices for that product.*
- f. An increase in the demand for a product will cause the price to go up because the supply starts to become smaller.*

In-class exercises like these help to reinforce the economic concepts introduced in the JiTT exercises and provide a hands-on, active-learning approach that research indicates aids student learning.

Summary

The multi-faceted approach of JiTT – out-of-class web-based exercises followed by an interactive lecture, class discussion, or collaborative problem-solving exercises based on students’ responses to the JiTT questions – creates a positive learning cycle that actively engages students in the learning process and puts students at the center of that process. Our classroom experience bears out some of the benefits of using JiTT techniques: better student preparation for class, greater participation in classroom discussion, and useful feedback for instructors and students.

Does JiTT Increase Student Learning?: Three Case Studies

The last section highlighted the benefits of using JiTT pedagogy, both from a theoretical perspective and our experience in the classroom. The real question, however, remains: does JiTT increase student learning? JiTT enjoyed early success in its early development for physics education at Indiana University – Purdue University at Indianapolis and elsewhere: cognitive learning (as measured by pre- and post-tests) in JiTT courses was found to be higher than in “traditional” physics classes and student attitudes toward JiTT components were very high. Are those effects transferable to economics education? In this section we report on our assessment of JiTT pedagogy with regard to cognitive gains in learning. Our results cover three

colleges/universities with widely varying learning environments for students and student body makeups. Not surprisingly, given the differences in institution types, our use of JiTT pedagogy varied somewhat across instructors, but in each case centered on the feedback loop outlined previously – web-based JiTT exercises and complementary in-class activities – that is the centerpiece of JiTT techniques. Our assessment techniques also differ – in one case using ANOVA, in another simple binomial tests, and in the last, regression analysis – but the question driving our analysis was always the same: Do JiTT techniques help improve student learning in the Principles of Economics course?

(1) JiTT in Economics at Stanford University

At Stanford University, Principles of Economics is a one-quarter course that covers both micro- and macroeconomics in a large lecture setting, with 100 to 500 students in a class. The course is structured in four 50-minute lectures per week, plus one weekly section for groups of 15 students at a time. The instructor teaches lectures, while teaching assistants lead the smaller sections. The JiTT experiment at Stanford was conducted in the winter quarter of 2001, with 168 students finishing the course; however, only 161 observations are included in the study because some students did not complete all the exams involved in the experiment. This particular experiment included both pre-lecture JiTT exercises and post-lecture activities patterned after the JiTT exercises. The initial study was set up to test whether pre-lecture (JiTT) or post-lecture activities similar to JiTT affected student performance on exams. The class was randomly divided into four groups – one for each treatment group – with the condition that each group contained the same number of students from each teaching assistant to avoid having a TA effect on the data. The table below shows the assignment of different treatment groups; group 4 is the no-JiTT “control” group.

		After lecture JiTT-type activities	
		Yes	No
Before lecture JiTT exercises (traditional JiTT)	Yes	Group 1	Group 2
	No	Group 3	Group 4

Students in the course completed four “midterm” exams. However, JiTT techniques were applied only between exams 2 and 3; questions 1 and 2 (out of 4) of exam 3 involved topics covered by the JiTT-based pre-lecture and post-lecture activities. The analysis that follows focuses on the measured improvement of student scores for questions 1 and 2 of exam 3 over the

scores from exams 1 and 2 for each student. In particular, the analysis focuses on two questions: (1) Does JiTT help improve student performance on exams? (2) Does JiTT improve student performance in exams more than post-lecture activities?

To determine whether JiTT exercises improved student performance on exams, two different hypotheses were tested. First, we tested whether students who only participated in pre-lecture activities (traditional JiTT) showed a larger improvement in test scores on questions 1 and 2 of exam 3 than those students who did not participate in either pre- or post-lecture activities. Second, we tested whether students who participated in pre-lecture activities (JiTT), whether or not they participated in post-lecture activities, showed a larger improvement in test scores on these same questions than those students who did not participate in pre-lecture activities.

To determine the answers to these questions, analysis of variance procedures were used to compare the effects of a particular treatment on exam scores. The first test compares the improvement scores for group 2 (those who completed only pre-class JiTT activities) with those of the control group, group 4. The mean improvement in scores was 3.3% higher for group 2 than for group 4. However, the difference between the two means is not statistically significant (p -value = 0.334). The second test compares the improvement scores of students that participated in pre-lecture activities (groups 1 and 2) against those that did not (groups 3 and 4). Mean improvement for groups 1 and 2 was 2.2% higher than for groups 3 and 4, but again the difference between means is not statistically significant (p -value = 0.408). In general, there appears to be a small positive effect from JiTTs, even when students complete post-lecture JiTT-like exercises.

