WebScience: Assessment of Just-in-Time Teaching at IUPUI

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Abstract

The purpose of the WebScience project, funded by NSF through the Physics Department at IUPUI, is to extend the use of “Just-in-Time Teaching (JiTT)” methods to courses in science and mathematics. The centerpiece of the JiTT strategy is to use feedback between the Web and classroom to increase interactivity, teamwork, and rapid response to students’ problems. Currently, the project includes undergraduate courses in Biology, Chemistry, Mathematics, and Physics. With JiTT strategies faculty adopt student-centered classroom activities that promote active learning. This paper presents efforts to use a mixed-method approach in conducting formative and summative evaluation for JiTT at IUPUI.
Introduction

Just-in-Time Teaching (JiTT) is a pedagogical strategy for using the World Wide Web to help create an active or interactive learning environment in the classroom. Developed at Indiana University Purdue University Indianapolis (IUPUI) and the United States Air Force Academy, JiTT is a method that helps engage students in their academic work and thereby enhances classroom activities. The WebScience grant, funded by the National Science Foundation (NSF), seeks to build on the success of JiTT in physics by extending the use of JiTT to other courses in science and mathematics. Currently, the project includes courses in Biology, Chemistry, Mathematics, and Physics, mostly at the undergraduate level. The purpose of this paper is to provide a brief assessment of the WebScience project as part of the evaluation work conducted for the NSF grant over the past two years.

The assessment component for the project brings with it several innovations including the use of the World Wide Web to deliver curricular and training materials for participants engaged in science courses at IUPUI, the application of inventive assessment methods and instruments that facilitate an assessment of the impact and effectiveness of the JiTT strategy. The ongoing assessment activities described in the present paper involve collaboration between the IUPUI Testing Center and faculty using JiTT in conducting assessment of student learning outcomes and other related formative and summative evaluation activities in support of the grant. More specifically, the IUPUI Testing Center provides assessment and evaluation support through the development and/or refinement of appropriate curricular and training materials aimed at guiding faculty in the assessment of student learning outcomes, and assist evaluators to conduct classroom observation and focus groups to obtain a view of the climate, rapport, interaction, and functioning of JiTT classes. The present paper will include an illustration (with specific examples of both quantitative and qualitative outcomes) of sound assessment tools (i.e., attitude surveys, classroom observation instruments, and focus group protocols) that should help participants using JiTT to document the effectiveness of the JiTT strategy in their respective courses. Thus, using a mixed-method approach, participants should be able to collect relevant quantitative and qualitative information that provides evidence of the adequacy and effectiveness of the JiTT strategies in facilitating interactivity, teamwork, or
collaborative learning among students and faculty. Following examples of instruments that will be presented, participants will be encouraged to employ a variety of data collection methods that include pre- and post-course attitude surveys, classroom observation rating scales, post-observation questionnaires, focus groups, content analysis of existing documents, and achievement tests. In discussing project findings to date, participants using the JiTT method should obtain comprehensive or integrated assessment and evaluation information that facilitate continuous improvement of the JiTT strategy in academic settings.

What is JiTT?
Just-in-Time Teaching is a teaching and learning strategy that consists of two components: classroom activities that promote active learning and World Wide Web resources that are used to enhance the classroom component. More specifically, JiTT involves a fusion of high-tech and low-tech elements. The high-tech element involves use of the World Wide Web to deliver curricular materials and to manage communication among faculty and students. The low-tech element calls for faculty to maintain a classroom environment that emphasizes personal instructor-student and student-student interaction. This fusion of high-tech and low-tech elements produce a learning environment that students find engaging and interactive. Most importantly, instructors use JiTT to combine high-speed communications on the Web with their ability to adjust content, thereby making classroom activities more efficient and more closely tuned to meet students’ needs. The essential element in JiTT is the establishment of a feedback loop between the web-based and classroom activities. Essentially, it is the feedback between the Web and classroom activities that increases interactivity and allows rapid response to students’ academic problems.

