Larry Krumenaker

No Child Left Behind and High School Astronomy

This article examines the impact of the No Child Left Behind Act on the high school astronomy course.

Astronomy was a required subject in the first American secondary level schools, the academies of the 18th century. When these were supplanted a century later by public high schools, astronomy still was often required, subsumed into courses of Natural Philosophy. Reasons given at that time to support astronomy as a part of general education include "training of minds," "mental discipline," and the practical aspects of geography, commerce, navigation and the refinement of a civilized person (Bishop, 1977).

The "Committee of Ten" changed this situation in 1892 by changing college admission standards to no longer consider the study of astronomy as favorable. By 1930, only 0.06% of all students in the whole country would take an astronomy class (Bishop, 1980). The launch of Sputnik I in 1957 created a brief renaissance of astronomy education, but eventually enrollment slipped back down to 1% in the 1980s, which was when the last significant nationwide examination of high school astronomy was done through Philip Sadler's 1986 survey (Sadler, 1992).

After Sadler, an era of budget cutbacks and increases in high stakes standardized testing began, and this became a dominating influence in 2001 with No Child Left Behind (NCLB) and its emphasis on reading and mathematics. Today astronomy is taken by about 4% of all high school students (Krumenaker, 2008). Despite the meager growth that this enrollment represents, it remains important to re-examine the subject of high school astronomy as well as the effects that NCLB has had on the availability and quality of these courses.

The results indicate that high school astronomy courses are far more affected by NCLB indirectly than directly.

This mixed-methods study looked at fully independent, self-contained astronomy courses available to students in grades 9-12. Therefore, courses, such as physics or earth science, that contain some astronomy units were not considered in this study. The data came from high school astronomy teachers via a survey available to them on a Webpage and as a Word file. (See Appendix A for an overview of the research procedures.) The study mirrored but greatly enlarged the scope of the Sadler study. Quantitative and categorical questions included diverse topics such as instructors' backgrounds, planetarium and telescope availability, financial support, course content, student demographics, school AYP status, and other items. Also included were open-ended survey questions, such as requests for recommendations about ways to go about starting a course, and these responses were coded and treated with qualitative or quasi-quantitative analyses. A detailed quantitative summary can be read in Krumenaker (2009a).

With an initial estimate of between 2500 and 3000 possible teachers derived from a national listing called the National Registry of Teachers supplied by the National Science Teachers Association, our initial survey sample of about 600 teachers represents 20-25% of the astronomy teacher population. In order for a sample of a small population to be considered reliable, Tuckman (1999) claims that it must consist of at least 10% of the target population, and this data exceeds that standard.

The survey had an overall response rate of about 40%, and out of this initial sample 237 surveys were deemed usable.

Additionally, in the Fall of 2007 the same questionnaire was sent in a second survey by postal mail, and this generated numerically half as many responses. All of these results

are essentially identical to the larger, first survey, which strengthens the conclusions and removes concerns relating to possible selection effects arising from the methods of solicitation and response (Krumenaker, 2009b).

Schools' AYP Status and Sizes

This article concerns itself with the part of the study that deals with the perceived effects that the No Child Left Behind Act may have had on high school astronomy courses. One key parameter to investigate is the AYP status of each school. AYP stands for Adequate Yearly Progress and is a measure of compliance with NCLB that relies mostly on high stakes testing scores. Filtering the results to include only currently employed public school teachers yielded 114 public schools with a Pass grade, 30 with a grade of Needs Improvement, and 5 with a Failing AYP, or a rate of 77% Pass, 20% Needs Improvement, and 3% Fail. The NCES (2007) values for 2005-2006 indicate the comparable national percentages were 60% Pass, 14% Needs Improvement, and 26% Fail. This shows that high schools with astronomy are more likely to be schools that Pass AYP. Needs Improvement percentages for schools with astronomy are also higher than the norm. The percentage of schools with astronomy that Failed are substantially lower than the national value.

This supports, though does not prove, studies that say that electives like astronomy are eliminated when a school does not pass AYP. Speculatively speaking, this also supports the contention that schools that pass AYP have the luxury of offering an elective like astronomy. But one must now ask: have the teachers, therefore, not felt any effects from NCLB?

