

Learning Critical Thinking Through Astronomy

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The purpose of this presentation is to justify the need for a new astronomy textbook designed around critical thinking.

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Abstract

An introductory astronomy textbook and course are presented that hopefully correct the primary deficiency in existing textbooks and courses, namely that reasoning and critical thinking are not present. Built around critical thinking, inquiry activities, and integrated assessments, this approach allows topics that are traditionally omitted to be included. The textbook should be ready by 2012.

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I include an abstract.

Why this course?

Why this book?

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What's wrong with existing courses and textbooks? A lot!

Which courses?

- courses that advertise critical thinking
- courses that advertise scientific literacy
- courses that everyone needs

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Which courses am I fed up with? In general, I'm fed up with courses that do not, and cannot, meet lofty marketing goals.

Descriptive Courses?

- nothing wrong with descriptive courses but...
- they can't "meet the marketing"
- why offer them for academic credit?
- better off in continuing education?

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I'm beginning to doubt the usefulness of so-called "descriptive" courses. Can they meet the marketing claims? Are they appropriate for academic credit? If not, then why continue to offer them? The reason is they're cash cows!

Problems with existing courses

- economic interests that promote mediocrity
 - large lecture courses
 - lack of depth
- often taught by inexperienced faculty who don't want to be there
- at smaller schools, often modeled after inadequate university courses

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Unfortunately, academics is largely driven by economics and most everything else except quality classroom instruction. What's wrong with this picture?

Problems with existing courses

- extraneous labs are nearly worthless and disconnected
- not integrated format
- most labs require numerical reasoning that students simply do not have

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In my experience, traditional labs are worthless for the majority of students who endure them. The cookbook approach fosters neither learning nor quality teaching and yet it is usually the only instructional experience graduate students get. This creates a self-perpetuating cycle.

Problems with existing courses

- some courses omit content that is potentially offensive to religious beliefs
- we must not let a vocal minority hinder education
- we are not obligated to tolerate incompetence

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Certain vocal minority groups sometimes have dictatorial control over what gets taught in science classes. We must stop tolerating this and stand up for science teaching as we would for any other profession.

Problems with existing courses

- critical thinking is gone (was it ever there?)
- too much emphasis on "facts and figures"
- no emphasis on reasoning
- numerically dumbed down (self fulfilling prophecy!)
- not inquiry based

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I'm amazed at how courses are dumbed down, which prevents learning and promotes mediocrity. It also permits more students to take these courses and we're back to economics.

Problems with existing courses

- content is not reasonable
 - too much material for even two semesters
 - need fewer topics and greater depth

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No one, I don't care how educated, can intelligently discuss the entire universe in one or two semesters. It's silly to even try.

Problems with existing courses

- students are not connected to topics
 - probability of participating in space travel is slim
 - exotic topics cannot be understood without proper preparation
 - few students are interested in research
 - need something tangibly useful

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Students need practical connections to science. They need something to take away from the classroom and actually use.

Problems with existing courses

- pandering to certain student populations
 - basic science should be understood at the same level by everyone
 - science majors who cannot articulate simple explanations
 - senior engineering students who claim introductory astronomy is too difficult!

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Science is science, and the basics must be the same for all student populations. Teaching students often resist, saying that an elementary teacher doesn't need the same preparation as a high school teacher or a science major. They're wrong, as evidenced by poor science skills of their students. However, teachers are products of the universities, where the fault actually lies.

Problems with existing textbooks

- lack of innovation (what is innovation?)
- publishers focus on what sells
- authors encouraged to maintain status quo

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Publishers are part of the problem.

Problems with existing textbooks

- science book = frequent revisions = \$\$\$\$
- the basics do not change
 - Nature's behavior does not change
 - our **description** of Nature's behavior is what changes
- presentations and applications may change

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Frequent revisions are a cash cow for the publishers (authors too?) and a financial burden on everyone else. There is no need to revise a textbook just for the sake of revising it. Regarding Nature's behavior, note that Newton's laws didn't suddenly become worthless after Einstein's relativity. The former were shown to be a special case of the latter.

Problems with existing textbooks

- extraneous ancillaries may raise costs
- possibly designed around questionable assessments and diagnostics
- there are (I hope) exceptions!

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Most ancillary material is just marketing; little is useful. Student solutions manuals are often misused and widely distributed, justifying more unnecessary textbook revisions.

Problems with popular level books

- contribute to propagation of misconceptions and errors (e.g. relativistic mass)
- possibly written for financial, rather than altruistic, reasons
- there are (I hope) exceptions!

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I assert that no one can fully understand exotica like black holes, warped spacetime, and quantum mechanics by reading a popular level book. Note the word "fully."

