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Debating Pluto: Searching for the Classroom of the Future and Ending Up in the Past

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Editor's Introduction

There is nothing more discouraging than an introductory astronomy class where the students are passive and uninvolved, sitting back to let the instructor do all the work. Tony Crider, a dedicated teacher, has found a new way to engage his students and we asked him to share the path to his discovery with our readers.

In my pursuit of "the classroom of the future," I have been quick to try my luck with the latest in educational technology. While at American University in 2001, I overhauled an abandoned basement into a studio classroom that mirrored the new SCALE-UP physics classrooms I had learned about at North Carolina State (see the resources at the end for links to many of the programs I describe). In 2004, my study abroad class used panorama-stitching and desktop planetarium software to recreate horizons seen by the ancient Maya. In 2005, I heard about yet another new tool, Second Life, a 3-D online virtual world that allows its users to construct and explore objects. Having often wished to run my own planetarium, I taught myself the building tools and programming language of Second Life and within a few weeks had a functioning virtual planetarium. Like so many other "gadget boys" of my generation, if it involved a new piece of hardware or software (e.g. video analysis, clickers, on-line homework), I was eager to try it.

The SCALE-UP studio classroom at American University, modeled after Bob Beichner's successful work at NCSU, was my first attempt to build "the classroom of the future."

In my fourth year teaching at Elon University, a new program was created to offer course releases for faculty willing to explore the scholarship of teaching and learning in their classes. The program director specifically requested projects that were high risk with the potential for high reward. I smiled because I had what I thought was the perfect proposal for this. I'd recently started playing an addictive video-game, *World of Warcraft,* and was convinced that its lure was a potent mix of three motivators commonly found in other games and hobbies: role-playing (e.g. Renaissance fairs), on-line socialization (such as Facebook), and "leveling-up." In many popular games,

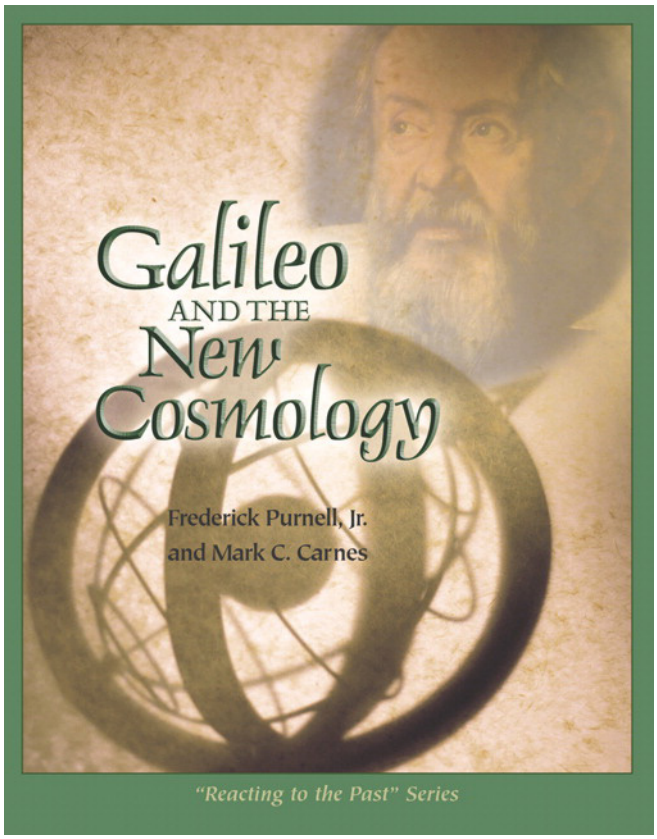
players choose their own quests, receive experience points for completing them, and eventually become eligible for more difficult quests. I proposed to restructure my astronomy classes to do the same, using Second Life as a game engine for offering my students "astronomy quests" in place of homework.

Unfortunately, I had incorrectly assumed that college-aged students are universally proficient with new technologies. Even for students who found Second Life to be a positive experience, it still served as a barrier rather than a bridge to understanding the astronomy content. Halfway through my two-year grant, I realized that the quests were too difficult for me to manage, and the Second Life technology was more hassle that it was worth for my students. However, one of my colleagues had a new suggestion to help me: *Reacting to the Past* role-playing games.