Have Astronomy Courses Been Affected by NCLB?

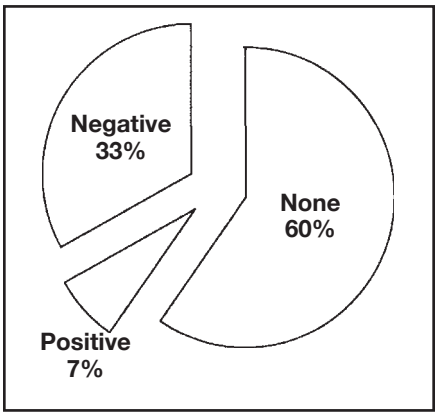
Among the open-ended questions in the survey was "What, if any, positive or negative effects have you felt *in the astronomy course* from the No Child Left Behind Act? (And, why do you feel this way?)".

Analysis of this (and other similar questions on the survey) was done by coding the responses in a manner akin to grounded theory techniques developed by Strauss and Corbin (1997). Each sentence in an answer, regardless of grammar or size, was given a code word or phrase indicative, in this case, of the purported effect of NCLB. The sentences were sorted alphabetically by code word, then grouped under larger headings; these might include 'administration', 'justifications', 'support', and so on. No presupposed groupings were used; each grouping would appear when a 'critical mass' of similar answers was gathered. As general themes became evident, larger groups could be split into smaller ones, and smaller ones could be combined into larger groups.

In addition, simple descriptive statistics were performed on most qualitative questions by counting and comparing the sizes and numbers of groups or themes.

Out of the 237 teacher pool, 30 belong to private schools where NCLB has no effect or standing. Others did not respond at all to this question or gave answers not related to their course. Of the remaining 139 responses, 83 teachers (60%) claimed that NCLB had no effect on their course. Forty-six made statements that can be construed as negative effects. Only 10 teachers gave responses that could be construed as positive. Of those that claim some effect from the Act, the resulting balance is clearly negative, 33%, versus 7% positive (Figure 1).

Figure 1: Teachers Reporting Effects of No Child Left Behind on Astronomy Courses



Why do so many astronomy teachers find themselves apparently immune from NCLB? One of the two most direct answers coming from survey results is that NCLB itself and the "high stakes testing" that is NCLB-inspired but directly controlled by state departments of education only apply to Math and Language Arts, not science, as of the time of this survey. The other common answer is that some states have few or no high school astronomy standards at all, such as the state of Texas' TEKS (Texas Expected Knowledge & Skills). Therefore the courses are not tested, and, consequently, they are ignored.

In the detailed discussion that will now follow, additional evidence about these perceptions, through representative quotations, will be presented. In them, a "Pass," "Passing," "Fail" or "Failing" comment indicates the school's AYP status. Numbers alone, such as "1.5K" or "1500" refer to the number of students in the school. Where the information

is not listed, either the status is unknown or not considered relevant to the discussion. Also, quotes are left intact as typed into the surveys by the respondents, including misspellings and grammatical errors.

Negative Effects

Negative effects due to NCLB, or related state high stakes testing or curriculum changes caused by NCLB pressure, manifest themselves in six areas: enrollment numbers, course cancellations, redeployment of teachers and certification issues, a change in the makeup of the courses' student bodies, loss of status as a science course, and loss of funding.

Numbers

Teachers report a decline in enrollment due to a strong and increasing emphasis on biology, chemistry, and physics. As these courses become more state-tested, and therefore more required of students, fewer students have time available for electives, and student scheduling abilities become more limited. Other studies such as Hunt (2006) indicate the same problem for other science electives. The October 2007 *NSTA Reports* found that "investment in these programs (environmental education) came to a screeching halt …" (NewsBits, 2007). Survey responses show similar concerns.

> NCLBA will cause course to be canceled after this year. School will concentrate on Biology which is the only state science test in Arizona. —Self-described pessimist, soon-to-retire Arizona teacher in a 0.6K student Passing high school whose class is open to all grade levels.

Cancellations

In addition to drops in enrollment, sometimes the courses themselves are dropped, or are expected to be dropped, for other reasons.

