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The Modern U.S. High School Astronomy Course, its Status and Makeup, and the Effects of No Child Left Behind

Larry Krumenaker
Department of Mathematics and Science Education, University of Georgia, Athens, Georgia 30602
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Abstract

A 2007 nationwide mixed-methods survey of high school astronomy teachers reports on its current characteristics and its changes over intervening decades that included the introduction of standards and the No Child Left Behind Act (NCLB). Some changes found include section enrollments trending downward even while the total number of courses offered and attending students are actually increasing. The teacher gender gap has been dramatically reduced; most teachers come from geosciences and biosciences. 15% of them have never had an astronomy course. The majority of teachers say NCLB has had no direct effect, but 40% report indirect effects. These are mostly negative reactions to school-wide adequate yearly progress status: teacher redeployment, funding diversions, students tracked into the traditional three sciences, course cancellations, and teacher job loss. Some positive NCLB effects are increased math and literacy rigor and, paradoxically in some places, enrollment increases. A stereotypical picture of a high school astronomy course is developed noting some changes in the 22 years since the last study of the field.

1. INTRODUCTION

Astronomy in high schools has had its ups and downs. Once it was a standard course in American secondary schools, even required as it still often is today in many, especially European (Trumper 2006) countries. But it became a mere, rarely taken, elective after the so-called Committee of Ten in 1892 set college admission requirements and formalized the now-familiar sequence of biology, chemistry, and physics courses in high schools (Bishop 1977; Bishop 1980). Today, if you ask any random group of 100 adults if they had a for-credit, stand-alone high school astronomy course, you will most probably get only about three or four raising their hands.

Harvard's Philip Sadler, in 1986, was the last to survey the field (Sadler 1992). Sadler, working with colleagues to develop a curriculum for astronomy in high schools, found that 11% of Boston's high schools taught stand-alone astronomy courses, a higher percentage than he expected. Among his findings were that few teachers taught just astronomy and usually just one section of it, that 41% spent the rest of their day teaching physics and more than 25% taught some earth sciences. Males made up 88% of the teachers, and as a rule, teachers got their astronomy expertise from a hobbyist perspective or personal interest. 80% wrote their own curriculum and only 14% used a text, which happened to be at a college level. The class contained an average of 22 students, mostly 11th and 12th graders. 35% of the courses were year long. About 5% of all students took the class which was found in about 1200 schools, or 9% of all high schools in the country.

But Sadler's pioneering work was before the Benchmarks for Science and the National Science Educational Standards were created, and nearly two decades before the landmark No Child Left Behind Act (NCLB). The current research project repeated and expanded Sadler's study and also investigated what effects, if any, can be seen from the changes that have come since.

Nearly 300 teachers responded to invitations, on email discussion lists or by direct email solicitation, to take part in a 55-question mixed-methods survey in the spring of 2007. The survey had quantitative, categorical, and qualitative questions asking teachers to describe their high school astronomy courses in some detail. Some of the questions studied the makeup of the student body; background information on the education and teaching experience of the instructors including professional development resources; course characteristics, such as duration, what materials such as textbooks, planetariums, and telescopes were used, how, when, and by whom the course was created; and what are the school characteristics—size, location, and Adequate Yearly Progress (AYP) status. Teachers were also asked to give free range with their thoughts on any effect of NCLB on their astronomy courses.

The results are based upon the rates of return for two major groups of teachers that evenly split our initial pool of teachers. We labeled one group the "hot" group. These were teachers who responded to broadcasted invitations on various mailing lists or listserves. This pool numbered 300 persons and we had a 60% rate of return of those who took the survey out of those that expressed their interest in it. The other one-half of the pool we called "cold" as in contacted by cold "calling." We had electronic mail addresses from websites, personal lists sent to us, lists of astronomy clubs or planetarians, and so on. Out of that 300 we had a 24% rate of return. Overall, the rate of return was 40%.