Reacting to the Past was initiated at Barnard College in the late 1990s. History professor Mark Carnes, the founder of the series, was trying get his students to engage more deeply with classic texts. The first games, all co-written by Carnes and published in 2005, involved debates centered on great books: Plato's *Republic*, Rousseau's *The Social Contract*, and Confucius' *The Analects*. Each is set at a particular pivotal moment in history: the establishment of democracy in 403 BC Athens, the French Revolution in 1791 Paris, and a succession crisis in 1587 China. During a *Reacting* class, students are assigned roles debating their interpretation of the text. They work in factions to achieve victory objectives and win the game. A few students in each game play characters who start the game undecided, or *indeterminate*, and cast their votes depending on the actions of the competing factions.

Instructors who have used *Reacting to the Past* report that their students are more engaged in class and read deeper into the material. As one student wrote in a course evaluation, "Overall I spent way more time on this game than I did in every other class I'm in this semester. It pretty much consumed me. That's why I was Instant Messaging you every night!" Given such positive student feedback (and a need to salvage my project), I attended a four-day *Reacting* workshop at Barnard College in New York and tried out *The Trial of Galileo: Aristotelianism, the "New Cosmology," and the Catholic Church, 1616-33*.

In this game, we played cardinals in the Holy Office debating nature of universe and the alleged heresy of Galileo. Does the Earth move? Are the heavens fixed, perfect, and immutable? Is the universe bounded or infinite? Is Copernicanism heretical? In preparation, I read *The Starry Messenger*, *Dialogue on the Two Chief World Systems*, and Galileo's letter to the Grand Duchess Christina for the first time. For years, I had told students what a genius Galileo was, but only after reading these documents firsthand did I realize how true that was. This is exactly how I wanted students to experience Galileo, but I balked at the time commitment required to play the game in class. Was four weeks of game-playing appropriate for an introductory astronomy class? At the workshop, I saw that the *Trial of Galileo* is split into two acts, with Act I introducing Galileo's discoveries and Act II emphasizing the political fallout. I decided to enact a compromise position (a common tactic used to win *Reacting* games, as I would later learn): I would only try Act I in my astronomy classes, ending my game just after the midpoint in which the student-Cardinals vote on whether Galileo is a heretic



Aristotelianism, the "New Cosmology," and the Catholic Church, 1616-33, is one of nine Reacting to the Past games published by Pearson-Longman. Other science games in the series include *Charles Darwin, the Copley Medal and the Rise of Naturalism, 1861-64*, *Kansas, 1999: Evolution or Creationism*, and *Acid Rain and the European Environment, 1979-89*.

and then elect a new Pope.

I scheduled three pre-game class periods in which the students and I read and discussed Galileo's writings together. Then the real game-playing began and I retreated to the back of the room. As an instructor, it can be very difficult to sit silently while students run the class. This was especially true whenever the student at the podium didn't present something correctly. In one class, a student was conducting a demonstration to illustrate how quickly the Earth would have to move to account for day and night. Unfortunately, he did not have a clear conceptual understanding of the difference between the Earth's rotation and revolution. To make matters worse, another student *did* understand the difference, but was mixing up the two words in his vocabulary. It was extremely difficult as an instructor not to intervene but, to my relief, within a few minutes, the other students unraveled both the misconceptions of the first student and the misnomers of the second.

It seemed as though the *Reacting to the Past* method was an enjoyable diversion for both faculty and students, but I was curious if it had any measurable impact on student learning. There was, at the time, very little quantitative research on the effectiveness of *Reacting*. Steve Stroessner and his colleagues had conducted a six-year assessment of the psychosocial effects of *Reacting* compared to traditional pedagogies. They found a few benefits for the students, namely small increases in self-confidence, rhetorical skills, and empathy. My own preliminary assessment of *The Trial of Galileo,* focused on content mastery, showed two other intriguing results. First, students did just as well at answering astronomy questions related to the game (for example questions about moon phases or the size of the universe) as those students in traditional classes.

