

Evaluation of Progress on NSF Grant EHR-9981111
WebScience: Creating an Active-Learner Classroom with WWW
Technology to Improve Introductory Science and Mathematics Courses

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I. INTRODUCTION

I wish to thank Andrew Gavrin for the invitation to assess progress on his NSF *WebScience* grant. I have previously indicated (Hake 2000) my enthusiasm for "Just-In-Time Teaching" (JiTT) but this gives me an opportunity to review the JiTT materials in the context of an ongoing project and to more carefully think about how JiTT relates to the educational reform effort in physics (Hake 2001c) and beyond.

As I understand it, the project entails a three year effort (1/2000-1/2003) to "adopt new pedagogical strategies and electronic curricular materials in five mathematics, chemistry, and biology courses" at Indiana University Purdue University Indianapolis (IUPUI), affecting about 8000 students. "In addition to improved student learning, this project. . . (aims to). . . produce and disseminate several concrete resources:

- a. Electronic curricular materials designed for use with JiTT pedagogy in 5 courses.
- b. General and content-specific training materials for faculty and undergraduate mentors.
- c. Training materials and teaching experiences for pre-service teachers.
- d. Faculty development workshops and internal funding for future efforts to adopt JiTT."

II. SOURCES OF INFORMATION

The project has done an outstanding job of placing project-related material on the web and should be commended for making it public so that it can serve as a model and resource for those considering the use of JiTT at their own institutions. I note that similar JiTT WebPhysics servers are listed at < <http://webphysics.iupui.edu/> > for 12 other sites around the country. The web availability of JiTT materials complements a national trend towards open courseware (see, e.g., Gilbert 2001; Hake 2001b; Goldberg 2001; Crowell 2001a,b; Furnstahl & Rosenberg 2000; Wittmann 2000). From the perspective of an evaluator, progress towards the project goals can be assessed to some extent by examination of the web material. The sites listed below were given to me by Andrew Gavrin as particularly relevant to the present physics-oriented evaluation.

A. IUPUI's WebScience Site < <http://webphysics.iupui.edu/webscience/webscience.html> >, which includes:

1. For physics the August-December 2000 JiTT interactive lecture ancillaries ("WarmUps", "Puzzles", and "What is Physics Good For") in thermodynamics, E & M, and geometrical optics at physics class materials archive

< http://webphysics.iupui.edu/webscience/physics_archive.html >. For brief explanations of the lecture ancillaries see Novak et al. (1998).

2. For physics, course Homepages for current August-December 2001 IUPUI introductory Physics 152 (Mechanics) and 251 (E & M, Geometrical Optics, Thermodynamics) for engineering and physical science students at

< <http://webphysics.iupui.edu/introphysics.html> >.

3. For the entire project, JiTT dissemination efforts – Talks and Workshops with links to talks by project workers at

< <http://webphysics.iupui.edu/webscience/dissemination.html> >.

4. For the entire project, JiTT assessment links at

< <http://webphysics.iupui.edu/webscience/assessment.html> > to:

(1) Qualitative Methods

(a) Attitude precourse surveys for fall semester 2000 and spring semester 2001,

(b) Classroom observation protocol for fall semester 2000,

(c) Focus group protocol (currently under development).

(2) Quantitative Methods

(a) Student evaluations,

(b) computerized test bank of introductory chemistry exam problems,

(c) nationally recognized tools such as the Force Concept Inventory.

B. Prentice Hall's Giancoli Site <

<http://ajax.prenhall.com/~bookbind/pubbooks/giancoli3/> > where interactive lecture ancillaries ("WarmUps", "Puzzles", and "Applications") for each chapter in Giancoli (2000) may be viewed. In addition Wolfgang Christian's Physlets [see

< <http://webphysics.davidson.edu/Applets/about-physlets.html> > and

< <http://webphysics.davidson.edu/Applets/Applets.html> > are shown for some chapters.

C. Andrew Gavrin's Material:

1. "Project Description" from NSF proposal for Grant EHR-9981111.
2. Review of JiTT at < <http://webphysics.iupui.edu/adg/education.html> >.
3. Rochester AAPT meeting presentation on the WebScience Project at IUPUI (Gavrin 2001); online at < <http://webphysics.iupui.edu/rochester/webscience1.html> >.

