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

-Chinese Proverb as quoted by Benjamin Franklin
AGENDA

Preworkshop Warmup Responses
- Warmups: Why and How – Browsing of Resource
- JiTTPhilosophy and Architecture
- JiTT and Education Research
- Preparing a JiTT lesson
- JITT in the Classroom
- Extending JITT with Worked Examples
- Q&A
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Preworkshop Warmup - Responses
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an alternative

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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 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?
Features of this pre-class exercise

• 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.
Just-in-Time Teaching

Web delivered daily pre-class warmups

• inform the upcoming lesson and
• encourage the students to examine their prior knowledge and to get informed about the upcoming topic, before coming to class.
Timely pre-instruction warmup assignments inform the upcoming lesson and encourage the students to examine their prior knowledge and to get informed about the upcoming topic, before coming to class.

There is much flexibility as long as two crucial criteria are met:

The assignments are

• thoughtfully constructed and

• constitute an integral part of the lesson
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JiTT RESOURCES - BROWSING

134.68.135.20/JiTt_NMSU_workshop
Mathematics

In some sections of the textbook, "the derivative" refers to a specific number. In other sections, "the derivative" refers to a function. Explain the difference.
Statistics

Estimate the probability that a North American male is precisely six feet tall.
Physics

Please explain in your own words what a focal point is. Do this without referring to any particular device.
Biology

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 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?
After having completed the readings assigned for Session 2, read the summary of the reports on the International Astronomical Union's action regarding Pluto's planetary status. Then answer the following questions:

1. Does a change in how something is represented (the modeling domain) change the thing itself (the target domain)? More specifically, does a change in how Pluto is classified change Pluto itself?

2. Does a change in how astronomers represent the solar system undermine the validity of the story that science tells? Does it change "our truth", as the woman from Kansas contends?
Hamilton's Principle says that a dynamical system traces out a path that minimizes the time integral of the difference between the kinetic and potential energies. Please try to explain this in your own words. What is the "path of the system" to which the statement refers?
History

Imagine that you are preparing to write an essay on the ways that Christians in various ages reinterpreted the Book of Revelation and other biblical prophesies of the end of the world in terms of the issues of their own time.

Find a short passage in the excerpts from Klaassen’s *Living at the End of the Ages* that might be useful as evidence.

Briefly explain how this passage might be used in the essay.

Find a short passage of apocalyptic writing on the Web that might be useful as evidence.

Briefly explain how this passage might be used in your essay.
Fine Arts - Photojournalism

After two short readings on “The Fallen Soldier”

- Summarize in your own words the argument that the photo was staged, then summarize in your own words the argument that the photo is authentic.
- Which argument do you find more convincing? Why?
- In your opinion, does it matter whether or not this photograph was staged? Why or why not? This is chance to explore and articulate your ideas about the truth value of photography.
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Interactive Engagement - Active Learning

WHY?
How did I learn?

• courses my discipline?
• required classes not in my discipline?

Lecture classes I still remember: WHY?
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What keeps changing?

STUDENT DEMOGRAPHICS AND ATTITUDES

TECHNOLOGY

EDUCATION RESEARCH

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**MILLENNIALS**
A PORTRAIT OF GENERATION NEXT

Confident. Connected. Open to Change.

- are easily bored
- expect variety
- are self-directed
- have high levels of self-esteem
- are collaborative
- are ethnically diverse
- crave interactivity

“I think it is important and useful when you hear lots of different opinions and lots of different voices in the class.”

