Ask Me about ISON: The Risks and Rewards of Teaching an Interdisciplinary Honors Course on a Scientific Event Unfolding in Real Time

William L. Vanderburgh and Martin Ratcliffe
Wichita State University

On September 21, 2012, two astronomers using a telescope in the International Scientific Observing Network near Kislovodsk, Russia, discovered a comet that came to be formally known as C/2012 S1 and was popularly called Comet ISON. Just a year later, two honors instructors in Wichita, Kansas, found themselves teaching a course on Comet ISON that came to be formally known as Fire in the Sky and was popularly referred to as "the comet course."

The behavior of comets is notoriously difficult to predict. Nevertheless, even from its first detection Comet ISON showed signs of being an unusual and significant comet. Some commentators went so far as to predict that it would be "the comet of the century," bright enough to be seen during daylight, with a tail extending as much as a quarter of the way across the sky. This possibility was enough to inspire us, a planetarium astronomer (Ratcliffe) and a philosopher of science with an interest in the history of astronomy (Vanderburgh), to propose a co-taught honors course that would look at scientific, historical, philosophical and other topics raised by this interloper from the edge of the solar system.

The success of new interdisciplinary courses is never guaranteed. Especially considering that we were deliberately planning to "make it up as we went along," that is, to adapt what we were teaching to the weekly news about the performance of the comet, we did not dare to predict that ours would be the course of the century. The course turned out so well, though, that we believe other honors instructors could profitably borrow some of what we did in similarly styled courses even if they are not lucky enough to have sufficient advance notice of a potentially stunning comet.

Our course was about a scientific event unfolding in real time. The potential of such courses as honors-quality experiences is excellent; the degree of

excitement, the opportunities for learning, and the prospects for the course being truly memorable are all high. The risks are also high any time the outcome of a course depends on something outside of it, perhaps more so in the case of a scientific event that might or might not turn out as hoped and that might or might not conclude in a time frame that is convenient to the period in which the course is offered. With unpredictability comes the possibility of failure along with nagging questions about whether the students will like it and learn from it or whether the event under study will turn out in an interesting and productive way. In our course we attempted to mitigate these risks by being ready to adapt to any eventuality as the scientific event unfolded and by having enough supporting material that the course would be meaningful even if the event failed to live up to expectations. By designing the course to be interdisciplinary, we coupled the contemporary science of comets with coverage of comets in history and the history of astronomy as it relates to comets. Furthermore, we introduced opportunities to discuss some social, political, and philosophical dimensions of comets and comet research. Co-teaching the class helped to make this breadth of subject matter possible.

Any on-going scientific, political, economic, or sociological event could profitably be the focus of a course like this. An event that involves elements of a journey or that can be packaged as a journey of discovery would likely work best. If the timings work out with the rhythms of the semester, a journey gives a beginning-middle-end structure to the course and can create a sense of urgency and immediacy that in turn motivates student engagement with the material. Some examples might include a course on geology centered on a mountain-climbing expedition or the progress of a Mars rover, a marine biology course that tracks the progress of a sailing voyage or a submersible mission to an ocean trench, or a course on meteorology that follows a trek to the pole or storm chasers during tornado season. Any such scientific mission will have news coverage and a website; most likely these days it will also have online educational resources, blogs, Facebook pages, webcams and live-Tweeting of the event as it progresses.

SOME PRELIMINARY CONSIDERATIONS

The title of the course, Fire in the Sky: The Comet of the Century, was borrowed from *Fire in the Sky* by Olsen and Pasachoff (1999), an elegant book about representations of comets and meteors in British art and literature in the eighteenth and nineteenth centuries. Ultimately we decided this book was only tangentially related to the course as we intended to teach it and that we therefore could not ask the students to purchase it. In fact, we were unable to find any existing books that suited our purposes. We relied instead on Internet resources, including webpages, news articles, blogs and even Facebook, which happened to have a well-curated and administered ISON group page. These kinds of sources added to the cutting-edge feel of the course and appealed to the millennial generation's proclivity toward electronic media although, in the end,

students probably read somewhat less than we might have preferred in an honors course. They didn't seem to mind. In any case, many of the students became so interested in the topics of the course that they did their own explorations on the Internet, often sharing with us good articles or websites they discovered. An additional and unexpected benefit of relying on blogs and social media for a good deal of the course material was that students got to see scientists struggling to interpret the data and arguing with each other about it, giving a truer picture of the tentative, confusing and messy process of doing science than one usually finds in the cleaned-up versions presented in textbooks.