Just-in-Time Teaching, as developed and implemented at IUPUI, could be summarized as follows: The JiTT system is built around web-based preparatory assignments called “Warm-Ups”, which are exercises due a few hours before class. The students complete these assignments individually, at their own pace, and submit them electronically. Upon reading through the students’ responses before class, faculty then adjust and organize the classroom lessons in response to the student submissions “Just-in-Time.” This establishes a feedback
loop between the classroom and the Web. Each lecture is preceded and informed by an assignment on the Web. The feedback cycle occurs several times each week, encouraging students to stay current and to do so by studying in several sessions that are short enough to avoid fatigue (Novak, Patterson, Gavrin, & Christian, 1999). The interested reader may obtain detailed information including examples of Warm-Ups and other web-based resources (e.g., “Puzzles”, “Good Fors”, News or information and communication pages) from the respective course websites:

- Physics 152 & 251:  
  http://webphysics.iupui.edu/introphysics.html

- Biology N100:  
  http://www.biology.iupui.edu/biocourses/N100/index.htm

- Chemistry 105:  
  http://webphysics.iupui.edu/webscience/courses/chem105/chem105home.html

- Mathematics M118:  
  http://webphysics.iupui.edu/webscience/courses/mathm118/mathm118home.html

The main instructional objectives for JiTT are as follows:

- Encourage frequent, short study sessions
- Connect textbook to the real world
- Encourage the development of critical thinking, estimation skill, and the ability to deal with ill-defined problems, and
- Develop cooperative work habits and communication skills.

(Detailed information about Just-in-Time Teaching is available at the following website: http://webphysics.iupui.edu/jitt.html.)

Assessment of JiTT

Overall, the purpose of the present evaluation effort was to address the following formative and summative evaluation questions:
Assessment of JiTT at IUPUI (Track 4)

1. To what extent is the JiTT strategy helping students?
2. In what specific areas is the introduction of JiTT making an impact in facilitating teaching and learning in science and mathematics courses?
3. In what ways can the JiTT courses be significantly improved?

It is worth mentioning that discussion of other major evaluation issues of the JiTT project such as sustainability, transferability of the JiTT strategies to new courses in various academic disciplines, dissemination of the existing work, benefits and obstacles to implementation of JiTT, and development of a clear focus for ongoing faculty development activities are beyond the scope of the present paper. However, the interested reader may obtain detailed information about evaluation issues by perusing the online documents available at: http://webphysics.iupui.edu/webscience/assessment.html.

Methodology

Participants. The present report is based on the use of Just-in-Time Teaching in science and mathematics courses at IUPUI (namely Biology, Chemistry, Physics and Mathematics). During the 2000-2001 academic year, the classes that participated in the JiTT project include Contemporary Biology (N100), Principles of Chemistry (C105), Mathematics (MATH M118, Finite Mathematics and MATH 164, Integrated Calculus and Analytic Geometry), and Physics (PHYS 152 - Mechanics and Sound and PHYS 251 - Heat, Electricity and Optics). Although most students take only one course using JiTT in a semester, there are cases where some students enrolled in two JiTT courses in a semester (e.g., Chemistry and physics, or Physics and Mathematics). The target pool of participants for the pre- and post-course surveys included all students enrolled in the respective science and math courses. However, for purposes of obtaining qualitative assessment data, students who either completed the “Physics JiTT course exit surveys” and/or participated in student focus groups comprised a convenience sample from a pool of all students who enrolled in the respective science and mathematics courses that participated in the present three-year JiTT project.

Instruments. Several instruments were developed and administered during the course of the present study, particularly to obtain assessment data in three broad areas: student attitudes, student cognitive gains, and
course attrition rates. The respective instruments used in the present study included a set of pre- and post-course surveys, classroom observation tools, student focus groups, and a standardized achievement test (or a departmental common final examination).

