

An implementation of *Physics by Inquiry* in a large-enrollment class

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Outline of talk

- ✦ The Evergreen State College
- ✦ "Traditional" *Physics by Inquiry*
- ✦ Modified *Physics by Inquiry*
- ✦ Learning outcomes
- ✦ Other outcomes
- ✦ Does modified *Physics by Inquiry* work?

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The Evergreen State College (TESC)

Four-year, public, liberal arts college

Curriculum consists mainly of **full-time** (16 q-h), interdisciplinary, team-taught "programs"

Programs may last up to three quarters, with mostly the same students

No departments, no grades, and no faculty ranks

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Two TESC programs

Technology, Cognition, Education

Two-quarter program offered once only to first-year students
Investigating how new technologies (such as the alphabet, or photography) change the way we think and learn (if they do)
Taught by a developmental psychologist, a computer scientist, a video artist, and a physics education researcher

Introduction to Natural Science

Two-quarter program offered every year to all levels of students
Offering a foundation in physics, biology, chemistry, math, etc.
Taught by a physicist, a biologist, and a chemist (last year)

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Introduction to Natural Science

Students in the program are...

Inexperienced in the sciences or math
Mostly headed for careers in health or environmental sciences; some rounding out a liberal arts education

Expectations for the program include...

Collaborative, active learning
Seminar component
About six hours a week of physics instruction
NO specific coverage goals

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Physics by Inquiry[†]

- Laboratory-based, step-by-step, in-depth introduction to the physical sciences
- Direct experience with the process of science; explicitly designed to develop scientific reasoning skills and provide practice in relating scientific concepts, representations, and models to real world phenomena
- A strong foundation for continued study, or a substantive excursion into science for liberal arts students
- Well-documented conceptual gains*

[†] McDermott et al., Wiley, 1996

* See, for example, McDermott et al., "Preparing teachers to teach physics and physical science by inquiry," *Phys. Educ.* 35(6), 2000; Thacker, "Comparing problem-solving performance of inquiry and traditional courses," *AJP* 62(7), 1994

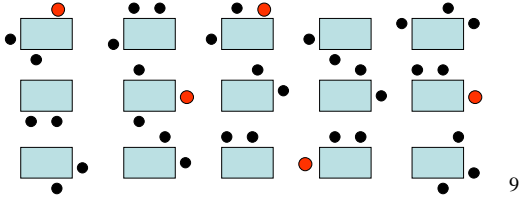
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“Traditional” (Univ. Wash.) *Physics by Inquiry* format



Students work through the exercises
in pairs, at their own pace.

Feedback is through
“checkouts,” homework, exams, papers.

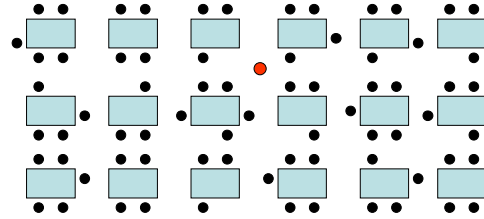


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Evergreen surprise



70 students, one instructor.



(No TAs or peer instructors available) 10

Modifications to format



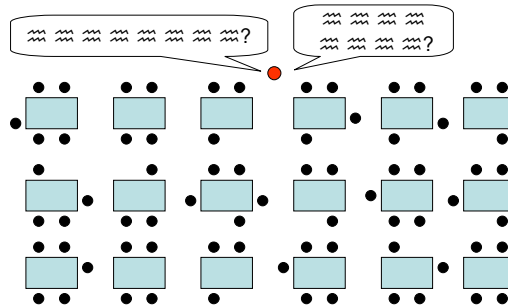
Pairs → Groups of four or more

Self-paced → Instructor-paced

Individual checkouts → Class “checkouts”

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Class “checkout”

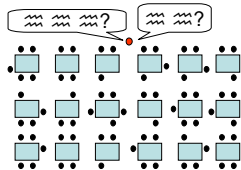


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Key instructional issues...



...are similar to those
in traditional
Physics by Inquiry
courses.



e.g.,

- What are the important questions to ask in a checkout?
- What difficulties will arise for the students? When?
- What instructional strategies are most effective at particular moments?

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Differences from traditional Pbl course



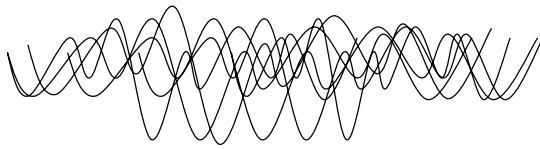
- Students began as skilled communicators.
- Students had too little (or too much) time for particular exercises.
- Students did not have issues addressed individually.
- Students had little opportunity for reflection. (no papers, no written feedback until quiz time)
- There was “constructive interference.”