Inadequately treated or omitted

- elementary critical thinking
 - necessary for all sciences
 - a learned skill that is omitted
 - Baloney Detection Kit is essential

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Science without critical thinking is not science at all. All introductory science courses should begin with critical thinking skills because students will not get this material anywhere else despite marketing to the contrary!

Inadequately treated or omitted

- doing science
 - need to practice observation and reasoning
 - research is useful, but questionable at this level
 - pushed into research for political or financial motives

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I distinguish between “doing science” and “research.” I (arbitrarily?) associate the former with building skills and the latter with applying them. There’s no need to push introductory students into research just for the sake of doing research!

Inadequately treated or omitted

- celestial sphere
 - students should know how to “read” the sky
 - make observations and draw coherent and consistent inferences

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Despite modern astrophysics, introductory students should know how to read the sky, make observations, and draw inferences. They must be able to make predictions.

Inadequately treated or omitted

- time
 - relevant to absolutely everyone
 - inadequately addressed
 - rich for inquiry!

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The subject of time gets wrongfully ignored in introductory astronomy. It's the most relevant topic in the course!

Inadequately treated or omitted

- basic physics
 - astronomy students need the same preparation physics students need!
 - existing treatments are too short to be meaningful
 - fraught with terminology errors that promote confusion

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Why do authors expect students to understand orbital motion without a proper physics background? It's silly! Astronomy students need a firm foundation in basic Newtonian physics.

This textbook's goals

- six chapters
- inquiry-based activities (mostly)
- integrated pre and post assessments
- WILL NEVER NEED UPDATING!
- precise terminology throughout
- freely available during development

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Here are some features that will make this textbook differ from the status quo. I'm very serious about producing a book what will never need updating.

Chapter 1

- ◉ cut and paste into ANY intro science course
- ◉ critical thinking, including logical fallacies
- ◉ Wedge Document
- ◉ Kitzmiller v. Dover Ruling

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Students must learn how to detect faulty logic when they see it. Students must understand the nature of modern social plots that seek to undermine science. This necessarily gets into some politics and other things we pretend don't exist, but we can no longer take this approach because the plots are slowly winning!

Chapter 2

- ◉ doing science by observing shadows
- ◉ emphasis on simplicity
- ◉ discriminating among scientific models
- ◉ Eratosthenes

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Studying shadows provides an extraordinarily rich environment for making observations, drawing inferences, making and using and discriminating among scientific models.

Chapter 3

- ◉ celestial sphere, real and Project STAR
- ◉ emphasis on making predictions
- ◉ much more depth than usual
- ◉ use of farmer's almanacs

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Here I emphasize patterns and celestial cycles. Students use inexpensive almanacs as a source of accurate astronomical data.

Chapter 4

- ◉ time
- ◉ extreme sunrise/sunset dates and times
- ◉ emphasis on the analemma
- ◉ use of farmer's almanacs

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I can't emphasize enough the importance of time. It provides a rich environment for inquiry activities. Most students have never heard of or studied the analemma.

Chapter 5

- ◉ gravitational interactions
- ◉ goal is to understand orbits
- ◉ language of the arrows (vectors!)
- ◉ basic physics

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I don't see how orbits can be understood without some solid physics, including a new language to describe these new physical quantities. Astronomy students CAN learn vectors as well as any other students!

Chapter 6

- ◉ measurements
- ◉ angular size
- ◉ parallax
- ◉ solar system structure

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This chapter will culminate in mapping out our solar system's structure.

Extras

- detailed glossary
- compendium of evidence (activity?)
- list of important fallacies
- troublesome words
- references

Precise terminology is very important. The glossary will give (hopefully) unambiguous definitions of terms. Students will add to their compendium of evidence as they progress through the course. Some words should be completely eliminated from the science vocabulary because of imprecise meaning and inconsistent usage.

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What? When?

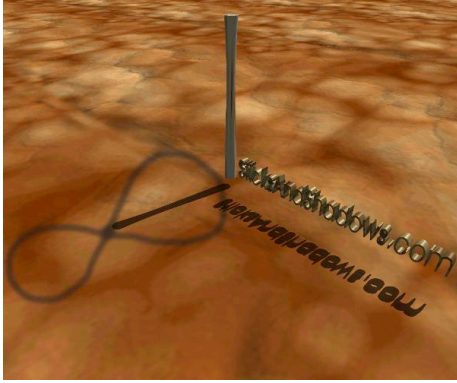
- develop inquiry activities (the hard part)
- develop assessments
- write text (the easy part)
- develop WebAssign content
- final product by fall 2012
- progress on website and AAPT meetings

I plan to give AAPT workshops as a way of getting feedback. Considerable time will be spent developing inquiry activities and accompanying assessments.

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Thank you!

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