One novel administrative move we tried was to cross-list the course under two different HNRS course numbers, one for humanities general education credit and the other for natural sciences general education credit. Given the truly interdisciplinary manner in which the course was structured and taught, this double listing was an appropriate way to attract a greater number and broader variety of students; had we offered it only for humanities credit, humanities majors might not have taken it, and had we offered it for natural sciences credit, science and engineering majors would not have been able to take it. Unfortunately, this plan resulted in some snags given some baroque details of the general education program at Wichita State University; suffice it to say that our interpretation of the catalog was different from that of the advisors in one of the academic colleges, and they refused to count the course toward the requirement that one student had thought she was fulfilling. As we support that student's appeal to the Exceptions Committee, the honors program is exploring catalog changes in how its courses count toward general education so that this situation does not come up again.

Otherwise, the cross-listing strategy was indeed successful in attracting the number and breadth of students we were looking for. Another contributing factor to getting the enrollment we wanted was that we offered the course for upper-division rather than lower-division credit. In an era when a great many honors students enter the university with a large number of college credits, lower-division honors courses are becoming less popular.

SAMPLE TOPICS AND APPROACH

Our course covered a wide variety of topics, all tied in some way to comets. We discussed the development of astronomical theory from the ancient Greeks through the scientific revolution, in part to explain the interest and difficulty of doing astronomy and in part to illustrate how appearances of comets influenced crucial figures like Tycho Brahe and Johannes Kepler. Isaac Newton's theory of universal gravitation was an important topic to cover because it allowed us to discuss orbital mechanics and to introduce Halley's Comet, the periodic orbit of which Edmond Halley was first able to predict thanks to Newton's theory. After establishing the basic motions and fundamental structure of comets, we talked about other major comet appearances from the eighteenth through the twenty-first century, including the public reactions to those events. From the 1980s until the present, quite a few interesting space missions have imaged comets and

even smashed spacecraft into them—Giotto, Deep Impact, and Stardust were just a few we discussed—and covering those space missions took us a couple of weeks. One of the guest lecturers we managed to schedule via Skype was the chief American scientist from NASA's Jet Propulsion Laboratory on the joint European Space Agency/NASA Rosetta mission, which will land a probe on a comet in 2014. Although we happened to have a personal contact that helped make this possible, scientists on federally funded projects are generally required to do public outreach in order to meet the "broader impacts" requirement of their grants, so it is worth asking. At least once a week we also gave an "ISON update," reviewing the latest news about the comet, including a discussion by one of us (Ratcliffe) of locally photographed images of the comet. Sometimes the ISON update lasted ten minutes; sometimes it took the whole class period.

The class often felt like playtime; we joked with the students that we could not believe they were earning academic credit for having so much fun. In truth, though, the fun was an important part of the course, promoting both camaraderie among the students and attachment to the subject matter. It is easy to overlook this emotional component of learning, but, as we learned, including opportunities for it makes a significant difference. Along the same lines, we used the honors program's funding to purchase t-shirts for all members of the class. The front of the shirt had the honors program logo while the back had the student-suggested slogan "Ask me about ISON" above a stylized picture of a comet. This small gesture, while not a serious expense for the honors budget, created a great deal of goodwill and excitement among the students while also providing some nice advertising for the honors program. For similar reasons, we took a break in the middle of the semester to watch the Bruce Willis movie *Armageddon* during class. The movie itself was even worse than we had remembered from seeing it at its release in 1998, but it gave the students an opportunity to apply what they had learned so far and give sophisticated critiques of everything the movie got wrong about comets and comet deflection.

OTHER THOUGHTS

We knew from the beginning that engaging students with the science was going to be an important aspect of the course. Fortunately, one of us (Ratcliffe) has a home observatory and therefore was able to invite the class to come view the comet for themselves. The fact that this viewing occurred very early on a very cold morning probably contributed to some class bonding. We were able to capture digital photographs of ISON and another comet (Comet Lovejoy) that happened to be in the morning sky at the same time as well as to look through a large telescope at Jupiter and its moons. A few students had sufficiently good eyesight that they were able to see a faint fuzzy patch when they pointed binoculars at Comet ISON.

Other instructors who try an interdisciplinary course like this one might not have access to a telescope of their own. However, on many campuses it should be possible to track down amateur stargazers or professors in the astronomy

program who would be willing to share their time and expertise. If the university operates an observatory, a visit should be possible. Other options for direct engagement with the science include local public observatories and planetariums. Courses not focused on astronomy could arrange laboratory tours in relevant sciences and/or trips to science centers, nature centers, or even a local Extension Office. Making this extra effort to engage the topic outside of the classroom is one way to make the course a true honors experience.