Comparing students who only participated in post-lecture activities with the control group (no pre- or post-lecture activities) indicates that students in group 3 (only post-lecture activities) had a 2.6% improvement relative to students in group 4, the control group. However, the difference is not statistically significant (p = 0.442). Thus, greater effort, as represented by completion of either pre- or post-lecture exercises, appears to lead to higher exam scores in this sample of students; however, the pre-lecture JiTT-effect is slightly greater. Directly testing the effects of pre-lecture JiTTs against post-lecture exercises, we find that pre-lecture JiTTs have a small advantage over post-lecture activities (0.7%) but once again the result is not statistically significant (p = 0.849). What do we conclude? That JiTT has a mildly positive, although not statistically significant, effect on student learning, regardless of whether students complete additional exercises following class lectures.

(2) JiTT in Economics at Glendale Community College

At Glendale Community College (Glendale, CA), introductory-level principles courses are taught in a two semester sequence, Principles of Macroeconomics and Principles of Microeconomics. During fall 2002, students completed eight JiTTs in two sections of each course, counting as 5% of the final grade. As noted above, JiTT submission rate was high, about 90%. Did JiTT completion lead to improvement in subsequent student test scores? To investigate this hypothesis we structured the experiment in the following manner:

- In each section students were randomly divided into two groups.
- For each JiTT submission, students completed one of two different JiTT problems on economic concepts depending on their random group assignment.
- On the subsequent test one question was designed to correspond to each of the JiTT exercises.
- Tests were scored by the instructor, assigning a point value to each answer. For each student, scores on the questions corresponding to the JiTTs were compared with the course mean score for those questions. The instructor then made a prediction for each student: does the student belong to random group 1, to random group 2, or are the deviations from the mean so similar that no prediction is possible? (if a student did not answer a test question or did not complete a JiTT, then no prediction was made) The following table provides an example of how the predictions were made.

	Question 1 (related to JiTT 1)	Question 2 (related to JiTT 2)	Prediction
Class mean	5	6	
Student A	9	7	Student in group 1
Student B	3	6	Student in group 2
Student C	5	6	No prediction

- After the predictions were made, actual group membership was compared with the prediction and the number of correct predictions totaled for each course. The accuracy of predictions was tested using a simple binomial test with a null hypothesis that the prediction rate was 50%.

Two examples of JiTT questions and corresponding exam questions are given below.

JiTT #1: Read the article "How much is that kidney in the window?" What is the strongest argument in favor of a non-market distribution method? How might the author of the article respond to this argument in favor of a non-market distribution?

Corresponding test question: *List the disadvantages of using a non-market distribution method for blood used in transfusions.*

JiTT #2: Read the Rand Corporation report on cocaine use. How much does it cost to reduce cocaine use by 1 percent with an enforcement policy? How much does it cost to

reduce cocaine use by 1 percent with a treatment policy? Why are these two policies different in their impact? Please use the word elasticity in your answer.

Corresponding test question: *Many economists argue that treatment is more effective than enforcement in solving problems related to illegal drugs. Use a supply and demand analysis to explain why this can be argued for a drug such as cocaine.*

The JiTT experiment was conducted for two tests in each course. The results are shown in Table 1. As the table illustrates, although the prediction rate was greater than 50% for three of the four exams analyzed, none of the results were statistically significant (p-value = 0.308 for a two-tailed test of total prediction rate for all sections). That is, the experiment shows no statistically significant evidence of a link between student answers to test questions and prior completion of related JiTT assignments. One reason for this result may be the effect of class discussion in which students learned about the JiTT assignment completed by students from the other group.