III. EVALUATIONS (subheadings follow Section II above)

A1. August-December 2000 JiTT interactive lecture ancillaries ["WarmUps" (17), "Puzzles" (14), and "What is Physics Good For" (14)] in thermodynamics, E & M, and geometrical optics at < http://webphysics.iupui.edu/webscience/physics_archive.html >.

I "spot checked" about 30% of the above (about 15 items) and found the physics to be correct, the WarmUps at about the right level to induce student effort, the Puzzles both interesting and challenging, and the "Good Fors" stimulating.

According to Novak et al. (1998) the WarmUps "are the heart of the JiTT instruction system. Each morning before class the instructor reads the student responses and then adjusts the lecture material to respond to the students' demonstrated knowledge. Conceptual questions are particularly valuable JiTT items A WarmUp question asking the students to write about these concepts motivates many students to reread a few sections. These answers are used as talking points for the instructor later that morning, while the issue is still fresh in the students' minds."

Thus it would appear that WarmUps need to be tailored to the particular text used by the students, and thus evaluating the WarmUps would be assisted by specification of the text at < http://webphysics.iupui.edu/webscience/physics_archive.html >. Traditional physics texts, and even those such as Giancoli (2000) that incorporate some of the "new pedagogy," often fail to dispel common student misconceptions and may even reinforce them. Thus their use may require WarmUps that assume near zero or even negative conceptual understanding by students of the material in the chapters they have read in preparation for the lecture. On the other hand, WarmUps might not need to start at ground zero if text books by physics education researchers (e.g., Reif 1995, Chabay & Sherwood 1995, Knight 1999, Serway & Beichner 2000) were to be used.

The construction of good WarmUps requires considerable "pedagogical content knowledge" (Shulman (1986, 1987; Hake 2001c) and such is evidenced in most of the WarmUps that I examined. (It's not clear to me whether or not the WarmUps at < http://webphysics.iupui.edu/webscience/physics_archive.html > were all written by Novak and Gavrin as suggested by the copyright sign at the bottom of each WarmUp page.) In any case, I would recommend that WarmUp writers at IUPUI and elsewhere take advantage of the store of good conceptual questions available in the literature (see, e.g., footnote 66 of Hake 1998b).

A2. Course Homepages for current August-December 2001 IUPUI introductory Physics 152 and 251 at < <http://webphysics.iupui.edu/introphysics.html> >.

I am impressed by the organization and web use demonstrated in these courses. I concentrated primarily on Physics 152 at < <http://webphysics.iupui.edu/152/152f01/152f01welcome.html> >. That URL brings up the "News" page with icons in the left margin for:

(a) "**News**" for the week indicating Physics 152 is being administered by "lecturer" Ricardo Decca, recitation instructors Fritz Kleinhaus and Farbod Shafiei, and lab instructor Kelley Cook. The text is Young & Freedman (2000). For week nine starting 15 October there was also a "recommended strategy of doing homework" (submitted on Thursday at the UTEXAS server) and "study hints" (the more elaborate set of hints from a professor at IU brought up a "not found" panel).

(b) "**Warm Up**" for the upcoming lecture. The Warm Up due before 8:30 am Monday, October 22 is on rotation. Because I know little about the Young & Freedman (2000) text, my evaluation of WarmUps is somewhat handicapped. The first and third questions require little deep conceptual understanding and should be answerable by any student who has scanned the text. The second question is "A skater is spinning with his arms outstretched. He has a 2 lb weight in each hand. In an attempt to change his angular velocity he lets go of both weights (by just opening his grip). Does he succeed in changing his angular velocity? If yes, how does his angular velocity change?" This does address a popular failure to realize that angular momentum conservation refers, in this case, to the system man plus weights and not just the man.

(c) **"Puzzle"** due at the start of the next week. The Puzzle due by 8:30 am Monday October 22 is: "Hold a basketball in one hand, chest high. Hold a baseball in the other hand about two inches above the basketball. Drop them simultaneously onto a hard floor. The basketball will rebound and collide with the baseball above it. Estimate the rebound speed of the baseball. Assume that the basketball is three to four times heavier than the baseball." In my opinion, that is a worthwhile and challenging exercise.