Another way we were especially fortunate was that one of us (Ratcliffe) had gone on observing trips to Kenya and Australia to photograph Halley's Comet in 1986 when he worked as a lecturer for the Armagh Planetarium and Observatory in Northern Ireland. His personal reflections, photographs, and observing logs added immeasurably to the students' appreciation of the excitement and difficulty in taking astronomical photographs of such faint and fleeting objects.

In an honors course built around coverage of a scientific event as it is happening, incorporating some history of science is a good idea. If the current event does not turn out as hoped, looking back to the history can provide context, suggest additional topics of discussion, and—let's face it—help fill the time left in the semester. The failure of a scientific experiment or idea can be turned into a valuable learning opportunity, affording an occasion to work through in detail, via a real-life application, how science actually works: it shows how scientists adapt to new information, setbacks, and observations that contradict prior expectations; it shows how theories, assumptions, questions and answers can all change over rather short time scales in the face of new data and theoretical developments; and it provides a lesson in the capriciousness of the natural world and of the scientific process. Besides painting a better picture of how science works, valuable in itself and an inspiration for students to try out some undergraduate research of their own, the possibility of failure encourages students to be circumspect in expressing hopes for how research might turn out.

THE MAJOR ASSIGNMENTS

One of the interesting features of comets is that they sometimes collide with other solar-system bodies, including planets. Our course included discussion of the impact of the twenty-one fragments of Comet Shoemaker-Levy 9 with the planet Jupiter, including the images taken by the Hubble Space Telescope that were released to the public more or less as the impacts were happening, a scientific first that captivated the public in 1994. This discussion allowed us to raise the theme of the public communication and reception of science, which became part of a signature assignment later in the course (see below). The Chelyabinsk meteor that exploded in the skies over Russia on February 15, 2013, the impressive effects of which were recorded by many video devices and were posted widely on social media, provided a nice segue to discussion of Earth impacts. These included the Tunguska Event (an atmospheric explosion in 1908 that flattened 2,000 km^2 of remote Russian forest that was attributed to the impact of an asteroid or comet) and the Chicxulub crater (the remnant on

the Yucatan peninsula of the asteroid or comet impact sixty-six million years ago that likely caused the dinosaur extinction). There is also some speculation that most of Earth's water was delivered by comet impacts in the very distant past.

These impact stories led us to current proposals that humans need to build robust "detect and deflect" schemes for so-called Near Earth Objects that could potentially impact the Earth. The proponents of such schemes talk about "city killers" and "civilization enders" and argue that, while the odds of such an impact in the immediate future might be low, it will inevitably happen again at some time in the future, and they suggest that it would be a wise investment to build such schemes now in order to be ready to prevent the end of civilization if we can. As it turned out, the United Nations held a conference to discuss potential asteroid and comet impacts on Earth in the middle of the semester in which we taught the course, a coincidence that helped turn what might have seemed a merely academic discussion into a study that had real-world relevance.

The topic of Near Earth Objects probably includes enough material by itself for an honors course. We touched on such matters as the science of impacts; ways to detect astronomical bodies that could hit the Earth; ways to deflect or destroy such potential impactors; the ethics of trying/not trying such schemes; the public funding of science; the politics related to national governments, international organizations, or private groups taking responsibility for dealing with such a global threat; and how the answer we give about dealing with Near Earth Objects should shape our responses to other kinds of global threats such as poverty, pandemics, and climate change.

Given the large number of diverse sub-topics relating to Near Earth Objects, we had an ideal opportunity to make this section of the course the students' responsibility to research and present. They worked individually or in pairs on parts of the topic and then made a whole-class presentation during which each person or team reported on the sub-topic they had researched. In preparation, the students met together outside of class for several hours on several occasions. During these meetings they assigned sub-topics, discussed presentation strategies, compared research notes, asked each other questions, and planned the presentation itself. Each student thus became an expert on a sub-topic, became familiar with the other topics, and got practice working in teams. The next class period after the long presentation was devoted in its entirety to a free-form discussion in which the students, with some tough Socratic questioning by the instructors, tried to decide the question of whether or not the United States ought to use taxpayer funds to build a "detect and deflect" program for Near Earth Objects. This class was originally conceived as an Oxford-style formal debate, but during the preparation period the concept evolved so that instead it ultimately resembled the kind of discussion that an expert panel at the National Science Foundation might hold to decide an important strategic question about what kinds of scientific projects to prioritize for funding. In all, this assignment was very successful, one that we would repeat again in similar form in other classes. In general such an assignment would work well in any course structured

around a current scientific episode since the question of the public funding of science can be raised in relation to any specific science.