(3) JiTT in Economics at North Carolina A&T State University

At North Carolina A&T State University introductory principles courses are also taught in a two-semester sequence, Principles of Microeconomics and Principles of Macroeconomics. This analysis covers students who were enrolled in two sections of the Principles of Macroeconomics course during the fall, 2002 semester. Students in each section were randomly divided into two groups (A and B) at the start of the semester, so that each section had approximately the same number of students in each group. Prior to the first exam, students in Group A completed four JiTT assignments, while those in Group B completed alternative assignments (two-page *Economic Issues* articles that asked students to summarize and comment on a macroeconomics-related current-event issue); following the first exam the groups switched assignments, with Group B completing three JiTTs and Group A completing *Economics Issues* articles; following the second exam the groups switched back to their original assignments (with group A completing three JiTTs). Overall, JiTT assignments accounted for 5% of students' course grades, and as in the Glendale Community College case, completion rates were quite high.

The analysis in this experiment focuses on the relative exam scores of students from each group on the three "midterm exams;" each exam included one or two questions that were directly related to JiTT questions assigned since the previous exam (or start of the course in the case of exam #1). The null hypothesis is that students who completed the JiTT assignments during the period leading up to a particular exam will perform better on that exam, and in particular, on the JiTT-related questions included on that exam, than students who were in the non-JiTT group for

that period. One advantage of this experiment over the previous two is that we were able to collect a variety of student characteristics that help to more directly test the effects of JiTT on student learning.

Student characteristics of the students completing each of the three midterm exams during the fall, 2002 semester are listed in Table 2. For each exam, the characteristics are listed according to whether students were in the JiTT or non-JiTT group for that exam. Note that the overall sample size diminishes throughout the semester as students drop the course; while 57 students completed the first exam, only 38 students ultimately finished the course.⁶ There are some differences between the two groups that are noticeable in the table: Group A has a lower percentage of female students throughout the semester, as well as higher SAT scores, higher GPAs, and fewer credit hours completed. These factors may be responsible for Group A earning higher exam scores on each of the exams, even when Group A was not completing JiTT assignments (see the results for exam #2); however, group A scored slightly lower than group B on the JiTT-related exam questions when group B was completing JiTT assignments (exam #2). The differences in student characteristics across groups highlight the need to control for these variables, in particular students' knowledge entering the course (as captured by SAT scores and GPA), when examining the learning benefits of JiTT during the semester.

Regression Results

Tables 3a-3c report regression results linking student exam scores to JiTT assignment activity, as well as student characteristics, for each of the three midterm exams; the first four columns of Table 3a (the first five columns in Tables 3b and 3c) illustrate the relationship between JiTT participation and students' total exam scores, while the last three columns in Tables 3a-3c focus on the relationship between JiTT participation and students' scores on only JiTT-related exam questions. The results in Tables 3a-3c are summarized below:

Exam #1 Results (Table 3a): The first model simply repeats the results listed in Table 1 showing the difference in mean exam scores between the JiTT and non-JiTT group; the JiTT group scored 12 points higher on average. The second and third models examine how much of this difference is related to students' knowledge at the start of the course, measured by SAT scores and GPA. The result is a familiar one to researchers in economic education: the coefficients on the SAT and GPA variables are positive and significant – smart students do well. However, there is still a significant “JiTT-group effect,” although the size of the effect is smaller than a simple comparison of sample means suggests. The last model in this group adds a number

⁶ One student was dropped from the sample due to lack of GPA and SAT scores.

of student characteristic variables to the regression. The coefficients on the added variables in this model all have the expected signs, although none of them are statistically significant at the 10% level. The JiTT group variable retains its statistically significant positive coefficient, even after accounting for a more complete set of student characteristics. According to these results, it appears that JiTT exercises have a positive effect on learning, at least as measured by exam scores. This result is also illustrated in the final three models in Table 3a, which link students' performance on JiTT-related questions on the exam to participation in the JiTT group and students' GPA or SAT scores. Completing JiTT exercises has a positive effect on students' scores, although the effect is not statistically significant at the 10% level when SAT scores are included in the regression.

Exam #2 Results (Table 3b): If completion of JiTT exercises matters for student exam performance, then after reversing roles following exam #1, the non-JiTT group from exam #1 (group B) should perform better than the JiTT group from exam #1 (group A) on exam #2. However, as Table 2 illustrates, that was not the case; group A (the non-JiTT group for exam #2) outscored group B (the JiTT group for exam #2) by nearly 6 points. Perhaps the differences in SAT scores and GPAs, which are higher for group A, are responsible for this difference. The regression results in Table 3b indicate that these factors clearly matter. After accounting for SAT scores and other student characteristics, there is still a weak positive independent "JiTT-group effect," although the effect is not statistically significant at the 10% level (see model 4 results). Including students' exam #1 score in the regression model increases the importance of the JiTT-group effect, but it is still statistically insignificant at the 10% level (see model 5 results). The results for models 6 through 8 are similar, showing a positive, but statistically insignificant, relationship between students' completion of JiTT exercises and their performance on JiTT-related exam questions.