(d) **Prelab Assignment for the Friday lab.** For week 9 the lab is titled "Newton's Second Law for Rotations" and is available online. The prelab exercise would not, in my opinion, be expected to induce much student thinking. The lab itself is of the traditional cookbook type giving step-by-step instructions, formulae, and diagrams. Some would argue that the lab, while contributing little to students' conceptual understanding, does at least give them some practice in manipulating equipment, tabulating, graphing, spread sheeting, and computer use. If other IUPUI physics labs are similar to the rotation lab, then the labs represent an area where cognitive achievement as measured by conceptual testing might be drastically increased. Possibly traditional physics lab goals could be met by only a few well-planned traditional plug-and-chug-tabulate-compute-graph labs.

Contrasting sharply with the IUPUI rotation lab would be a lab such as Socratic Dialogue Inducing Lab #5 "Angular Momentum" Hake (2001a), designed to "promote students' mental construction of concepts through their (1) conceptual conflict, (2) extensive verbal, written, pictorial, diagrammatic, graphical, and mathematical analysis of concrete Newtonian experiments, (3) repeated exposure to experiments at increasing levels of sophistication, (4) collaborative peer instruction, and (5) Socratic dialogue with instructors.

(e) **"What's Physics Good For?"** (an exercise that can yield extra credit if responded to by 5pm Friday.) For the ninth week the "Good For" topic is the fascinating but challenging Coriolis Effect.

First, students are asked to: "Consider the situation schematically illustrated in the diagram on the left. Imagine two people sitting on a rotating platform. The people are represented by the red and the green dots. We are looking down at the platform which is rotating clockwise beneath us. Relative to X-Y coordinate system on the ground, the red dot has a tangential velocity in the positive y-direction, the green dot has a tangential velocity in the positive x-direction. Suppose that at the instant depicted in the diagram the person in red is instructed

to throw a ball in such a way that the person in green could catch it a quarter of a period later, i.e. when his location would be where the white dot is now. In the ground-based frame of reference the ball has a y-velocity as indicated by the black arrow in the vector diagram. The green person has to throw the ball in the direction indicated by the blue vector. As a result the ball will start with an initial velocity represented by the red vector in the velocity vector diagram. The magnitude of the resultant velocity has to equal the distance between the green dot and the white dot, divided by the quarter period of rotation of the platform. What would the path of the ball look like, as recorded in a coordinate system attached to the platform?"

The above is the type of material that might be considered as a substitute for the above criticized IUPUI cookbook rotation lab. For example in SDI Lab #3 (Hake 2001a) [*Circular Motion and Frictional Forces*, Appendix A, "Playing Catch on a Merry-Go-Round" students gleefully actually take part in this astonishing experiment. (No comparison to following the suggestion in the "Good For" to passively observe "The merry-go-round video from a server at the Department of Geology, San Jose State University."

Secondly there are three "extra credit" questions, one of which is:

"Flushing a toilet or emptying a bathtub causes the outflowing water to form a vortex. Is that a Coriolis Effect?" [For the case of the bathtub, the correct answer is "It *could* be," see e.g., Hake (1994) for references and SDI Lab #3 (Hake 2001a) [*Circular Motion and Frictional Forces*," Appendix B. "Cyclone and Bathtub Vortices"] for a relevant introductory-course lab experiment.

(f) "**Basics**" These are evidently the "basics" for the entire semester. An explanatory note reads "From this page you can to access brief summaries of the basics of each topic. We suggest that you look at the basics first, then skim the appropriate sections in the book, then do the WarmUp exercise and finally study the topics chapter in the textbook. After you have studied the material, visit this page for review. Note: These materials, adapted by IUPUI student Erin McGarrity, are a short version of *Cockpit Physics, developed at the United States Air Force Academy when Dr. Novak was a Visiting Professor at the Academy in 1995.*" (My *italics*.)

This *may* be a very useful outline of the course, but its not clear to me how much "adaptation" was done by Erin McGarrity and to what extent the "basics" in the outline are relevant to the present course.