Per a reviewer's comment that this may not be entirely a representative group for the whole population being studied, we would like to say that we did a variety of statistical testing against several factors. A multiple linear regression included an indication that there were no differences because of "group" membership. Plus, various comparisons to other known quantities were made that fully indicate representativeness. These included measuring response amounts against U.S. population distributions, distribution of teachers in an astronomy-teacher mailing list from the National Registry of Teachers, geographical distribution of planetariums, national statistics provided by the National Center for Educational Statistics, and against the statistics or raw data provided by a few specific states. All show strong agreement with our results; therefore, I do believe this group of responding teachers is representative of the high school astronomy course teacher population. Teachers ranged from those who started teaching in the 1960s up to a 10% of the pool that were teaching their first year of astronomy so it is quite likely that a good cross section of experiences are represented, from newbies to old hands.

2. TODAY VERSUS TWO DECADES AGO

Tables 1 and 2 list similarities and differences between Sadler's study and this one. At first glance, Sadler's description of the situation seems largely and surprisingly unaffected with the passage of time or the imposition of standards and NCLB. The course today is an all-inclusive look at the whole universe, taught year-long 45% of the time. Of course, although the number of high schools has grown in more than two decades, regular-sized (20–30 students) astronomy classes are found in only a slightly higher proportion, about 12%–13%, or 2500, of all high schools in the country. The courses may be found in any locality or size school, urban or rural, large or small, but are found more often in public schools averaging nearly 1581

Table 1. Some things have not changed (or at least not by much). This survey compared to the 1986 Sadler study

Item	Sadler 1986	Krumenaker 2007
Class Size	22	22.7 (public) 22 (overall) 17 (private)
Percent teaching one section	57%	55%
Capstone class	"Most"	75%
Top three other courses taught by teacher	1. Earth Science + Geology[a]	1. Physics
	2. Physics	2. Earth Science + Geology[a]
	3. Physical Science + General Science[a]	3. Physical Science
Teacher's length of time in course	9 years	9 years

[a]Because of changes in course naming terminologies, some course titles have had to be combined to make consistent across both surveys.

Table 2. Differences between the this survey and Sadler's 1986 results

Item	Sadler 1986	Krumenaker 2007
Number and genders of teachers	1760, 88% males and 12% females	3200, 67% males and 33% females
Teachers teaching two sections	18%	25%
How they keep up	Mainly magazines	Websites, workshops, and magazines (but less)
Number of students taking astronomy	5% (but NCES says ~1%)	3.5% (latest NCES value is 3.3%)
Textbooks	14% "rely on"	75% use
Number of schools	1318 (stated 10–15% of all schools but actually was 9%)	2500 schools, 12%–13%

[standard deviation (sd)=867] students, twice as large or more than the average-sized U.S. high school (Hehn and Neuschatz 2006). (Private schools average 734 (sd=615) students, 50% higher than average). The schools do tend to be more suburban than urban or rural (49%:29%:26%.) The courses are found in private schools 13% of the time, about the same proportion as there are private schools in the United States.

The overall average number of students per class is still 22 though public schools (which make up 87% of the high schools with astronomy) are slightly higher at 22.7 and private schools lower at 17 (all with sd=7).

But these numbers are a little deceiving. Evidence given by teachers' current and average all-time enrollments indicate that that "22" is on an enrollment down slope, which means somewhere in the intervening years, enrollment actually had a peak at a higher value. More courses' enrollments were declining than growing. Also, in many states, there is a "secondary peak" in what we call "single digit classes" where more than 20% of all students taking the course are in classes numbering an average of five students. This actually raises the number of schools that offer astronomy to about 3200 out of a nearly 19,000 pool of high schools (NCES 2007a) today but hardly adds to the 3.5% pool of all students in high school that take this course. Although regular classrooms may be more common in the suburbs and rare rurally, single digit classes may be the norm in rural schools.

As in the 1980s, existing courses are more often created by the course's current teacher; today that is by a nearly 2:1 ratio, primarily by those who simply have interest and desire to teach the subject. About one-half of the rest are inherited courses. The remainder are from administrators who created the course for the practical reason of having an easier (by perception or more likely, misperception) science elective to help students get enough science credits, or for a second, more advanced science elective choice. From this data and those of retired teachers in the survey, most of the courses are not and would not be inherited courses in the future—when teachers leave the school or retire, the course often disappears.

This makes the longevity of the courses correlated with that of the teachers: the median time length is 7 years, the average is 9 years. Eighty five percent of the pool were actively teaching during the survey period (less than 1% were teachers preparing to start the next year, 15% were no longer teaching). Out of the 200 teaching, 10% were in their first year but 3% knew their classes were going end this year.