> However, our administration has told us that IF our API scores drop in the future or we do not meet the benchmarks that have been set by the State, we will have to remediate these students someway. That will cause the teachers of elective courses (including science electives) to become overseers of remedial courses. Regular class enrollment will drop and courses will be eliminated as we have to add remedial sections. —Teacher in a 2.2K, Passing Oklahoma high school.

Student academic levels

Teachers reported substantial increases in the numbers of students of lesser academic abilities in their classes. Comments indicated that more special education students are believed to be placed in astronomy classes, despite the fact that often there are prerequisites of passing grades in math, especially algebra, and other sciences that these students do not meet. There were more comments on the effects of inclusion than for any other individual, negative coding.

> … the emphasis of inclusion has resulted less in includiung a few special education students into regular education classes and more in classes becoming special education. … the math prerequisites for the astronomy course are ignored for special education students. With time, more and more students enroll in the course without the necessary math background thereby requiring drastic alterations to the curriculum. For example, students are not proficent with measuring angles and solving one variable algebra problems. —Teacher in a 1.2K student Passing Pennsylvania high school with a planetarium.

Teaching qualifications

Another effect seen by surveyed teachers, and the only effect directly caused by NCLB, is change in, or elimination of, teaching assignments, particularly because of the 'highly qualified' specification. Some teachers wrote that they have had to make choices in what they can, or will, teach. Sometimes the change has been forced upon teachers. This particular certification issue was further and vividly exemplified in an email from a responding teacher that came just after the formal end of the survey.

> Well I thought I would update you to a new road block to having astronomy in our classrooms. One of the provisions of No Child Left Behind (No Teacher Left Standing) is that a teacher must be "Highly Qualified" in every subject they teach. In most states including mine, that means you have to take a test to prove you are qualified. Having a degree no matter what your GPA doesn't count. If you haven't taken such a test you have to go through all sorts of "hoops" to earn enough points to prove you know your subject.
>
> Since there is no Astronomy test then the process is overly complicated for any teacher to attempt starting out a new program. I my case I have both a BA and

Master of Education. Although I am considered highly qualified in Biology, a course I have never taught, I am not in Astronomy since it isn't recognized on any state list. I have taught astronomy for 27 years. Awarded [a prestigious award from a renown society but name removed to keep letter writer anonymous] … for teaching high school astronomy but can not get the state of [omitted] to acknowledge I am highly qualified.

Loss of status

Teachers report that astronomy is being 'left behind' other sciences.

Students are required to take Biology and two other Science electives. NCLB does not empasize the importance of taking any Earth and Space courses. Earth/Space seems to take a 'back seat' to Chemistry and Physics. —Teacher in a 1.3K Minnesota Passing high school.

Loss of funds

Financial resources are also diminished, according to some reports.

So many financial resources are directed to remediation of these that materials funding has been cut past the bone. I get about one dollar per student for the year. —An Alaska teacher at a 2K student Passing high school.

the courses have been de-emphasied by the administration because it is not testable material and uses resources better spent on improving test scores. —Self-described pessimistic former teacher from a small 400-student, Passing Wisconsin high school.

Secondary effects

There are secondary negative consequences mentioned.

Teachers can't go to a workshop if it doesn't fit NCLB. Can't make a workshop, can't write to state standards, must be federal. Attendance is down. —Former small school Maine teacher who gives workshops.

Further evidence of reduced professional development opportunities comes from Pennypacker (2008) who coordinates a global version of the Hands-On Universe (HOU) teaching training program. His chart of the number of teachers who have taken the HOU training program over the years shows a rising trend-line abruptly curtailed at the 2001 year mark, and which descends in 2004, just after the War in Iraq began (Figure 2). We can not state there is a clear cause and effect here, but clearly the HOU graph parallels similar effects reported by the surveyed teachers.

Teachers claim they can not call in as many outside resources.