(g) "Communication" An explanatory note reads "The communication system in Phys 152 is designed to keep you in touch with the instructors and with fellow students in the course. The system consists of two parts: THE BULLETIN BOARD and THE SUGGESTIONS BOX. You can post messages on the bulletin board and you can read the posts, yours and other people's. You can post comments to the suggestions box but only instructors can read them."

The BULLETIN BOARD consists of questions from students regarding homework problems, course exams , grades, exams, etc., and frequent helpful replies from lecturer Ricardo Decca. I think the BULLETIN BOARD is probably very helpful to some students, despite the fact that a few persist in posting puerile non-physics questions and comments.

(h) "INFO" Gives essential course information: the text; the staff; the organization of the class; an explanation of the nature, credit, and due dates for WarmUps, Puzzles, Good-Fors, and Lab Preps; and the grading policy.

All this is, of course, essential information and much better distributed via the web than the traditional hard copy handout sheets distributed to students at the start of university courses. Commendably there appears to be *no curve grading* as might deter collaboration among students.

A3. JiTT Dissemination Efforts – Talks and Workshops with links to talks by project workers at < <http://webphysics.iupui.edu/webscience/dissemination.html> >.

Fourteen talks and workshops have been given by project personnel. It is especially heartening that JiTT in Biology, Chemistry, and Math is being demonstrated at IUPUI and then advertised (although no mathematics talks or workshops are listed). As indicated in the review by Stockstad (2001), chemistry and biology appear to be somewhat behind physics in reforming their introductory courses. See also Lesson #3 of Hake (2001c) – for the references see that article:

"High-quality standardized tests of the cognitive and affective impact of courses are essential for gauging the relative effectiveness of non-traditional educational methods. As far as I know, disciplines other than physics, astronomy (Adams et al. 2000; Zeilik et al. 1997, 1998, 1999), and possibly economics (Saunders 1991, Kennedy & Siegfried 1997, Chizmar & Ostrosky 1998, Allgood and Walstad 1999) have yet to develop any such tests and therefore cannot effectively gauge either the need for or the efficacy of their reform efforts. In my opinion, *all disciplines should consider the construction of high-quality standardized tests of essential introductory course concepts.*"

JiTT is currently relatively little known among educators in biology, chemistry, math, and higher education, at least those who subscribe to discussion lists. This is shown in the discussion list archive survey indicated in Tables 1a & 1b.

Table 1a. Prominent Biology, Chemistry, Mathematics, and Higher Education Discussion Lists.

FORUM	SUBJECT	ARCHIVE
Biopi-L‡	Biology Education	http://listserv.ksu.edu/archives/biopi-l.html
Chemed-L	Chemistry Education	http://www.optc.com/chemed-l-thread
Math-Learn*	Mathematics Education (K-12)	http://www.mathforum.org/epigone/math-learn/
Math-Teach	Mathematics Education (all levels)	http://www.mathforum.org/epigone/math-teach/
PHYSHARE‡	Sharing resources for high school physics	http://lists.psu.edu/archives/physshare.html
Phys-L‡	Physics Education	http://mailgate.nau.edu/archives/phys-l.html
PhysLrnR‡	Physics Education Research	http://listserv.boisestate.edu/archives/physlrnr.html
POD‡	Professional and Organizational Development	http://listserv.nd.edu/archives/pod.html
STLHE-L‡	Teaching and Learning in Higher Education	http://listserv.unb.ca/archives/stlhe-l.html

* = moderated, ‡ = LISTSERV with superlative archives

Table 1b. No of JITT Hits for Discussion List of Table Ia.