Elon University students playing *The Trial of Galileo* game. To add a sense of liminality, most *Reacting to the Past* games include a historical ritual or prop. In this case, a meeting of the cardinals of the Holy Office was held at the campus chapel.

Curiously, though, the incorrect answers given by these two groups of students were at times very different. For example, at the end of a traditional course, when students are asked about the center of the universe, some will say incorrectly that it is an unknown, distant galaxy. After playing *The Trial of Galileo*, however, some students answered that the Sun or the Earth were the center of the Universe. Part of this was due to a common confusion students have between solar systems, galaxies, and the universe. But it also echoed a serious concern frequently asked by historians about *Reacting to the Past*: Will students learn the "wrong" history? While the number of students affected was only a handful, this still troubled me. Since then, I have enhanced the existing end-of-game "post-mortem" sessions to be explicit and direct in how we can compare and contrast Galileo's work with our modern understanding. I recorded and made this lecture available for other instructors via YouTube so that other faculty can use this material as well. My colleagues and I are now in the midst of a new, expanded assessment of *Reacting to the Past*, examining changes in student attitudes towards science and in content mastery.

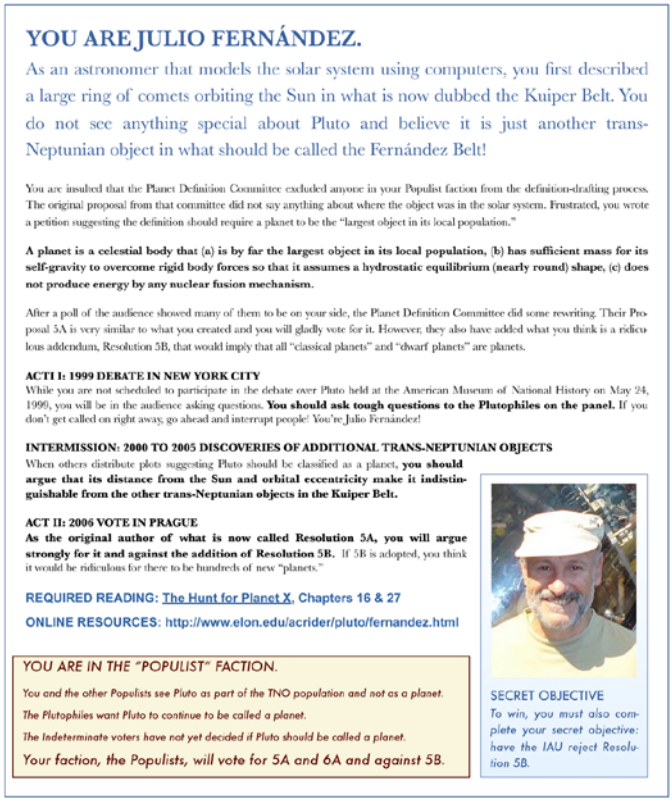
Even with better assessment, the barrier to faculty adoption of *Reacting* is considerable. My initial concern about the games was that I knew they would require between nine and 15 class periods to conduct. Even after figuring out a way to scale down *The Trial of Galileo* to just Act I, it was a big risk to throw out my tried-and-true lesson plans. To allow other instructors, in both astronomy and other disciplines, to sample *Reacting to the Past* without throwing out their well-developed lesson plans, I decided that someone needed to write shorter, chapter-length games. Why not me? I began considering possible topics for a short, science-based game to be used in introductory science classes such as Astronomy 101.

At first, the 1995 Paczynski-Lamb debate over the distance to gamma-ray bursters seemed perfect to me, since it was related to my Ph.D. research. The 1920 Curtis-Shapley debate over the scale of the universe,

however, seemed more historically significant. These both were interesting debates concerning true scientific disagreements. However, few people outside of astronomy know what a *gamma-ray burst* or a *nebula* is, and the appeal of a game like this to a general science audience would be limited at best. A simpler topic, one I had used for years to teach about planetary science, concerns the classification of Pluto. Even before I explain the rules, students can understand immediately the essence of the conflict: should Pluto be considered a planet?