**Student Attitudes Surveys.** Pre- and post-course attitude surveys were designed to assess student attitudes before and after taking the respective JiTT courses in science and mathematics. The pre- or post-course survey consists of 30 items and is categorized into six sub-scales: confidence, expectations, rapport, study skills, group work, and computer. Preliminary reliability (alpha) coefficients for the sub-scales (based on an initial analysis of the post-course surveys administered to the fall 2000 cohort) ranged from $\alpha = .49$ for study skills to $\alpha = .90$ for group work.

Note that prior to fall of 2000 when use of pre- and post-course surveys was introduced, students who took Physics courses completed anonymous end-of-semester surveys that were designed to solicit their opinions and thoughts about their courses in general and JiTT in particular.

**Classroom Observation.** The purpose of classroom observation was to obtain a view of the climate, rapport, interaction, and functioning of the JiTT classes in the respective science and math courses. Through classroom observation, we collected some relevant information pertaining to the adequacy and effectiveness of the JiTT strategy that facilitates interactivity, teamwork, or collaborative learning among students and faculty.

**Student Focus Groups.** A focus group protocol was developed for the purpose of evaluating the impact and effectiveness of JiTT course activities (including use of Web resources) and instruction in support of teaching and learning in science and math courses at IUPUI. A primary goal of the focus group was to obtain students' perspectives and experiences regarding use of web-based resources to enhance teaching and learning, particularly with respect to making classroom activities more interactive, efficient, and more appropriate for meeting their academic needs. Also, the focus group was an attempt to gather student reaction and assessments with reference to the strengths and weaknesses of the course activities they participated in as part of JiTT course activities, and also to identify ways to improve JiTT courses at IUPUI.

Further details on the assessment of JiTT at IUPUI including copies of evaluation instruments used in the
present study are available online at the following URL: 

Procedure. A preliminary student focus group, conducted by the principal evaluator and two evaluation assistants (graduate students hired by the IUPUI Testing Center) during fall of 2001, was tape-recorded after each participant’s consent was obtained. The two evaluation assistants helped in transcribing the tape-recorded focus group protocol. The Physics post-course surveys were administered in spring of 1998 (92% responses), fall of 1999 (54% responses), and spring of 1999 (76% responses). Note that the Physics 251 post-course survey was administered anonymously to students who enrolled and completed the course, but not all students completed and/or returned the questionnaire; hence the nonresponse problem is a serious limitation. Although efforts were made to increase the survey response rate by granting extra course credit to students who completed and returned the surveys, some students did not take advantage of this offer.

The conduct of the present evaluation activity was guided by the program evaluation standards (see Joint Committee on Standards, 1994).

Data collection methods consisted of both qualitative and quantitative methods (i.e., mixed-method approach) including:

- Document review (previous annual reports, articles, workshop/conference presentations, book and related material posted at the website for the JiTT project were reviewed for purposes of identifying key evaluation issues including learning outcomes pertaining to course attrition rates, student cognitive gains, and student attitudes toward science and math courses at IUPUI)
- Student attitude surveys or end-of-semester surveys for students enrolled in JiTT courses at IUPUI
- Classroom observation of JiTT classes, and
- Focus Groups for students who completed JiTT courses at IUPUI

Because of the relatively low participation rates for the student focus groups, the data obtained from surveys formed the primary basis of the findings and discussion of the present evaluation study. However, because of the unrepresentative nature of samples obtained in the present study, the results of the student surveys ought to be interpreted with caution. Similarly, results of the focus
groups are somewhat lacking in completeness simply because the few students \((n = 5)\) who participated in the initial process comprised a sample of convenience. However, use of method and data triangulation helped to improve credibility of the evaluation findings reported in the present paper.