<u>FORUM</u>	<u>SUBJECT</u>	<u>N</u>	<u>HITS ON</u> <u>"JITT" +</u> <u>"Just-In-Time" +</u> <u>"Just In Time"</u>
Biopi-L‡	Biology Education	650	0 + 0 + 0 (key word search)
Chemed-L	Chemistry Education	1200	0 + 2 + 0 (key word search)
Math-Learn*	Mathematics Education (K-12)	400	0 + 0 + 0 (key word search)
Math-Teach	Mathematics Education (all levels)	500	0 + 0 + 0 (key word search)
PHYSHARE‡	Sharing resources for high school physics	481	0 + 0 + 0 (search for slot)
Phys-L‡	Physics Education	650	0 + 0 + 0 (subject slot only)
PhysLrnR‡	Physics Education Research	475	0 + 0 + 0 (subject slot only)
POD‡	Professional and Organizational Development	600	0 + 0 + 0 (subject slot only)
STLHE-L‡	Teaching and Learning in Higher Education	600	0 + 0 + 0 (subject slot only)
Total		5556	0 + 2 + 0

* = moderated, ‡ = LISTSERV with superlative archives N = Approx. Number of Subscribers

The above lists with a total of 5556 subscribers yielded only 2 hits for JITT and its variants. A few more hits would doubtless have been found if searches had been conducted by typing "JITT," "Just-in-time," and "Just in time" into the "search for" slots in LISTSERV archives, but that would have taken too much time to find the legitimate hits, e.g., to separate the real JiTT hits from non-real hits such as Jitterbug. Both hits indicated in Table Ib were in ChemEd, one due to Robert Blake and one to myself. *It would seem that these discussion lists might provide a way of creating more interest in JiTT among various disciplines.* (Hake 2001c).

A4. JiTT assessment links:

< <http://webphysics.iupui.edu/webscience/assessment.html> >

(1) Qualitative Methods

- (a) Attitude precourse surveys for fall semester 2000 and spring semester 2001,
- (b) Classroom observation protocol for fall semester 2000,
- (c) Focus group protocol (currently under development).

(2) Quantitative Methods

- (a) Student evaluations,
- (b) computerized test bank of introductory chemistry exam problems,
- (c) nationally recognized tools such as the Force Concept Inventory.

The assessment methods appear to be quite thorough.

It's possible that the *Maryland Physics Expectations* (MPEX) (Redish et al. 1998), or the *ASU Views About Sciences Survey* (VASS) (Halloun & Hestenes 1998, Halloun 1997) [available for physics, chemistry, biology and mathematics at < <http://modeling.la.asu.edu/R&E/Research.html> >] might be used in addition to or in place of the "Attitude precourse surveys." I note that the MPEX test has previously been administered in JiTT courses. Novak et al. (1998) state:

"We administered the Maryland Physics Expectations (MPEX) survey, designed to measure student attitudes toward physics courses, as a pre- and post-course survey of the 'consistent JiTT' students in our second semester course. Our preliminary analysis shows that, in each of the attitude dimensions measured by the survey, there was either a small improvement or essentially no change in student attitudes in the 'consistent JiTT' course sections. This is in contrast to data from other institutions which show declines in student attitudes among students taking the first semester physics course[(Redish et al. 1998)]. Further, broader work with the MPEX survey is on-going and is needed in order to set the context and determine the significance of our results."

The "Classroom observation protocol" is somewhat similar to ASU's Reform Observation Protocol (RTOP) (Sawada et al. 2000, MacIsaac & Falconer 2001). I am somewhat skeptical of the some of the claims made for the RTOP, but *the RTOP it might be worth examining for possible use at IUPUI.*

Regarding physics tests IUPUI might consider using the problem-solving *Mechanics Baseline Test* (Hestenes & Wells), the *Conceptual Survey in Electricity and Magnetism* (CSEM) (Maloney et al. (2001), and the very recent *Thermal Concept Evaluation* (TCE) (Yeo & Zadnik 2001). For a reasonably complete listing of physics diagnostic tests and their locations see NCSU (2001).

Various concept tests in chemistry were summarized in my 10 October 2001 Chemed-L post "Re: conceptual chem." This post will eventually show up on Chemed threaded archive at < <http://www.optc.com/chemed-l-thread> >. I have heard from Jerry Epstein (2001) that he has submitted a proposal to develop a "*Calculus Concept Inventory (CCI)*, that will measure a student's grasp of the most basic and fundamental concepts of differential calculus."