I took my simplistic Pluto debate rules and began to cast it in the mold of *Reacting to the Past* games. I needed a setting, roles, and a book. The 2006 International Astronomical Union meeting in Prague served as a natural setting for the game since this was where one of the real debates happened. I then started selecting roles, relying at first on what little information I could gather from press releases, news articles, and blog postings. Each role needed to represent a specific viewpoint and to have adequate information online for student to read in preparation for the game. I ultimately settled on Govert Schilling's *The Hunt for Planet X* as the class resource, since it describes the study of Pluto from the perspective of multiple astronomers. Students take different roles with different required chapters from the book, leading them to bring up many different facts and viewpoints. Some argue for a planet definition that appeals to the public. Others argue that our understanding of science is not absolute and can change over time. Still others debate whether a planet definition based on physical properties is enough or if dynamical properties should also be included. It is amazing how students enthusiastically adopt their roles. While the first 10-15 minutes of class are often quiet, by the end of class students are boisterously interrupting each other, intent on making their case one last time or refuting their opposition's claims.

I should note that *Reacting to the Past* is not the only role-playing game being used in astronomy classrooms. Paul Francis at the Australian National University has been creating and using role-play in his astronomy classes since 1998. Tim Slater described his own astronomy mini-debates in a recent article in *The Physics Teacher*. Their exercises have students working in teams, each armed with a different set of



YOU ARE JULIO FERNÁNDEZ.

As an astronomer that models the solar system using computers, you first described a large ring of comets orbiting the Sun in what is now dubbed the Kuiper Belt. You do not see anything special about Pluto and believe it is just another trans-Neptunian object in what should be called the Fernández Belt!

You are insulted that the Planet Definition Committee excluded anyone in your Populist faction from the definition-drafting process. The original proposal from that committee did not say anything about where the object was in the solar system. Frustrated, you wrote a petition suggesting the definition should require a planet to be the "largest object in its local population."

A planet is a celestial body that (a) is by far the largest object in its local population, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) does not produce energy by any nuclear fusion mechanism.

After a poll of the audience showed many of them to be on your side, the Planet Definition Committee did some rewriting. Their Proposal 5A is very similar to what you created and you will gladly vote for it. However, they also have added what you think is a ridiculous addendum, Resolution 5B, that would imply that all "classical planets" and "dwarf planets" are planets.

ACT I: 1999 DEBATE IN NEW YORK CITY
While you are not scheduled to participate in the debate over Pluto held at the American Museum of National History on May 24, 1999, you will be in the audience asking questions. **You should ask tough questions to the Plutophiles on the panel.** If you don't get called on right away, go ahead and interrupt people! You're Julio Fernández!

INTERMISSION: 2000 TO 2005 DISCOVERIES OF ADDITIONAL TRANS-NEPTUNIAN OBJECTS
When others distribute plots suggesting Pluto should be classified as a planet, **you should argue that its distance from the Sun and orbital eccentricity make it indistinguishable from the other trans-Neptunian objects in the Kuiper Belt.**

ACT II: 2006 VOTE IN PRAGUE
As the original author of what is now called Resolution 5A, you will argue strongly for it and against the addition of Resolution 5B. If 5B is adopted, you think it would be ridiculous for there to be hundreds of new "planets."

REQUIRED READING: The Hunt for Planet X, Chapters 16 & 27

ONLINE RESOURCES: http://www.elon.edu/acrider/pluto/fernandez.html

YOU ARE IN THE "POPULIST" FACTION.

You and the other Populists see Pluto as part of the TNO population and not as a planet.

The Plutophiles want Pluto to continue to be called a planet.

The Indeterminate voters have not yet decided if Pluto should be called a planet.

Your faction, the Populists, will vote for 5A and 6A and against 5B.

SECRET OBJECTIVE
To win, you must also complete your secret objective: have the IAU reject Resolution 5B.