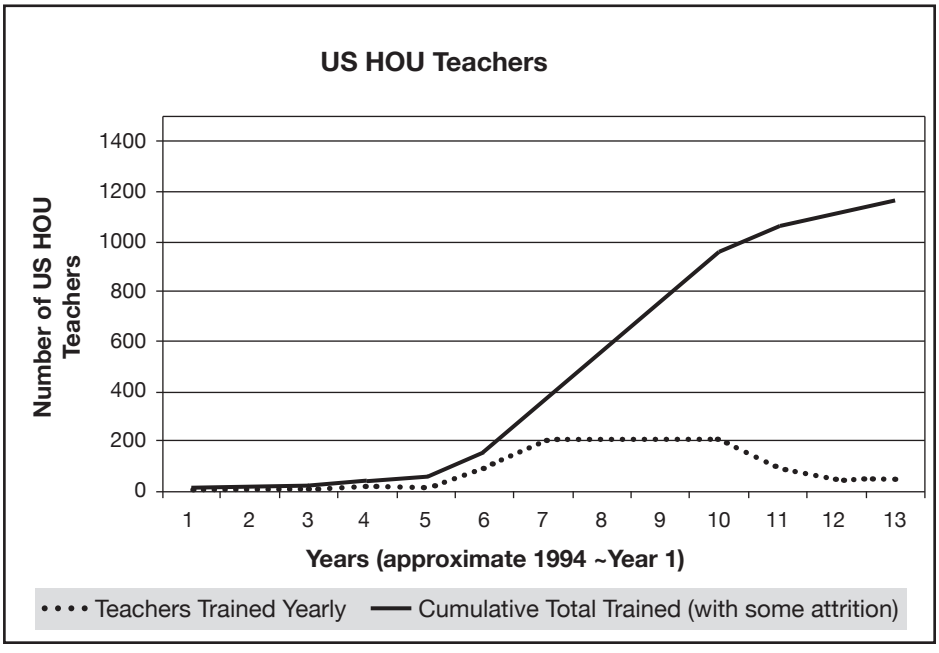
We [astronomy club members] have seen a drop off in the number of request for the club to come out to schools and put on star parties. Teachers are commenting that they are so under presure to meet NCLB mandated standardized tests that they don't have time to cover much astronomy. —A private school teacher in Hawaii who also is in an astronomy club.

It is also reported that there are fewer opportunities for collaborations and, consequently, a purported stifling of teacher creativity.

Positive Effects

Fewer positive effects are reported than negative effects. Two of them are at odds with some previously mentioned negative effects. One positive effect is that courses are actually experiencing increased enrollments.

Figure 2: The number of teachers taking the HOU workshops, 1994-2007, from Pennypacker (2008), used with permission.



Since No Child Left Behind analyzes our failure rates, it has caused an increase in the astronomy enrollment due to students trying to make up lost science credits. —Teacher in a 2K, high minority, Needs Improvement, planetarium equipped New Mexico school.

The existence or lack of astronomy standards affects administrative perspectives about whether the course is worthy of being offered.

The other at-odds positive effect is the paradoxical increase in the amount of time spent on astronomy, but not in astronomy courses. Instead, the astronomy courses themselves are eliminated, but more astronomy is taught in geoscience courses, so the net effect is that more students, at a lower non-capstone level, are taught more astronomy than prior to NCLB.

Positive effects, besides increasing enrollment at some schools, include having more literacy work and math work included in courses that, presumably, had previously been more conceptual.

> I firmly believe in the intent of No Child Left Behind. Reading and Writing in the context of Astronomy improves the students abilities in all courses. I approach the math component usign the Read/Analyze/Compute/Evaluate (R.E.A.D.) method. The honors Geometry classes have visited my astronomy classes to see first hand how the fundamentals of mathematics came into being. Holding the students to a high level is essential to improve their attitudes about learning and gives them confidence. The students will be doing several major term papers each semester. There is a rich history behind the science that helps to students see the interconnections between science in general and their other core classes. —Teacher in a 1.8K student, high minority, Needs Improvement school in New Mexico.