**Data Analysis.** The primary purpose of data analyses conducted for the present study is to assess how well JiTT works in teaching science and mathematics courses at IUPUI. As previously mentioned, the JiTT strategy is designed to encourage both attitudinal and cognitive gains among students and faculty. Thus, assessment efforts were focused on three broad areas: (a) assessment of the impact of JiTT on course attrition rates, (b) assessment of student cognitive gains as reflected in student performance on achievement tests and end-of-semester course grades, and (c) assessment of student attitudes, opinions and thoughts about their courses in general and JiTT in particular. In the course attrition area, we provide appropriate data and results that compare course attrition rates prior to and since the adoption of JiTT-based courses at IUPUI. With respect to the assessment of cognitive gains, we provide some findings that compared students' academic performance in JiTT and traditional ("no JiTT") classes based on a standardized achievement test or common final examination administered to students by faculty who participated in the present project. In the student attitude area, students were asked to complete pre-course and post-course attitude surveys that included six sub-scales: students' perceived confidence, expectations, rapport, study skills, group work, and computers. The survey data was analyzed using some basic descriptive (mean and standard deviation) and inferential statistics (e.g., \(t\)-test). Note that for each sub-scale, delta was calculated to examine change in students' attitudes between pre- and post-course survey data.

The qualitative data from end-of-semester surveys administered to Physics 251 students in spring 1998, fall 1999 and spring 1999 semesters were analyzed using both qualitative and quantitative approaches that included content analysis, formulation of coding categories, and use of frequency counts and/or percentages of occurrences (Fraenkel & Wallen, 2000; Miles & Huberman, 1994; NSF, 1997). A detailed description of content analysis is presented elsewhere in the literature on qualitative data analysis (e.g., see Bader & Rossi, 1999; Krueger, 1997; Krueger & Casey (2000); Miles & Huberman, 1994).
Results

Assessment of JiTT (particularly in physics courses) has focused on three broad areas: (1) course attrition rates, (2) student attitudes, and (3) student cognitive gains, as reflected in academic performance in the respective JiTT courses. With respect to the attrition/withdraw area, a comparison was made in course attrition rates after the adoption of JiTT-based courses at IUPUI in contrast to those before introduction of JiTT. Overall, preliminary results in Physics courses suggest that attrition at IUPUI has dropped by approximately 40% in each of the two Physics courses (PHYS 152 and PHYS 251) since the inception of JiTT-based courses in the introductory sequence. As Novak, Patterson, Gavrin, and Enger (1998) report in their paper:

“At IUPUI, one of the clearest quantitative indicators of the effect of the JiTT strategy is in the calculus-based introductory course attrition rates, which have fallen from 47% to 32% in the first semester course and from 37% to 18% in the second semester course, averaged over the three semesters of JiTT implementation” (p. 3).

Table 1 shows the attrition rates for the two Physics courses (PHYS 152 and 251) for the past several semesters at IUPUI. For Physics 152, the overall “DFW” rate has dropped from 48% (no JiTT) to 29% (with JiTT), which reflects a 19% decrease in the attrition rate. Likewise for Physics 251 the overall DFW rate prior to using JiTT was 33% and dropped to 17% when JiTT was used, which reflects a 16% decrease overall. These results are based on five semesters without JiTT (Spring 1994 to Spring 1996) and ten semesters with JiTT (Fall 1996 to Spring 2001). Figures 1 and 2 provide a summary of attrition rates based on the first semester Physics 152 course and second semester Physics 251 course, respectively. The results shown in Figures 1 and 2 reflect a noticeable drop in attrition rates due to introduction of the JiTT strategy in the respective Physics courses. As part of the evaluation of progress to date on the present NSF-funded WebScience project, Hake (2001) provides a more detailed discussion on the impact of JiTT in Physics courses at IUPUI.
In addition to a decrease in attrition rates in introductory physics, student enrollment in both courses has increased (Department of Physics Annual Report, July 1999; Novak et al., 1999).