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The Millennials

• are the most diverse generation of students in U.S. history
• value discussions
• were raised in a child-centered society
• tend to prefer informal settings and endorse the norm of equality
• are relatively thin-skinned and reluctant to put themselves in a position in which they may look foolish, or even incorrect
• are team-oriented and sensitive to feeling judged or alienated by their classmates
The Technology

• Powerful Information Processing
• The Resource Richness of the Web
• 24/7 Communication
• Social Media
• Data Collection and Mining
EDUCATION RESEARCH

• Cognitive Science
• Educational Psychology
• Discipline - Specific Issues
• SoTL
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Passive vs Active
An Experiment at UBC

Experienced, award-winning, charismatic lecturer vs Two trained inexperienced instructors with research-based highly structured lessons

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pre-class reading  pre-class reading quiz

in-class clicker questions with student-student discussion SSD

small group active learning task ALT

targeted instructor feed back TIF

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Flipping the Classroom with Just-in-Time Teaching
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Flipping the Classroom with Just-in-Time Teaching
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www.nap.edu/books/0309070368/html/
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Assessment Centered

Ongoing assessments designed to make students' thinking visible to both teachers and students are essential... An important feature of assessments in these classrooms is that they be learner-friendly: they are not the Friday quiz for which information is memorized the night before, and for which the student is given a grade that ranks him or her with respect to classmates. Rather, these assessments should

- provide students with opportunities to revise and improve their thinking,
- help students see their own progress over the course of weeks or months, and
- help teachers identify problems that need to be remedied (problems that may not be visible without the assessments)
Knowledge Centered

The content knowledge necessary for expertise in a discipline needs to be differentiated from the pedagogical content knowledge that underlies effective teaching. The latter includes information about typical difficulties that students encounter as they attempt to learn about a set of topics; typical paths students must traverse in order to achieve understanding; and sets of potential strategies for helping students overcome the difficulties that they encounter...

Pedagogical content knowledge is not equivalent to knowledge of a content domain plus a generic set of teaching strategies; instead, teaching strategies differ across disciplines.
Learner Centered

Learner-centered teachers present students with "just manageable difficulties" - that is, challenging enough to maintain engagement, but not so difficult as to lead to discouragement.

They must therefore have an understanding of their students' knowledge, skill levels, and interests.
LEARNER CENTERED INSTRUCTION
Challenge and Support

“To be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation. Within this context, it is proposed that strategies promoting active learning be defined as instructional activities involving students in doing things and thinking about what they are doing.”

• Students construct knowledge through gathering and synthesizing information and integrating it with the general skills of inquiry, communication, critical thinking, problem solving, and so on.
• Emphasis is on using communicating knowledge effectively to address enduring and emerging issues and problems in real-life contexts.
• Professor’s role is to coach and facilitate.
• Professor and students evaluate learning together.
• Teaching and assessing are intertwined.
• Assessment is used to promote and diagnose learning.
• Emphasis is on generating better questions and learning from errors.
• Desired learning is assessed directly through papers, projects, performances, portfolios and the like.
• Approach is compatible with interdisciplinary investigation.
• Culture is cooperative, and supportive.

LEARNERS AND LEARNING STYLES

Felder-Silverman Learning Style Model

sensing learners (concrete, practical, oriented toward facts and procedures) or intuitive learners (conceptual, innovative, oriented toward theories and meanings);

visual learners (prefer visual representations of presented material--pictures, diagrams, flow charts) or verbal learners (prefer written and spoken explanations);

inductive learners (prefer presentations that proceed from the specific to the general) or deductive learners (prefer presentations that go from the general to the specific);

active learners (learn by trying things out, working with others) or reflective learners (learn by thinking things through, working alone);

sequential learners (linear, orderly, learn in small incremental steps) or global learners (holistic, systems thinkers, learn in large leaps).

http://www.engr.ncsu.edu/learningstyles/ilsweb.html

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TEACHING TO ALL TYPES - TEACHING AROUND THE CYCLE

Teach theoretical material by first presenting phenomena and problems that relate to the theory (sensing, inductive, global).

Balance conceptual information (intuitive) with concrete information (sensing).

Make extensive use of sketches, plots, schematics, vector diagrams, computer graphics, and physical demonstrations (visual) in addition to oral and written explanations and derivations (verbal) in lectures and readings.

To illustrate an abstract concept or problem-solving algorithm, use at least one numerical example (sensing) to supplement the usual algebraic example (intuitive).

Use physical analogies and demonstrations to illustrate the magnitudes of calculated quantities (sensing, global).

Occasionally give some experimental observations before presenting the general principle, and have the students (preferably working in groups) see how far they can get toward inferring the latter (inductive).