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Rolesheets for *The Pluto Debate* provide students with a brief background on their character, guidelines for Act I and Act II, the assigned reading, the secret victory objectives for winning the game. This particular sheet includes the instructions for playing Julio Ángel Fernández, a Uruguayan astronomer who was author of a key proposal at the IAU meeting in 2006.

facts and opinions, trying to resolve some question in astronomy. However, they do not have three key ingredients believed to make *Reacting to the Past* games successful: clear victory objectives for winning the game, indeterminate student voters who must be convinced by their peers, and a real historic setting for the debate. The victory objectives increase the competitive nature of the class and, by the end of a longer game, are more powerful motivators than the course grade. The indeterminate students create a sense that the debate is authentic; there is someone in the room who might be convinced by the arguments. Unlike simpler games set in a fabricated or unspecified place and time, the real historic setting helps direct students to resources not provided by the instructor. Many students playing *The Pluto Debate* come to class with print-outs related to their own characters. One set of students playing *The Trial of Galileo* scoured dozens of primary sources for material, even though this was not required reading. While it is still difficult to quantify the impacts of *Reacting*, the fact that it

Astronomers at the 2006 meeting of the International Astronomical Union voting on resolution 5A, the first formal definition of a planet. *IAU/Robert Hurt (SSC)*

compels many students to complete unassigned and ungraded "homework" is clearly some indicator of intellectual engagement.

It is ironic, of course, that my quest for the "classroom of the future" led me to some decidedly old school methods for learning: games, acting, and debate. I continue to be a strong advocate for new hardware and software in the physics curriculum, and I badger everyone who will listen about the need for innovative learning spaces across the campus. However, I am increasingly aware that my students are not necessarily adept with nor keen to use what they perceive as extraneous technology. In fact, as *Reacting to the Past* has demonstrated, face-to-face reading and discussion of the written word plays its own important role in modern education.

About the Author:

Tony Crider is chair of the Department of Physics at Elon University. His work with data visualization during graduate school at Rice University (in gamma-ray astrophysics) and at Los Alamos National Laboratory (in remote sensing) eventually led him to create virtual planetariums, telescopes, and lunar landscapes within the 3D online world of Second Life. In 2006, he co-founded the SciLands, an archipelago of Second Life islands dedicated to science education and outreach. Currently, Dr. Crider is assessing the effectiveness of both Second Life and short "Reacting to the Past" role-playing games in science courses. He recently was President of the North Carolina Section of the American Association of Physics Teachers and currently serves on the Science *Reacting to the Past* Advisory Board.

Resources for Further Information

The primary website for the *Reacting to the Past* curriculum includes details about the games in the series, related publications, and upcoming workshops: http://reacting.barnard.edu/

Reacting to the Past: STEM Games provides student game materials for *The Pluto Debate* and other STEM-centered Reacting to the Past games. http://sites.google.com/site/reactingscience/

Setting Student's Minds on Fire, an article by Mark Carnes in *The Chronicle for Higher Education* (March 6, 2011), describes the rationale for and some history of the *Reacting to the Past* series. http://chronicle.com/article/Setting-Students-Minds-on/126592/

The Hunt for Planet X: New Worlds and the Fate of Pluto (2008, Springer) a book by Govert Schilling, serves at the primary reading material for The Pluto Debate game.

The Pluto Files: The Rise and Fall of America's Favorite Planet, a book by Neil deGrasse Tyson, provides an account of the 1999 panel discussion on Pluto. (W.W. Norton & Company, 2009)

A discussion among planetary astronomers and astronomy educators about the Pluto decision at the IAU meeting can be found at: http://dx.doi.org/10.3847/AER2006028

Teaching Science by Reacting to the Past, by Derek Bruff, has a reflection on these games after having tried The Pluto Debate at a faculty workshop. http://derekbruff.com/site/blog/2011/04/16/teaching-science-by-reacting-to-the-past-stem11/

Using Role-Playing Games to Teach Astronomy: An Evaluation an article by Paul Francis in *Astronomy*

Education Review (2001, Vol. 4, Iss. 2), describes his development of exercises similar to *The Pluto Debate* prototype.
http://aer.aas.org/resource/1/aerscz/v4/i2/p1_s1

Enhancing Learning through Scientific Mini Debates, an article by Tim Slater in *The Physics Teacher* (2010, Vol. 48, Iss. 6), describes the debates he sets up in his classes.
http://tpt.aapt.org/resource/1/phteah/v48/i6/p425_s1?isAuthorized=no

The SCALE-UP Project is described at:
http://www.ncsu.edu/per/scaleup.html ✦