B. Prentice Hall's Giancoli Site

< <http://ajax.prenhall.com/~bookbind/pubbooks/giancoli3/> > where interactive lecture ancillaries ("WarmUps", "Puzzles", and "Applications") for each chapter in Giancoli (2000) may be viewed. In addition Wolfgang Christian's Physlets [see < <http://webphysics.davidson.edu/Applets/about-physlets.html> > and < <http://webphysics.davidson.edu/Applets/Applets.html> > are shown for some chapters.

I spot checked Chapter 4 of Giancoli (2000). I think the sections on Objectives, Practice Questions, MCAT Study Guide, Warm-ups, Applications, Puzzles, Online Destinations, Ranking Task Exercises, Netsearch, and Practice Problems are excellent except for:

(a) "Online Destinations" where the link to "Cartoon Physics" is broken; "great simulations of force and motion" are not, in my opinion, so great; and I would NOT advise students to ask "Dr. Math" a physics question; and

(b) "Netsearch" where the premier search engine Google < <http://www.google.com/> > is not available.

Except for "Online Destinations" the links to relevant web material throughout the world are very well chosen, enlightening, and often amazing in their revelations – a real inducement to students to engage in "distance learning." How about linking to MIT ? (Goldberg 2001).

I think Prentice Hall is to be congratulated for publishing books such as Giancoli (2000) that feature reform methods of instruction. Although Chapter 4, as most texts, has not incorporated *really effective* methods (Hake 1987, 1992) of bringing students into the Newtonian World, in other respects it is so professional, complete, and JiTT oriented that I wonder why the current IUPUI Physics 152 and 251 courses switched to Young and Freedman (2000). Possibly it was because student files are full of Giancoli problem solutions, or Young and Freedman now contains interactive-engagement and JiTT-type material inserted since its earlier days as "Sears & Zemansky," or the current IUPUI instructors had some personal preferences for Young and Freedman, or yet some other reason(s).

I note that on the "Objectives" page of Giancoli (2000) appears the statement: "Note to Mac users: Currently, Physlet Problems will not run on a Macintosh Power PC since browsers for this platform do not support both Java 1.1 and Java to JavaScript communication."

I use a Mac and was interested in comparing Physlet animations with those by *Interactive Physics* and those currently used in SDI labs [Force Motion Vector Animations (*FMVA's*) by Randall Bird]. Consistent with the Prentice Hall admonition, I found that Physlets did *not* run on my machine. However, following the very helpful advice of Wolfgang Christian, I succeeded in playing Physlets by downloading (a) the latest Mac Java application listed at < <http://www.info.apple.com/support/downloads.html> >, vis., "Macintosh Runtime for Java" called "Java MRJ 2.2.5", and (b) Sun's "Hot Java Browser" at < <http://java.sun.com/products/hotjava/index.html> >. If Physlets are being employed at IUPUI, I assume Mac-using students are given this information. According to Christian "Mozilla " (a.k.a. Netscape) may be about to make life much easier for Mac users who wish to play Physlets.

Although the Physlets located at < <http://webphysics.davidson.edu/Applets/Applets.html> > run fine on my Hot-Java-Browser-augmented Mac (G4/500MHz, 1GB RAM), I had some trouble with those of Giancoli (2000), Chapters 4 & 5 (the only ones I examined). The problem was that scrolling messed up the displays in all but the first animation at the top of the page. Although all Physlets that I've checked in Giancoli (2000) and at Davidson are very nice, I was somewhat disappointed by two things:

(a) None of the Physlets that worked for me displayed simultaneous color-coded force, velocity, and acceleration vectors as do *Interactive Physics* and (*FMVA*) animations.

(b) *The FCI is on the web and available to all web surfers at*

< <http://webphysics.davidson.edu/physletprob/PhysletFCI/default.html> >!

WAIT!!! *Late breaking news* – in checking URL's at 11:54pm, PDT, 19 October 2001, I was delighted to find that Wolfgang Christian has password protected the above URL. *Good show, Wolfgang!!*

As I indicated to Wolfgang, I think that the results of recent PER studies that utilize the widely disbursed 1992/95 FCI must be treated with considerable caution (Hake 2001d). As stated three years ago (to deaf ears) in footnote 48 of Hake (1998a):

"It is unfortunate that the national-assessment value of arduously constructed and validated standardized tests such as the FCI and the MB is gradually being eroded by distribution of answers to students at some institutions. The danger of question leakage is especially severe if the posttest FCI/MB scores are used to determine part of the final course grade. . . .