Provide class time for students to think about the material being presented (reflective) and for active student participation (active).

Encourage or mandate cooperation on homework (every style category).

Demonstrate the logical flow of individual course topics (sequential), but also point out connections between the current material and other relevant material in the same course, in other courses in the same discipline, in other disciplines, and in everyday experience (global).
Research Suggested Teaching Strategies

• Student-perceived relevance of the subject matter
• Clear expectations, practice, and feedback
• Appropriate tests
• Reasonable workload
• Choice over learning tasks
Research Suggested Teaching Strategies

A. Variety and choice of learning tasks
   1. Varied problem types
   2. Varied levels of assignment definition and structure
   3. Choice on assignments, tests, and grading policies

B. Explicit communication and explanation of expectations
   1. Instructional objectives covering high-level tasks
   2. Study guides and tests based on the objectives

C. Modeling, practice, and constructive feedback on high-level tasks
   1. Assignment of relevant tasks and modeling of required procedures
   2. Practice in assignments followed by inclusion of similar tasks on tests

D. A student-centered instructional environment
   1. Inductive learning
   2. Active and cooperative learning
   3. Measures to defuse resistance to student-centered instruction

E. Respect for students at all levels of development
   1. A sense of caring about students
   2. Awareness of and respect for current levels of development while promoting higher levels
Research Suggested Student Activities

Predicting outcomes

Interpreting and modeling physical phenomena

Generating ideas and brainstorming

Identifying problems and troubleshooting

Formulating procedures for solving complex problems

Formulating problems

Making judgments and decisions and justifying them
The "Ersatz Learning vs Genuine Learning" Challenge

• Students are motivated by the desire to survive rather than excel.
• If the course structure permits, it is more effective to cope than to learn.
• Students can study and pass without learning.
• Knowledge does not transfer.

Authentic Testing vs. Inauthentic Testing

An authentic test requires that the student performs some real task, similar to what that practitioners in the discipline perform.
Arteries
a. Are more elastic than veins
b. Carry blood that is pumped from the heart
c. Are less elastic than veins
d. Both a and b
e. Both b and c

VS
Imagine being asked to design an artificial artery--would it have to be elastic?
Why or why not?
Components of Intelligent Thinking (Perkins)

- raw brain power (brain as computer)
- content (context-specific content knowledge)
- tactics (repertoire of strategies to accomplish a given task)

The Notion of a Thinking Frame

- A guide to organizing and supporting thought processes
- content (context-specific content knowledge)
Frame Acquisition

- inventing your own
- soaking up from an enriched environment
- by direct instruction

Research suggests

- Soaking does not occur.
- Modeling, without explicit pointing to the principles modeled leads to little or no learning.
- Instruction should, explicitly, teach frames and/or promote frame invention
Research-Based Pedagogies

Inductive vs Deductive
• Students grapple with content before instruction
• pre-class work
• student-response-based lessons

Active Learning
• Students actively participate in class

Collaborative Learning
• Students work in teams
Cooperative Learning
Students work in teams on structured assignments

Process Oriented Guided Inquiry Learning (POGIL)
A research based learning environment where students are actively engaged in mastering course content and in developing essential skills by working in self-managed teams on guided inquiry activities.

Studio Approach
Student work at workstations, supervised by graduate students. There may be an occasional lecture. This is similar to Cockpit Physics that we tried at USAFA in 1995.

Peer Led Instruction (pioneered at Dickenson as Workshop Physics, not to be confused with Peer Instruction)
Students work in small groups on very structured assignments. The groups are led by specially trained undergraduates from previous semester classes.

Peer Instruction (pioneered at Harvard by Eric Mazur)
Students vote on answers to a question, discuss in small groups and re-vote. Can get very sophisticated with clicker software and clever questions.

Tutorials (pioneered at University of Washington)
Groups of students, led by a trained graduate students, interact in Socratic dialogues. Can be watered down to group worksheet work with little or no supervision.
Inductive Pedagogies

Just-in-Time Teaching - JiTT
Students do lesson preparatory work that becomes the basis for in-class activity. There is a lot of flexibility in how the JiTT assignments are constructed. There are, however, two critical JiTT requirements:
1. There must be a carefully constructed assignment for students to complete before every lesson.
2. Student work must have a prominent role in the lesson activities.