Exam #3 Results (Table 3c): The results for exam #3, with group A again completing JiTT assignments, are similar to those from exam #1, but the "JiTT-group effect" is more pronounced. This group scored over 20 points higher than the non-JiTT group, on average, on exam #3. The JiTT-group variable remains positive and statistically significant at the 5% level even after including the more complete set of student characteristics in the regression model. However, including students' previous exam scores reduces the significance of the "JiTT-group" variable significantly. The results are similar for models using JiTT-related exam scores as the dependent variable.

Summary: The regression results suggest that completing JiTT exercises prior to class has a positive effect on student exam performance, both on JiTT-related questions and overall.

However, as the exam #2 results indicate, JiTT participation does not explain the whole story of student exam performance. Students in the non-JiTT group performed better than students in the JiTT group on this exam, although there was still a weak positive JiTT-group effect when additional student characteristics were added to the regression model. One factor possibly contributing to the weakness of this effect on exam #2 is that students who participated in the JiTT group for exam #1 (group A) may have changed their study habits based on their JiTT participation, leading to a "residual JiTT effect" on exam #2 (and exam #3) that weakened the JiTT-group effect on this exam. Because of this possible residual effect, there may be reason to focus more on the results from exam #1, which obviously contain no such effects.

Student Perceptions of Effort and Learning

To better understand the role of JiTT exercises from students' perspectives, students were asked in an end-of-semester questionnaire to rate a variety of course activities in terms of "how helpful the activity was to learning in the course," and "how much effort the activity required" during the semester. Mean student responses (based on 38 students who finished the course) are listed in Table 4 (on a scale of 1 to 5, with 5 representing the "most helpful" or "most effort"). JiTT questions were rated as being important for students' learning in the course (on an absolute scale) but not quite as helpful as homework assignments and about as helpful as class lectures, various in-class activities, and overall use of web resources (including the Blackboard course management system) in the course. The numerical results are consistent with students' written comments - which were generally positive - some of which were included earlier in this paper. Students indicated that the JiTT component of the course should be retained in future semesters. In terms of effort required, students ranked JiTT exercises in the middle of the pack, relative to other activities in the course. Studying for exams and completing homework assignments, along with a month-long Federal Open Market Committee simulation project, were viewed by students as requiring more effort than JiTTs.

The finding that students viewed JiTTs as not requiring a great deal of effort, coupled with their view that they were important to learning, also led us to think about the relationship between student effort (or at least students' perception of that effort) and activities that were perceived to provide the most help in learning. That relationship, based on the results in Table 4, is illustrated in Figure 1, which also includes a fitted regression line through the plotted points. The fitted line clearly shows the positive correlation between students' perceived effort for various course activities and students' perceptions of those activities' aid to learning. Note in particular, that JiTT exercises appear to add greater than expected (according to the fitted regression line) benefit

to student learning for the level of effort required. These results suggest that JiTT exercises provide an efficient way of helping students to achieve greater learning.

What Have We Learned?

Overall, what have we learned from our experiments with Just-in-Time Teaching in the Principle of Economics course? The classroom results suggest that there is a small, measurable, positive effect on cognitive learning with JiTT-based pedagogy, although that effect varies across the three institutions included in this study. However, the strongest arguments for JiTT techniques are perhaps captured in the section outlining the general benefits of JiTT. We have found that students come to class better prepared, leading to more effective in-class discussions and activities than before we used JiTT, and we have a much better understanding of students' misunderstandings and misconceptions of economic concepts *prior to class*, providing the opportunity for meaningful "teachable moments" throughout the semester. We believe that the positive learning feedback loop generated by JiTT techniques helps to motivate students to take greater responsibility for their own learning and thereby increase their learning potential. While the measured effects of these benefits are difficult to capture - as is often the case when examining the cognitive effects of specific teaching techniques - our classroom experience suggests that they matter in our everyday experience. Students also believe, when asked, that they matter. We would like to see more instructors adopting JiTT-based pedagogy and sharing their experiences and results with the economic teaching and learning community; only then will we truly be able to determine the efficacy of JiTT's pedagogical structure.

References

To follow...