Why 'No Child' Has No Effect

The results indicate that high school astronomy courses are far more affected by NCLB indirectly than directly. Enrollments drop often, not because of a shift of student interest, but because students are channeled increasingly into the main three sciences (shades of the Committee of Ten effect) and state mandated/tested courses, leaving fewer students (or schedule time) available for students to take an astronomy course. As a result, fewer sections are offered, and this can lead to outright elimination of the course. Because NCLB does not mandate that Earth/Space Science classes be tested, funding for these courses is reduced, which in turns makes teachers unable to bring in outside resources or obtain professional development related to astronomy. Consequently, teachers report a loss of status for astronomy teachers compared to those of other sciences.

Because the existence of state standards pertaining to a specific content area often correspond to state mandated testing of student performance, another paradoxical situation arises. The existence or lack of astronomy standards affects administrative perspectives about whether the course is worthy of being offered. Astronomy course standards may not be specified by the state, and, therefore, the courses are ignored by administrations that must be more concerned with achieving acceptable pass rates in math, language arts, and state-tested sciences like biology or physical science. However, in other schools located in states that lack astronomy standards, that situation results in the termination of the course:

> They cancelled my course because it wasn't tested! —Self-described pessimistic teacher at a large 2.5K-student Passing Texas school, with a portable planetarium.

Yet, in still another paradoxical situation, this untested specification can cause an increase in enrollment, because this science is perceived (incorrectly at times) to be an easier path for students who have difficulty with the tested sciences. It also means more students are placed into these courses without sufficient academic background, which adds to the perception that these courses are less academically challenging. Astronomy course standards created using NCLB-"approved" standards (whatever they may be) can be helpful to the course's survival. This tactic has had some positive effects, such as increasing math and literacy-based work.

However, the presence or absence of standards does not uniformly predict the existence of astronomy courses throughout the country. Because the overall survey indicated that large schools are more likely to have astronomy than small schools, size of the school may be a significant factor with regards to astronomy course availability, usually in the form of a capstone class, whether or not there are

established standards (Krumenaker, 2009a).

When all of the reasons given for the lack of direct effect on the course by NCLB are examined, it is found that, currently, astronomy hangs on primarily as a capstone course that is offered only to seniors or upper division students who have essentially passed all NCLB-created hurdles, such as graduation requirements and mandated end-of-course tests. Specifically, 75% of astronomy courses are offered exclusively to upperclassmen. These factors may be putting astronomy beyond the target range of NCLB. Should science become a factor in AYP, this relationship is likely to change, and the indirect effects would be overshadowed by direct ones.

Defending the Course

Even though quite a few teachers appear to have avoided being directly negatively impacted by NCLB, there are documented cases included in this study of courses being cancelled or curtailed. In other cases, the course has been threatened, but teachers have been able to defend the course successfully.

To find out the tactics and rationale that teachers have used (or suggest should be used) to defend the existence of the course, the following open-ended question was asked: "If you should have to defend or justify the course at some future date, what arguments would you use? Why?"

The question generated 428 responses, where 'response' indicates a particular defense mechanism. Six primary themes are listed in Table 1; percentages do not add up to 100 due to rounding.

Table 1: Themes Teachers Use to Defend the Course

Theme	Number	Percentage of Responses
Defending with the nature of the course	137	32
Defending with student interest	88	21
Defending with cultural linkages	78	19
Helps improves students, school, AYP	54	13
Defend with traits of science	24	6
Institutional benefits	22	5
Other	25	6

By far, the largest theme is "Defending with the nature of the course." The most common reason given is that astronomy, by nature, is interdisciplinary in that it involves math, other sciences, logic, history, and more. "An integrated course" is given as all or part of a response in a full one-third of all the Nature of the Course responses.

The second largest defense theme is "Defending with student interest." The most common sub-theme is "students are interested in astronomy, often more than for any other science, so we should teach it," and it was given by 53% of those teachers providing responses that fell within the scope of this theme of defense.

Closely following is the theme of "Defending the course with its cultural linkages." This defense mechanism utilizes historical, sociological, and philosophical arguments and intangible connections that astronomy has with human thoughts and societies. A common sub-theme is that astronomy teaches students about their place in the universe and about the wonder of it all. The historical argument that astronomy is the first science or the foundational science is listed frequently. More tangible linkages include ways that astronomy is part of everyday life, for example, as cultural myths, the origin of the calendar, and so on.