If you last 4 years in the course, then there is relative job security for years 5–20. There is a sizable number of people in the survey who had been teaching past the three decade mark. Since we have already noted that many teachers create the class out of personal interest, it seems that if you can get your course organized and established, in a few years you can probably teach it as long as you want to work.

The longevity for those teachers surveyed who no longer teach the class are generally 2 years less than for current teachers. The teachers left for any of a variety of reasons, such as retirement, moving, or course cancellation.

Two other noticeable changes about the teachers are as follows. Astronomy teachers are no longer so male dominated, females now account for up to 33% of the teaching corps. Teachers have more relevant backgrounds today. Sixty five percent of all teachers have undergraduate majors in sciences and 16% more in science education areas, but more come from the biosciences and geosciences than astronomy and physics. Only 8% of the astronomy teachers were astronomy majors; compare this to physics teachers (Neuschatz and McFarling 2002) where 33% had physics or physics education degrees and 61% of bioscience teachers (NCES 2005) have biology majors or minors. Eighty seven percent of the astronomy teachers who went onwards to graduate degrees earned them in education more than science.

Because there are no state certifications in astronomy, one might expect physics or broadfield certificates to be dominant, but here again earth/space science leads at 70%, and physics only edges out biosciences 54% to 49% (teachers can have more than one certification). Despite this, the other courses taught by the astronomy teacher are mostly physics, followed closely by earth science. A more important finding is that most teachers have taken only one to two astronomy courses at either the undergraduate or graduate levels, but a large minority, 28% did not take any course during their Bachelor program. Fifteen percent have *never* had a course at *any* level.

If "highly qualified" is defined as *appropriate training in astronomy*, most high school astronomy teachers are not highly qualified. If the definition is broadened to be just any science degree and/or an astronomy course, then most teachers would pass the criterion but there still is a large out-of-field group teaching astronomy.

In addition to having comparatively little preservice training in astronomy, teachers reported that in-service astronomical content and pedagogical professional development is as little as before. "Keeping up" comes primarily from monitoring certain websites (mostly NASA's) and attending workshops from NASA and some science education association conferences, plus the two major astronomy magazines, and supplemented by trade books. Teachers still feel a desire to find training and most astronomy or astronomy education organizations are not reaching the high school teachers we surveyed.

The teachers also still feel isolated, with good reason. They *are* the only astronomy teacher 68% of the time. A common complaint in the survey was teachers were unaware of other astronomy teachers. Eighty percent teach just one or at most two sections, astronomy is a bonus on top of their other classes where are more often physics (39%) or geoscience (35%). Only perhaps one in seven gets to teach astronomy full time.

The 22 students in the class are generally representative of their school's own gender, racial, and ethnic percentages, and closely match the overall national population percentages tabulated in the latest census as well, though Hispanics and others are a little under-represented. There is a small gender gap, 4% more males (and fewer females) than the national 49–51% percentages would suggest. (Table 3). Compare this to physics (Hehn and Neuschatz 2006), where it is disproportionately Caucasian and Asian, and girls make up about one-third of the students.

Table 3. Racial and gender demographics

	Race/Ethnicity					Gender
	Caucasian	**African Americans**	**Asians**	**Hispanic**	**Other[a]**	**Male/Female**
2007 survey	77%	8%	4%	8%[b]	2%[b]	53%/47%
2000 census[c],[d]	75%	12%	4%	15%	9%	49%/51%

[a]Includes Native Americans, Pacific Islanders, biracials, and multiracial.
[b]Difference is significant with $p < 0.05$.
[c]U.S. Census Bureau (2000a).
[d]U.S. Census Bureau (2000b).

For 75% of the students, this is a capstone course. One might suppose this is because it usually requires one prior science or one math course to get in. One out of four courses requires no prerequisites at all; not all of these are freshmen or sophomore introductory courses but some capstones as well.

The use of textbooks is up dramatically in the past two decades but the complaints on their suitability have not lessened. All of the book titles that follow are college texts, with readabilities generally grades 14 and up, and rarely as low as grade 12. Daily materials for the curriculum, though, now come often from the World Wide Web.

We noted a second severe problem with these textbooks after their unsuitability for use in high school—often earlier editions are actually used, presumably because of high costs of newer ones.