In the student attitude area, preliminary quantitative data from pre- and post-course surveys suggest that JiTT has a potential of impacting positively in changing student attitudes; but more quantitative data are needed to establish a specific pattern and/or to determine both practical and statistical significance of the results to date. However, preliminary data obtained from students who completed anonymous end-of-semester surveys or pre- and post-course surveys indicate overwhelmingly positive ratings for JiTT courses. More specifically, 94% of the respondents indicated that Warm-Ups were a good idea. Also, a majority of students commented repeatedly that Warm-Ups helped them to learn rather than memorize the course material, they were better prepared for class, and that Warm-Ups helped students to keep up with material throughout the semester.

For instance, when students were asked "If you could pick your instructor and you had a choice between two equal instructors, except that one instructor used Warm-Ups and the other didn't, which instructor would you pick?" 91% of the respondents preferred the instructor who used Warm-Ups. High approval ratings for JiTT courses are corroborated by overall focus group results, in which most students report that the use of web-based resources such as "Warm-Ups", "Puzzles", and "Good Fors" are very helpful in facilitating the learning process. Although it is difficult to provide empirical data that show a direct causal relationship between use of web-based resources and improvement in students' cognitive skills, students' self-reported data suggest that JiTT has a positive impact on learning as well as their attitudes toward the respective courses. For
instance, one student provided the following comment about Warm-Ups and Puzzles:

I do find the warm-ups and puzzles beneficial to learning the subject. I’ve had them for CHEM 105, MATH 164, and PHYS 152. The warm-ups provided me with two main benefits. First, they can help get my mind geared up for what's going to be talked about in the lecture (which often involves reading ahead in the chapter to understand what the question is even about). This also gets me more involved in the lecture because I already have a little background to the day's subject. Second, they provide a way to get some extra points to help out with my grade. That's always a plus. The puzzles are similar, except they make you think even a little more deeply about the subject. This is good, because it often forces you to look at the material from a different angle, which helps in grasping the subject at a deeper level.

The overall theme portrayed in the preceding paragraph was echoed by many students who perceived JiTT to be an effective teaching strategy. The survey results obtained to date in physics courses suggest that JiTT helps to improve students’ study habits by discouraging cramming and encouraging daily work as well as facilitating development of practice skills that enhance the learning process (i.e., analytic thinking, estimation skills, ability to address ill-defined problems, communication, and teamwork).

Likewise, initial assessment data for the JiTT-based Biology course (N100) suggests that the use of Warm-Ups is beneficial to “successful” students (i.e., students who earned grades C or higher in the course), in that they felt the Warm-Ups helped them stay “caught up” with the course material. Overall, the initial report suggests that Just-in-Time Teaching has a positive effect on students’ study skills, particularly for students earning C or higher grades in the course (Department of Biology, June 2001 Annual Report; online document is available at: http://www.planning.iupui.edu/prac/2000-2001reports/Biology.html)

As additional assessment data are collected for the duration of the WebScience project, our ultimate goal is to compare student attitudes toward the respective science and math courses before and after students complete the JiTT
courses. Thus, an extension of the student attitudes study that is currently underway is aimed at obtaining data that will enable us to compare student attitudes between those who enrolled and completed JiTT courses and those who completed the conventional “no JiTT” courses.

With respect to students’ cognitive gains, preliminary results in Physics indicate that students in JiTT-based courses score well above students in traditional courses, as reflected in students’ performance on the Force Concept Inventory (FCI), a nationally recognized test designed to gauge students’ conceptual understanding in Physics 152 (Department of Physics Annual Report, July 1999). Overall, initial results suggest that “student FCI test scores increase nationally 23% for traditional courses but increase 48% for interactive engagement courses.” ... At IUPUI, students’ scores on the Force Concept Inventory increase by 35% to 40% (Department of Physics Annual Report, July, 1999). The average gain reported in Physics courses taught between fall of 1998 and spring of 2000 is 30% (see Department of Physics Annual Report, June 2001), which reflects a remarkable improvement in students’ cognitive gains that could be attributed to use of JiTT strategy in teaching Introductory Calculus-based Physics. A complete summary of “DFW rates” in Physics 152/251 (from spring 1994 to spring 2001 semesters) is presented in the online annual report for the Department of Physics (http://www.planning.iupui.edu/prac/2000-2001reports/Physics.html). We hope that ongoing research in this area will continue to show positive effects of JiTT on teaching and learning.