The next largest theme is "Astronomy helps improve students, school, and AYP measures." This uses the defense that astronomy helps schools meet state standards, helps students pass state end-of-course and school graduation tests, and provides alternatives for students who have difficulties passing the biology, chemistry, and physics course sequence.

The last two themes are less common and roughly equally proportionate in influence. "Defending the course with traits of the science" utilizes the arguments that astronomy is physically and mentally more accessible to students and that astronomy is less static than other sciences. "The Institutional Defense" promotes the idea that astronomy courses help the school's image and economics. Finally, there are responses that do not fit any of the stated defenses, including a few unique defense strategies that will not be discussed here.

In order that other astronomy instructors may find these useful, a discussion of each defensive argument follows.

Nature of the Course

The most common theme mentioned in the survey that is useful to defend the course from external threats is the argument that astronomy is the most integrated, interdisciplinary, multidisciplinary science course that can be offered. Astronomy involves mathematics, literacy and language,

and other sciences such as chemistry, physics, various life sciences, and geosciences. The argument is given that astronomy is the only capstone course that inherently incorporates all the listed subjects, or at least that it can, if the curriculum is designed to do so. Because a capstone course culminates a sequence, it can also reinforce prior learning.

> Requires mastery of all disciplines and integrates these like no other course can. My students learn more history than in some history classes. They use trig to rediscover Kepler's laws as well as analyze many articles about current research. —Teacher in a minority, Needs Improvement, 1.7K student public high school in Georgia.

> Astronomy is truly a multi-disciplinary course in which the different sciences may be blended, but also one in which students may see direct application of other course content as well. For example, math is obviously required, but government policy/legislation with respect to aerospace expendatures, aerospace spinoffs that help solve Earth-bound problems, ELA communication of important findings and discoveries to the general public, understanding the environment by working to create closed ecosystems for colonization, etc., etc., etc. Beyond all this, it is a wonderful venue for teaching problem-solving skills because space exploration is still in its infancy. —First year teacher of astronomy in a large 2.8K public high school in Texas.

> Astronomy at the high school level should now integrate many other areas of science and mathematics. We can now do comparitive geologies, meteorologies, and possibly some day comparitive biologies to better understand our Earth's systems. —Teacher in a 500-student Wisconsin public school.

When all of the reasons given for the lack of direct effect on the course by NCLB are examined, it is found that, currently, astronomy hangs on primarily as a capstone course that is offered only to seniors or upper division students who have essentially passed all NCLB-created hurdles, such as graduation requirements and mandated end-of-course tests.

Knowledge about the universe has changed rapidly over recent years. Consequently, the content and textbooks used in early science classes are likely to no longer be current, and the high school course may be the last chance that the education system has to correct misconceptions gained in elementary and middle schools.

Astronomy courses can incorporate many science and inquiry skills. Depending on the curriculum design, these courses can be taught from a very descriptive, low-math perspective or one that incorporates higher-level physics and math.

Astronomy has no academic level restriction.

> The course was taught in an inner city school with students that had low math skills and generally were not science kids (not also enrolled in courses like AP chem or AP Physics), yet this course got them excited and enthusiastic about science. Kids joined the astronomy club and were INTERESTED! This is/was very uncommon for the school, and definitely encouraged many minority and minority female students to take a science class and join a science club. —Former teacher from a high minority, Connecticut, 1.2K-student public high school.

Astronomy courses can be directly and concretely beneficial. For example, a Washington-state teacher made arrangements for transferable college credit. She wrote "they can get 5 University of Washington credits for taking the course (at a price of $293) through the UW in the High School Program."

Student Interests

Astronomy courses have interest and appeal among students. Representative comments include:

- "Many students are interested in Astronomy and it therefore is an excellent medium for teaching fundamental science principals (i.e., science inquiry, nature of science, etc."
- "Students enjoy the course; it is sometimes the only advanced science course some students take;"

Because of this attraction, some surveyed teachers found students that normally resist science voluntarily take their class; others also found that astronomy changed students' attitudes by drawing them into the field of science and even to causing them to become scientists. Student interest in

astronomy also benefits the teacher by increasing or maintaining enrollments or keeping the course on the schedule. Additionally, the success in college of prior astronomy students is considered another top defense argument.