The textbook most often cited as being used was *Astronomy Today* by Chaisson and McMillan ($n=51$), nearly a quarter of all teachers. At least three editions are being used, from the third to the fifth. The second most often used is Seeds' *Foundations of Astronomy*. Editions explicitly stated included all editions from the fourth to ninth (except the fifth edition); this is a large and dated basis for teaching the subject! Next was Comins and Kaufman's *Discovering the Universe* with fifth, sixth, and seventh editions mentioned, and Arny's *Explorations: An Introduction to Astronomy* (third and the fourth editions), *Cosmic Perspective* by Bennett *et al.* (at least one third edition in use and fourth edition), and *Astronomy, a Beginners Guide to the Universe* by Chaisson and McMillan (fourth edition mentioned, fifth edition out in 2007, not possible to know if it is being used at this time). [Edition and publisher information can be found in Bruning (2007).] Ten other titles were given. Nevertheless, this accounts for 75% of all schools in the pool, a far cry from Sadler's "only 14% relied exclusively on a commercial text." But even he admitted that all the texts he knew about (he does not list them) are college level, so the situation has not changed much.

Eight users said they were trial testing TERC's "Investigating Astronomy," modules that presumably will be published as a book later on.

Several earth science texts are used as well, from Prentice Hall, Holt, Heath, and Pearson, and one by Nanowitz and Spaulding, plus Holt's Spectrum Physical Science and Conceptual Physical Science of Hewitt *et al.*

"Curriculum materials" spans a wide net. By far the most used materials appear to be from the Harvard-Smithsonian Center for Astrophysics *Project Star*. The only other frequently mentioned materials were those from Hands-On Universe and the ASP's *Universe at Your Fingertips*. Mentioned repeatedly but less than the aforementioned include SETI's *Voyages Through Time*, StarLab materials, RBSE/TLRBSE materials, SPICA, and Harvard *Project Physics*.

Various NASA Education and Public Outreach offices, websites, and programs are mentioned heavily as sources of materials, at least 15 times each. But outnumbering them are 24 teachers who say they make their own curricula or at least cherry pick without any standard book or package. Nineteen teachers say they use no text at all and 16 explicitly say much of their classroom material comes solely from the internet.

Total planetarium numbers may have dropped over the decades since the heyday of the Space Age but 10% of all high school astronomy courses still have immediate access to a fixed dome and at a minimum 3% of all such courses own their own portable planetariums which are used as frequently as a fixed dome, about 15 class sessions per course. The number taking field trips, or borrowing a portable dome, have dropped significantly due to financial concerns expressed by teachers. A recent and rapidly growing development is that some have adopted the use of "planetarium software" (e.g., Starry Night, for one) for use in classrooms.

Telescopes are less a concern, as most courses have an average of three portables they can use and some have used their internet access to use remotely operated visual and radio telescopes. Schools with their own domes are rare.

This survey shows that astronomy classes operate on generally 200–500 dollars for expenses, with a handful of rare cases that are primarily new planetariums or successful grant getters that go as high as several thousand dollars. If the money is not explicitly budgeted for astronomy or the science department is not supportive in general in doling out adequate funds, the school administration is no more beneficent than the teacher's own wallet.

One can conclude that the creation of national science standards and the NCLB have created minimal overall structural changes since the Sadler (1992) study. The major changes over time have been a larger number of women teaching the course than before, changes in where curriculum materials are obtained, a teacher base not coming from the traditional domain of physics but instead out of bioscience and geoscience ranks, and some overall increase in total numbers of courses and students. Teachers are better prepared for astronomy in that they at least have majors in a science instead of teaching it from hobbyist interests but, unlike other science courses, there are still few who have taken a significant amount of astronomy courses.

3. SNAPSHOT OF A HIGH SCHOOL ASTRONOMY COURSE

A stereotypical astronomy course might be still a single section, maybe two, teaching solar and stellar astronomy in a half year. It will more likely be found in a larger suburban public school. The 22 students match the demographics of the school and the nation closely and usually are upper-division students in a capstone course created by a single, interested but not highly astronomically trained, (two-thirds of the time) male teacher also teaching physics or geoscience. He or she would be considered well educated, often with a Master's degree, but with few, if any, astronomy courses taken during their college years as part of a curriculum for their other science or education major, more often biology or geoscience, with little formal postcollege astronomy professional development. No more than one in six schools has access to any kind of planetarium system and while textbooks are used far more now, the predominant curriculum materials come from the internet.