Inquiry-based
Students are presented with a challenge – a question, an observation, a data set, a hypothesis to be tested. They accomplish the learning by responding to the challenge.

Problem-based (PBL)
Students, working in teams, are presented with an ill-structured open-ended real-world problem to solve. They formulate and evaluate alternative solutions, select the best one and make a case for it. Instructor acts as a guide.

Project-based
Students work an assignment to produce a product; a process or product design, a computer code or simulation. The outcome is a report.

Case-based
Students study historical or hypothetical cases involving scenarios likely to be encountered in professional practice.

Discovery
Students are confronted with a challenge and left to work out the solution on their own. The instructor provides feedback but little or no direction. A variant is guided discovery.
Cooperative Learning

TEAM WORK UNDER CONDITIONS THAT MEET THE FOLLOWING CRITERIA:

Positive interdependence. The team members must rely on one another to accomplish the goal.

Individual accountability. Each team member is held accountable for doing his or her share of the work and for all of the material in the assignment, regardless of who was principally responsible for it.

Face-to-face interaction, at least part of the time. Some or all of work must be done by members working together (as opposed to parceling out the assignment to individual members and putting the completed pieces together without discussion).

Appropriate use of interpersonal skills. Team members must practice and receive instruction in leadership, decision-making, communication, conflict management, and other critical teamwork skills.

Regular self-assessment of group functioning. The team members periodically reflect on what they are doing well as a team, what they could improve, and what (if anything) they will do differently in the future.
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How concepts develop?

explorations
to intuitive rule-based reasoning
to explicit rule-based understanding

If I add a bulb in a series circuit all bulbs will shine less brightly.

At a node in circuit the current splits into several paths.

Whenever and object changes it movement a force is exerted on the object.
HOMEGROWN

Lightning never strikes the same place twice

Color is inherent to an object, e.g. a red book.

Current is a substance, stored in a battery, consumed by a lamp (like a fuel.)

Most body heat is lost through a person's head.
Globalizing Inequality: ‘Centrifugal’ and ‘Centripetal’ Forces at Work

“An interesting model of economic geography must include both centripetal and centrifugal forces. The corresponding spatial equilibrium is then the result of a complicated balance of forces that push and pull consumers and firms until no one can find a better location.”
RESEARCH GUIDE TO INTERVENTION STRATEGIES

Scientific explanations are counterintuitive.

Directly confronting misconceptions typically fails

If instruction wants students to understand a particular concept, the students need to discover this concept at least intuitively before they are likely grasp related conceptual information.

Some misconceptions explicitly point to misleading or missing experiences which, in turn, have to be made during instruction.
Learning $\Rightarrow$ Conceptual Change

Assimilation

Accommodation

Acceptance is easier if the new concept is
• intelligible (student is able to understand)
• plausible (makes sense)
• fruitful (having the potential to solve new problems)
What is a good JiTT question?

• yields a rich set of student responses for classroom discussion
• requires an answer that cannot easily just be looked up
• encourages the student to examine his/her prior knowledge and experience
• requires that the student formulate the response, including the underlying concepts, in his/her own words
• contains enough ambiguity to require the student to supply some additional information not explicitly given in the question. (This feature enriches the subsequent classroom discussion.)
targets a conceptual bottleneck
spawns a wide range of creative responses
is just outside the comfort zone
connects to many parts of the lesson content
is extendable
is memorable
• prepares for a discussion of a complex, possibly controversial topic
• creates a need to know. Good questions are sufficiently captivating so that even weak students may be interested in the answer
• goes beyond the bare definition
• encourages metacognition
Constructing good JiTT questions?