Cultural Linkages

Astronomy is a part of every culture, not just Western. There are sky legends from other cultures, the calendar, the way things are named for celestial objects, and more everyday connections to students' lives and backgrounds.

Astronomy also has direct relevancy to modern society. While the subject matter, unlike chemistry, physics, or earth science, may be physically distant from the students, it is still relevant to their everyday lives.

> As one of the oldest sciences, astronomy has influenced our lives through use of calendars, vocabulary, and the scientific thought process. Most recently, the 'demotin' of Pluto to a dwarf planet has engendered much discussion about how science changes as improved technology brings new information to us. —Teacher in a 1K student public school in Massachusetts.

Helping with AYP Issues

With science possibly becoming a factor in determining AYP status, teachers have noted schools seem to be seeking more options.

> Astronomy as an elective provides an interesting and exciting 4th year of science. Students will opt out of science if it isn't something they are interested in. —Teacher at a AYP Passing tiny 150-student Arizona public high school.

An appropriately designed astronomy course will meet a variety of states' standards and national ones as well.

> Honors Astronomy involves all of the important skills that virtually all state and national teaching standards emphasize: critical thinking, application of math and computer skills, project-based learning, development of presentation skills. —Grades 10-12 astronomy course teacher at a high minority, 1.8K student Passing California public school.

> We use a variety of technology (telescopes, CCD imagers, computers) and software (Hands-On-Universe, Adobe Photoshop, TheSky, Starry Night Pro) to aid the state mandate to make sure all students are technologically literate. —Teacher at a Failing school in West Virginia.

It can even substitute for some of the regular science courses; it does so in at least two states: New Mexico and Wyoming.

Administrators should find astronomy helps raise test scores in science. We note that no state reported having astronomy end-of-course tests, but many astronomy concepts do appear in other tests, including some national ones.

> Kentucky's Core Content has a subsection based on astronomy. According to KSTA, the lowest scores in the state deal with the universe's formation. Since our state's test is one the engines that drives this train here at [deleted school name] this fact will always make a good case for my astronomy class. —Teacher at a 1.4K student Passing public high school.

Furthermore, AYP status depends on language arts, and astronomy can play a role in that as when "the students are required to produce research papers and other analytic essays," as exemplified by a teacher in a small Pennsylvania school.

One of the most common reasons astronomy courses are able to avoid deleterious effects is the frequency with which they are offered as capstones for seniors who have already completed the courses that are directly examined for AYP status.

Institutional Benefits

Good public relations is always a positive reason to have a course.

> [When the Oregon Department of Education said schools ranked an "F" for astronomy in the state,] Our Superintendent immediately told the press/ public about our thriving Astronomy courses and his commitment to continue to teach this relevant and stimulating course. —Teacher at an Oregon public high school.

The existence of an astronomy course can be attention getting to school-shopping parents.

> As a selling point to prospective students/parents. Few other schools are doing astro. —A Georgia 400-student private school teacher.

In a strictly economic sense, a very common response from one particular group of teachers—those with planetariums—is that such an

expensive resource should not be wasted.

The Science Itself

Many teachers believe that astronomy is more accessible to student minds than other sciences.

> Also its one of the few courses that you can learn something that day and use that knowlege that night. —Teacher at a 1000-student, Minnesota public high school.

Astronomy is the rare science in which amateurs do make significant, valid, and valuable contributions, and this can be a real jumpstart to a college career. Students can actually contribute original research—some have discovered new asteroids, for example—to astronomy, and this allows high school students to feel an ownership of the material.

> This course gives students an opportunity to contribute to the school and astronomy research. Many of my students are non-athletes who really love astronomy. They are involved in several reseach programs through NASA and get their observations publicized frequently. They have the same pride in contributing to astronomy as athletes do in sports. —Teacher at a small, 400-student Kansas public high school, with a portable planetarium and an observatory.