Because of the above mentioned dispersal of answers at some institutions, and the fact that the FCI and MB tests were published in the open literature, their useful lives may not extend for more than another year. New and better tests (treated with the confidentiality of the MCAT) are sorely needed in time for a calibration against the original or revised FCI. The necessary steps in the laborious process of constructing valid and reliable multiple-choice physics tests have been discussed in refs. 1a, 9a, and 50." [For references see Hake (1998a.)]

C. Andrew Gavrin's Material:

1. Review of JiTT at < <http://webphysics.iupui.edu/adg/education.html> >.
2. "Project Description" from NSF proposal for Grant EHR-9981111.
3. Rochester AAPT meeting presentation on the WebScience Project at IUPUI (Gavrin 2000); online at < <http://webphysics.iupui.edu/rochester/webscience1.html> >.

In "1" and "2" above, Gavrin(2000) gives good accounts of JiTT and the current NSF Grant EHR-9981111. In "3" Gavrin indicates the impressive progress on the WebScience Project at IUPUI. The drastic reductions in the percentage of students receiving D and F grades or withdrawing with W's is especially impressive. Somewhat less impressive are the normalized gains $\langle g \rangle = 0.3$ on the FCI, as compared to the average 0.48 for 48 interactive engagement courses in my survey (Hake 1998a). The IUPUI $\langle g \rangle$'s may improve with greater experience of the instructors and possibly the use of non-traditional texts, more conceptually-oriented labs, and WarmUps especially tailored to the text being used.

III. SUMMARY

My earlier (Hake 2000) enthusiasm for Just-In-Time Teaching (JiTT) has been enhanced by the present examination of activities under the current NSF Grant EHR-9981111. Gavrin and others working on the project have made considerable progress towards several of the enunciated goals of the proposal to improved student learning and produce and disseminate several concrete resources:

- a. Electronic curricular materials designed for use with JiTT pedagogy in 5 courses.
- b. General and content-specific training materials for faculty and undergraduate mentors.
- c. Training materials and teaching experiences for pre-service teachers.
- d. Faculty development workshops and internal funding for future efforts to adopt JiTT."

The sources of information that I have examined (Section II) suggest that objectives "a," "b," and "d" are being very effectively pursued. Especially encouraging are:

(1) the JiTTworkshops listed at

< <http://webphysics.iupui.edu/webscience/dissemination.html> >, and

(2) the dissemination of interactive-engagement methods to other disciplines such as chemistry, biology, and mathematics through the talks listed at the above URL, and the evidently successful JiTT courses currently being given at IUPUI in those subjects.

Regarding objective "c" it would be interesting to know the number of pre-service teachers that are enrolled in the current Physics 152 and 251 courses for engineering and physical science students. Are the courses for prospective K-8 teachers at IUPUI partaking in any of the JiTT effort? Upgrading of science/math instruction in the K-8 area is, of course, crucially important to the national educational reform effort. (Lopez & Schultz 2001, Mahajan & Hake 2000).

In closing I wish to commend Andrew Gavrin, his coworkers, and IUPUI for undertaking and successfully pursuing the nationally important effort to demonstrate the effectiveness of the JiTT instructional method and propagate it to other disciplines.

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Epstein, J. private communication regarding proposed *Calculus Concept Survey* to R.R. Hake, 30 May 2001.

Furnstahl R.J. & S. Rosenberg. 2000. "The Bazaar Approach to Physics Education," *AAPT Announcer* **30**(4), 120 (2000), online as "aapt_jan2001_v0.9.pdf" at
< <http://www.physics.ohio-state.edu/~ntg/aapt/> >. The authors propose a curriculum development and reform model based on the "bazaar approach" to computer software development described by Raymond (2001). In the case of physics education, individual teachers or departments would be the counterparts of the community of code warriors (hackers) who have contributed so effectively to the development of open-source software such as Linux.

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