• The Arons List
• Learning Taxonomy
• Learner Maturity
• Decoding Cycle
The Arons List

Unrealistic expectations that students can

- Perform Qualitative, Phenomenological Reasoning or Thinking
- Paraphrase a Paragraph of Text
- Understand the Need for Operational Definitions
- Translate Words into Written Symbols and Written Symbols into Words
- Draw Inferences from Data and Evidence
- Discriminate Between Inductive and Deductive Reasoning
- Check Inferences, Conclusions, or Results
# Cognition and Knowledge Taxonomy

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LEARNER MATURITY

Baxter Magolda

Absolute knowing. Knowledge is viewed as certain. Teachers are the authorities; learning is about facts; all points of view are either right or wrong. Teachers must communicate knowledge and the students must memorize and repeat.

Transitional knowing. Some knowledge is uncertain. Authorities don’t know everything and are expected to provide more information about the applicability of knowledge. Learners are focused on understanding knowledge rather than simply acquiring it.

Independent knowing. Knowledge is mostly uncertain. The learning environment is supposed to reward thinking and logic over particular views and opinions.

Contextual knowing. The legitimacy of knowledge claims is depends on the context. The learner constructs a point of view, but must have supporting evidence.”


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From Novice To Expert

Flipping the Classroom with Just-in-Time Teaching
Gregor Novak - USAFA and IUPUI

Decoding the Disciplines: Helping Students Learn Disciplinary Ways of Thinking
David Pace
Joan Middendorf
EDITORS

New Directions for Teaching and Learning

New Mexico State University - January 31, 2014
An example from introductory physics

Everyday words often have different meanings in physics:

- position, displacement, velocity
- focus, image, magnification
- interference
- potential
Another type of bottleneck - a stretch to far

Suppose a swimming pool has two drains. Drain A takes three hours to empty the pool. Drain B takes six hours to empty the pool. How long does it take to empty the pool if both drains are open?
Suppose a swimming pool has two drains. Drain A takes three hours to empty the pool. Drain B takes six hours to empty the pool.

What fraction of the pool does drain A empty in one hour?
What fraction of the pool does drain B empty in one hour?

How long does it take to empty the pool if both drains are open?
Mining the Responses

Student responses fall into a set of categories. Select representative examples. Don’t ignore the comments.

Revise the lesson flow in light of the actual responses. The fact that the wording actually comes from the class makes the lesson fresh and interesting to the students.

Go to class and be ready to improvise if necessary. The lesson flow is pretty much predetermined, but the words used in class will flow from the student responses and, most importantly, will be influenced by the feedback from the live class.
Building on Student Responses

- Group the responses
- Select representatives
- Respond to issues raised by
  - mini-lecture
  - group activities
  - clicker activities
  - demos
Weaving the Responses into the Lesson
adapted from Andy Gavrin

• Always show some good answers, not just weak ones
• Always be positive, never be critical.

Some specific comments:
• "This makes sense, but it is missing something...."
• "This is all true, but what if something else occurs simultaneously...."
• "This is correct, but for the reason isn't quite right...."
• "This is a great response...."

Other useful phrases:
• "This has a great beginning, but there is more that could be added...."
• "This is a great answer, but to a different question...."
• "This is the right idea, but I think the person meant something slightly different here...."
Weaving the Responses into the Lesson

Extensions:

- Ask students to extend or respond to one another's responses
- Ask the class "What part of this is completely correct."
- Ask the class "Under what circumstances would these be correct?"
- Ask the class "What word or two could be changed to fix this completely?"
- Ask the class "What is particularly good about this response?"

Expansion:

- Ask students to expand the scope of the question
- Ask the class "Is this true for other cases? Which?"
- Ask the class "When is this statement false? What happens then?"
- Ask the class "Is this similar to something we have done before? What?"

Comparison:

- Two very different answers, not obviously exclusive:
  - Ask if they are exclusive
  - Two obviously exclusive answers:
    - Ask for a vote on which is correct
    - Do some analysis
Combining with Other Techniques

Inductive Pedagogies
• Inquiry-based
• Problem-based (PBL)
• Project-based
• Case-based
• Discovery
• Just-in-Time Teaching

Interactive Engagement
• Process Oriented Guided Inquiry Learning (POGIL)
• Studio Approach
• Peer Led Instruction (not to be confused with Peer Instruction)
• Peer Instruction
• Tutorials
Extending JiTT with Worked Examples

• New material is introduced via carefully crafted worked examples of problems.