Conclusions

Most teachers of astronomy in American high schools claim not to have been directly affected by the No Child Left Behind Act but do say they have suffered indirectly and negatively, notably by effects of the Passing or Failing of math and language arts high stakes testing and an emphasis on moving more students into biology, chemistry, and physics courses which have testable standards. The indirect effects include drops in course enrollment, number of courses offered, cancellation of courses, and redeployment of teachers. Loss of funds, status, and collaboration and professional development are also reported. The only major direct effect appears to be that of meeting the 'highly qualified' status, which is difficult to achieve because no state offers teaching certification in astronomy. A few other teachers have allowed NCLB to positively, directly affect their classes by incorporating more math and literacy exercises than before. One of the most common reasons astronomy courses are able to avoid deleterious effects is the frequency with which they are offered as capstones for seniors who have already completed the courses that are directly examined for AYP status. Additionally, in many states (but not all and not always), a lack of state standards means a lack of oversight for the course. However, sometimes that lack of standards means a course is not considered important enough to keep on the schedule, and sometimes astronomy enrollment increases only because the course is made into an alternative source of science credits for students who have difficulty passing the mandated courses.

Astronomy, if it exists, is usually in an AYP Passing school or Needs Improvement school, and schools offering astronomy are often larger than average in student body size. Furthermore, schools with astronomy generally have higher Pass and Needs Improvement status rates than the nation as a whole.

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Larry Krumenaker is a long-time astronomy and science educator, and recent Ph.D. from the University of Georgia. He is editor-in-chief of the new publication The Classroom Astronomer. As a science journalist he has written astronomy, science, education and technology stories for numerous trade magazines and newspapers in the United States, Germany and elsewhere. He currently lives, works and teaches both students and teachers in Atlanta, GA. Correspondence concerning this article can be sent to <larryk@toteachthestars.net>

Appendix A: Survey Procedure

The courses' teachers were gathered from announcements in such venues as the email mailing lists/discussion groups or print newsletters of astronomy and science educational associations, including the National Science Teachers Association (NSTA), the American Association of Physics Teachers (AAPT), the Astronomical Society of the Pacific (ASP), and the American Astronomical Society (AAS), as well as state and regional association discussion groups for physics, earth science, and general science teachers. Also used were other discussion mailing lists that have interested astronomy teachers, such as Dome-L for planetarium teachers, the 200,000-subscriber newsletter for the "Starry Night" software program, and the newsletter for StarLab portable planetarium operators. Several state science coordinators and educators who work with astronomy teachers passed along our invitation in their own media, including their own discussion or 'news broadcast' lists. The "science brokers" at NASA, who work with teachers and maintained contact lists were of enormous help (sadly, after our study, the "science brokers" program was terminated). Additionally, educational personnel associated with NASA-operated missions, such as Cassini, broadcast our appeal for qualified survey respondents to the larger community, as did national observatories and other programs, including SETI and NRAO.

The teachers gathered by these means were labeled our 'hot' group, because they volunteered to take part. A voluntary response group is not necessarily the best research design, because there may be other factors at play, such as extreme views or overwillingness that may not be representative of the whole population. To counteract the non-probabilistic 'hot' group, a more randomly selected sample, which is labeled the 'cold' group, was created. These teachers were invited through our direct email solicitation. Their names and contact information were obtained primarily either by lists given to us from personnel at astronomy-related conferences, publishers, some state departments of education, or private individuals who volunteered names. Names were also amassed through searches on the Internet, which yielded lists of planetariums and high school astronomy clubs obtained from the *Sky and Telescope* magazine website, the International Planetarian Society *Directory* (IPS, 2005), and several American regional planetarium groups. Finally, snowball sampling—having responders recommend other people to survey—was also used.

The spring 2007 survey started with over 600 names, evenly split between 'hot' and 'cold' groups. The 237 usable responses included seventy from the 'cold' group, which resulted in a response rate of about 24%. The 'hot' group responded at a 60% rate. The second, printed postal survey took place in the Fall of 2007. Participants were acquired via a 2176-piece postal mailing using primarily a mailing list from the National Registry of Teachers plus about 600 names and addresses acquired in the spring without email addresses. Eighty-five percent responded by sending the survey back via a prepaid, pre-addressed envelope, the remainder answered using a Web questionnaire as in the first survey. Response numerically was half as much as the Spring survey but proportionally much smaller.