Earlier in the course, after completing the section on the history of astronomy, we asked each of the students to choose a unique "comet in history," research it, and give a five-minute presentation about it. We held several presentations at the beginning of each of four consecutive class periods so that not just the instructors were presenting all the time, the students got comfortable with talking in class, and we could cover material that might have seemed somewhat repetitive had the instructors presented it all.

The other major assignment, due at the end of the semester, was an analysis in essay form of popular accounts of Comet ISON. Here is the assignment prompt we used:

> This assignment challenges your analytical and critical skills as applied to the topic of "communicating science to the educated but non-expert public" with specific reference to the popular news coverage of Comet ISON. Find three popular articles about Comet ISON, from its initial discovery to now. (Completing the assignment may be easier if you choose longer rather than shorter target articles. In your list of sources, give full citation information including a URL if available.) Analyze each article in turn; comparing and contrasting them among themselves is acceptable but is not required. Go into detail about the strong and weak points of each article. Consider such factors as accuracy, sensationalism, relevance, clarity, level of explanation, ways the author generates and sustains interest, word choice, writing level, the use of metaphors and analogies, the use of story, the use of quotations and expert testimony, the use of images and illustrations—or any other factor that is relevant to judging the quality of the work.

The papers we received from the students were of good quality and were genuinely interdisciplinary. Humanities students were able to apply their skills in textual analysis to a topic area with which they had had limited previous experience, and natural science/engineering students had an opportunity to reflect on effective ways of communicating technical information to non-expert audiences. We also offered a bonus assignment in which students were asked to write their own 500–1000 word article explaining Comet ISON to a popular audience. Only a few students had time at the end of the semester to complete the bonus assignment, but the ones who did so turned in nearly publishable work. If we were to offer such a course again, we would make this a regular assignment rather than a bonus assignment, and we would place it earlier in the semester.

CONCLUDING REMARKS

At the end of the semester we stopped to marvel what luck it was that Comet ISON reached perihelion on Thanksgiving Day, with just two class periods left in the semester. The comet fizzled. It was brightening wonderfully as it approached the Sun but then started fading just before it disappeared behind the occulting disk of the SOHO spacecraft that was recording its journey. It emerged from perihelion as a mere puff with no bright central nucleus. We had some moments of excitement later when it seemed to brighten again, but the online articles about a "zombie comet" back from the dead turned out to have been overstated. Still, the open discussion and disagreement between experts on the ISON Facebook page revealed the real human process of science in a way no textbook could have conveyed. After its closest approach to the Sun, ISON never became bright enough to see with the naked eye, let alone to be considered the comet of the century. We were in touch by email with our students throughout the day while all this was happening, and several of them were quite distraught by the turn of events.

What would we have done had we built the course around a comet that had fizzled a month or two earlier in the semester? The truth is that the course would have gone well anyway, with more than enough comet-related material to fill a semester. Some of the excitement of anticipation would have been lost, but the opportunities for learning would have been just as good. For example, had the comet fizzled earlier in the semester, we could have spent more time on impact threats, space mission design, and understanding the origins of the solar system as well as on literary and artistic responses to comets and the social/political stories to which they become attached. Also, since there is often more than one comet in the sky, we could have given more attention to other current or recent comets.

Before we left for Thanksgiving break, we took a class opinion survey about how ISON would perform. None of us voted that it would fizzle although we all recognized that the possibility existed. In the class period after Thanksgiving, we were able to use our survey results to talk about how biases can skew scientific predictions.

This course was a peak experience for both the instructors and the students. Part of its success can no doubt be attributed to the high degree of prior interest in the subject that the instructors and students shared. The instructors' enthusiasm for the material surely did help motivate the students, and the uncertainty of the comet's fate made this science story more immediate and interesting than some other topics might have been. Other contributions to the success of the course were the opportunities for fun, for students to take responsibility for teaching part of the course themselves, for assignments that required deep engagement with the content while working together with other students, and for meaningful out-of-class experiences related to the material. We recommend such opportunities for any honors course. However, the most important factor contributing to the success of our course was that it engaged a significant real-life event, while it

was happening, from an interdisciplinary perspective that made the experience richer. This approach could fruitfully be applied in fields of study that range from business and engineering to politics and sociology, not just the hard sciences.

For anyone considering a comet course of their own, Comet C/2013 A1 (Siding Spring) will make a very close approach to Mars on October 19, 2014, and the Rosetta mission will land a probe on the Comet 67P (Churyumov-Gerasimenko) in November, 2014.

REFERENCE

Olsen, Roberta J. M., and Jay M. Pasachoff. (1999). *Fire in the Sky: Comets and Meteors, the Decisive Centuries, in British Art and Science*. Cambridge: Cambridge University Press.