Discussion

The present section addresses the evaluation questions posed at the end of the introduction section of this report, particularly with reference to the effectiveness and/or impact of JiTT in teaching science and math courses at IUPUI. One major feature of the JiTT strategy is its ability to use feedback between the Web and classroom to increase interactivity, teamwork, and rapid response to students’ problems. By using the JiTT strategy, faculty and instructors adopt student-centered classroom activities that promote active learning among students. In particular, students like JiTT-based courses partly because the instruction students receive is based on “real-world” information; this facilitates understanding and application of new concepts covered in the respective courses. From an educational perspective, it was noted that students engaged
in solving real challenges as part of classroom instruction, which made their learning more immediate and transferable. In turn, through use of web-based exercises, faculty could learn about student’s prior knowledge as well as identify common misconceptions among students (i.e., incorrect interpretations or misunderstandings of ideas, concepts, or processes). Indeed, when one considers the wide variety of JiTT-related literature that exists to date (e.g., Hake, 2001; Novak, et al., 1998; Novak, et al., 1999; Department of Biology, June 2001 Annual Report; Department of Physics, 1999, 2001 Annual Reports), the impact of JiTT as a pedagogical method is unequivocal.

Concluding Remarks

The JiTT project, funded by the National Science Foundation, was designed to promote the active learning and interactivity among students and faculty engaged in science and mathematics courses at IUPUI. More specifically, JiTT has brought together high-tech and low-tech elements that produce an active learning environment that students find engaging and instructive. Most important, JiTT employs a seamless feedback loop between the Web and the classroom to increase interactivity and allow rapid responses to students’ questions. Instructors and students are nurtured in a multi-dimensional environment and equipped with academic knowledge that includes a hands-on approach to understanding concepts and how they can utilize Web technology to explore and solve real-world problems. Also, as course instructors adopt a student-centered learning approach, students learn the course material while being challenged with contemporary problems; hence the notion of learning by doing. Consequently, the JiTT strategy provides students and faculty with sound educational experiences that facilitate work on solving relevant real-world problems in a highly interactive learning environment.
References


Assessment of JiTT at IUPUI (Track 4)


## APPENDIX

**Table 1.** Attrition rates for Physics Courses at IUPUI

<table>
<thead>
<tr>
<th>Measure</th>
<th>No JiTT</th>
<th>Using JiTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFW rate (PHYS 152)</td>
<td>48%</td>
<td>29%</td>
</tr>
<tr>
<td>DFW rate (PHYS 251)</td>
<td>33%</td>
<td>17%</td>
</tr>
<tr>
<td>&lt;g*&gt; on FCI</td>
<td>Not Available</td>
<td>0.31</td>
</tr>
</tbody>
</table>

*Note: To gauge the students' **cognitive gains** on the Force Concept Inventory (FCI), students took the thirty-item test in the first week of classes before any instruction had taken place and then they took the same test again in the last week of classes. The results were measured in terms of "normalized gain" \( \langle g \rangle \), which is defined as the \( \frac{\text{PostTest} \% - \text{PreTest} \%}{100\% - \text{PreTest} \%} \). (See Department of Physics, 1999)*
**FIGURES 1 and 2**

**First Semester Attrition (152)**

- Figure 1. Attrition rates in Physics 152 course at IUPUI

**Second Semester Attrition (251)**

- Figure 2. Attrition rates for Physics 251 courses at IUPUI
Evaluation instruments for the Just-in-Time Teaching (JiTT) Project at IUPUI

Note: Copies of evaluation instruments used in the assessment of JiTT at IUPUI are available online at the following website: [http://webphysics.iupui.edu/webscience/assessment.html](http://webphysics.iupui.edu/webscience/assessment.html).

Author Notes

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