• Students study worked examples and try to construct a rudimentary version of the conceptual knowledge.

• In-class time is spent in elaborating on the self-constructed knowledge and firming it up.

• After the lesson students work additional homework problems
SELF-EXPLANATION

- A self-explanation is a comment about an example statement that contains domain-relevant information over and above what was stated in the example line itself.

- In an intervention study, Chi et al. found that high-ability and average-ability students benefited equally from being prompted to generate self-explanations.
Does It Work?

We look for:
Cognitive Gains - Deeper Learning
Study Habits and Time Management
Attitudes and Motivation

We use:
Standardized Tests
Surveys
Focus Group Interviews
# Learning Gains

**Intro Biology - Kathy Marrs**

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**Intro Physics - Duane Pontius**

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Learning Gains - Deeper Probing

Five Semester Study by Sarah Formica and colleagues at North Georgia.

Students’ transition from Common Sense (CS) to Newtonian Thinking

Four Force Concept Inventory Questions

Conceptual gain
37.6% vs 17.9%

Newton’s threshold
51% vs 6.6%.
Flipping the Classroom with Just-in-Time Teaching
Gregor Novak - USAFA and IUPUI

Study Habits - Time Management

Intro Biology - Kathy Marrs

<table>
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<tr>
<td>A students</td>
<td>16%</td>
<td>44%</td>
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<tr>
<td>B students</td>
<td>34%</td>
<td>63%</td>
</tr>
<tr>
<td>C students</td>
<td>41%</td>
<td>65%</td>
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<tr>
<td>D students</td>
<td>64%</td>
<td>71%</td>
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<tr>
<td>F students</td>
<td>68%</td>
<td>69%</td>
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Attitudes - Motivation

"Opportunities for feedback should occur continuously, but not intrusively, as a part of instruction."

Climate Question Example:

Below is a space for your thoughts, including general comments about today's assignment. What was hard or confusing (or cool)? What would you like to spend extra time on in class?
Students on JiTT

• If you want to get the grade for it you have to do it. So this helps students get rid of the procrastination and get the work done.

• Sometimes they are difficult, and they take a long time to cover in class the next day. This then subtracts from more in-depth learning.

• The biggest advantage to the Just-in-Time questions is that they provide a way for you to honestly figure out where you are in the course and it sometimes is nice to see those percentages of the people who picked the same answer as you (right or wrong).

• We did the work to answer the questions, and that work was meaningful, but perhaps the JIT questions could be taken from a source other than our textbook? That way, the questions would require more thought because they would be novel.

• We are given the just in time questions on things that we go over the next day. I feel that we should go over the topics, then get the just in time questions that night so that we can actually see if we understand the what we learned in class.
Best JiTT Practices

- Let students know that JiTT will be used, why, and how it works.
- Use it regularly
- JiTT counts toward the final grade
- Include climate questions
- Write questions with learning sciences in mind
- Look for patterns in responses
- Link responses to in-class activity
- Use JITT questions on exams - use responses in distractors
- Keep JiTT short and manageable
- Ask students how they reached their answers
- Make responses easy to submit and manage
- Grade for effort - make clear what a quality response looks like
- Provide personal feedback as much as possible
Instructor Challenge

• Be prepared for a trial and error period while adapting existing JiTT materials and creating one’s own
• Be sensitive to students’ ideas, attitudes, and state of knowledge and constantly monitor the progress of their learning
• Have a good grasp on the material and have a repertory of conceptual pathways for the subject matter at hand to be able to appreciate and respond to students’ ideas
• Be creative and able to develop learning tasks to support this kind of learning, and
• Be able to maintain a classroom climate where everybody is free to participate without the experience degenerating into frustrating chaos.

New Mexico State University - January 31, 2014
Flipping the Classroom with Just-in-Time Teaching
Gregor Novak - USAFA and IUPUI

THANK YOU

New Mexico State University - January 31, 2014