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“Constructive interference”



Traditional *Physics by Inquiry* course



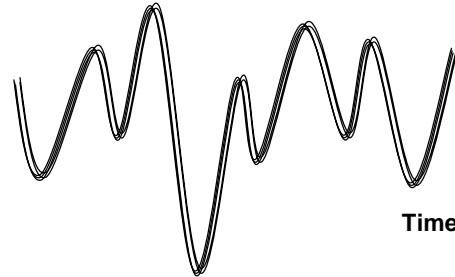
Time →

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“Constructive interference”



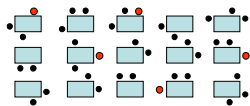
Modified *Physics by Inquiry* course



Time →

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Summary of implementation

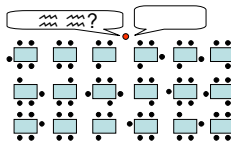


Physics by Inquiry converted to interactive lectures.



Manageable for me

Did students learn?



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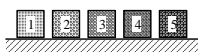
Outline of talk

- ✧ The Evergreen State College
- ✧ “Traditional” *Physics by Inquiry*
- ✧ Modified *Physics by Inquiry*
- ✧ **Learning outcomes:**
PROPERTIES OF MATTER
- ✧ Other outcomes
- ✧ Does modified *Physics by Inquiry* work?

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The “Five Blocks” question

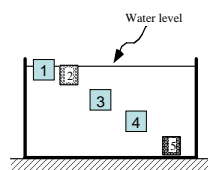
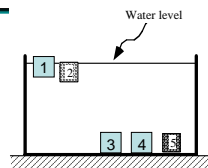
$$m_1 < m_2 < m_3 < m_4 < m_5$$



Sketch final positions of blocks 1, 3, and 4.

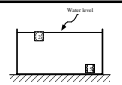
Common incorrect response:

“[The denser block] would displace more water...I can’t think of the displacement as a volume, I have to think of it as a mass.”



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The “Five Blocks” question



After instruction

Alg-based intro course* (N=219)	23% correct
Calc-based intro & 2nd-year thermo course (N=945)	41%
Traditional <i>Physics by Inquiry</i> (N=117)	81%
Modified <i>Physics by Inquiry</i> (N=63)	84%

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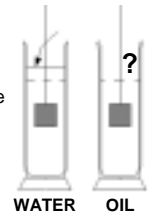
On certain conceptual questions, students in the modified *Physics by Inquiry* course perform comparably to those in the traditional *Physics by Inquiry* course.

Oil-displacement question

Two identical graduated cylinders are filled to the same level. One is filled with water, and one is filled with oil.

An aluminum block is lowered into the cylinder containing water, causing the water level to rise as shown.

An **identical** aluminum block is lowered into the cylinder containing oil. Is the liquid level in the cylinder containing oil *higher than, lower than, or at the same height* as in the cylinder containing water?



Correct answer: *At the same height.*

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Results of oil-displacement question



	After instruction
Algebra-based intro course (N=64) Lecture/text instruction on fluids	47% correct
Modified <i>Physics by Inquiry</i> course (N=63)	98%

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Like other *Physics by Inquiry* students, students in the modified course perform much better on certain conceptual questions than students in lecture-based courses.

Similarities to traditional Pbl course



➤ Students have difficulty adjusting.

"Without learning formulas, I don't feel like this is preparing me for further studies."

"The way the book sets me out, I feel I will write the stupidest thing first then it will show me how dumb it was."

"This class feels like a waste of my time and money. I am angry and frustrated."

"I understand the philosophy behind the 'deconstructivist' approach but feel it is condescending."

"All this explaining reminds me of my childhood."

"What are we doing? What do you want me to learn? Can we have more of a focus here?"

(written feedback after 5 weeks of class) 48

Similarities to traditional Pbl course



☆ Students reflect on the program favorably.

"Five months ago I opened the text for the first time and was immediately turned off by its approach. I am happy to say that my opinion of its tactics has changed completely."

"The answers always came from within us and not from an outside voice. I don't believe I would have learned or retained as much without being taught in this way."

"Because my learning style has been acquired from traditional teaching methods, the way in which physics was taught was challenging for me. But within every challenge lives a great opportunity. I found myself thinking in intensive ways that I had not been used to."

(written feedback after 20 weeks of class) 50

Did it work?



Learning outcomes

Student response

comparable to traditional
Physics by Inquiry courses

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Why did it work?



Evergreen students are skilled communicators and active learners.



The UW PEG provided excellent preparation and support.



Physics by Inquiry is a powerful curriculum.

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