The course will be found in about 11–12% of all high schools, both public and private. Overall, only about 80,000 $\pm \sim$3000 students take an astronomy course each year, and that is a growth of only $\sim$10 000 since the early 1980s. This represents only about 3.5% of all high school students. Compare that to 35% of all students taking physics (Hehn and Neuschatz 2006), 60% chemistry, and more than 90% biology (National High School Center 2006).

An anonymous reviewer suggested that since the aforementioned data on student demographics, course levels, and more are teacher-derived instead of from national databases, it might not be reliable. In fact, the sizes of the schools were verified against NCES data during the school size analyses and for the suburban/urban/rural analysis as well and teachers were generally on target—a school of 1500 students would be estimated by the teacher rarely more than 100 students off the NCES data. When necessary, we did correct those widely off, such as a teacher giving his class numbers in place of school numbers. Second, a gender and racial/ethnic analysis of a sample of the class data, against the school data given on the NCES website indicated less than 10% were statistically different from the school proportions, measured with a chi-square test. The overall sums and proportions of student demographics match the national figures so well that it too lends credence to the teacher-derived measures. We believe this is enough evidence to claim reliability in the data.

4. EFFECTS OF NCLB

Schools with astronomy are found in a higher proportion of schools with a "Passing" or "Needs Improvement" AYP status than the general population of schools (Table 4). This may indicate that schools with astronomy do better because of it, or more likely, those with astronomy that "Fail" have the course knocked off the schedule in favor of more remedial math and language arts. Why average class sizes may have started to decline in recent years (and numbers of courses decreased) may also be an effect of the influence of the NCLB.

Table 4. AYP status amounts in the nation and this survey.

Survey	Status	National (2006)[a]
77%	Pass	60%
20%	Needs Improvement	14%
3%	Fail	26%

Note: No relationship between school size and AYP status found; difference between Pass versus Needs Improvement + Fail is statistically significant (chi-square=24.78, df=3, p<.001)
[a]NCES 2007b.

Teachers were specifically asked "What, if any, positive or negative effects have you felt in the astronomy course from the No Child Left Behind Act? Explain why you feel this way." Even if the teachers did not specifically say positive or negative, or none or mixed, it was relatively easy to determine the tone of the answer. The open-ended question was analyzed using grounded theory and inductive analysis techniques. Each sentence would be "themed" by its content, such as the sentence referring to student enrollments, curricular additions, restrictions on content taught, and so on. Then within each type of effect (e.g., positive), the reasons behind the feeling were analyzed and counted and an overall proportion to the responses was made. This analysis could be repeated and verified independently by asking any other large sample of teachers the same question.

One of the results is that 60% of the teachers indicated that their astronomy courses have not been *directly* affected by high stakes testing and NCLB at all. This is likely so as math and language arts courses more than science courses have been included in the AYP mandates or analyses. But 40% say NCLB's effect is more indirect and negatively so. Astronomy teachers report dropping enrollments and course cancellations because the focus on math and language takes time away from elective courses and puts it into remediation and testing, taking teachers out of astronomy and into remedial operations. In addition, funding diversions were reported as money goes toward math and language and out of astronomy. Add the pressures to put more students into the main three science courses and to increasing the school's science testing grades (when they are tested to state standards) and students are drained away, making courses shrink and even disappear due to lack of enrollment.

The one major direct effect identified comes from the "highly qualified" aspect of NCLB. Some veteran teachers reported they had lost their courses and even jobs as states find them suddenly "unqualified." Teachers report a need for some kind of astronomy certification process. Currently no state offers a certification in astronomy, as they do for physics or biology. There are many strategies for a teacher to teach astronomy—as one person said, call the course a light version of physics with an astronomy theme and let the physics certification make the teacher highly qualified—there just is not an official *astronomy* way to do so.

Some indirect positive NCLB effects were reported—increased math and literacy rigor, and paradoxically in some places, enrollment increases as astronomy is perceived as a good course substitute for students struggling with biology, chemistry, or physics.

This study would conclude that if science becomes a major AYP factor, then the remediation efforts seen in language arts and math with the subsequent elimination of non-core courses will repeat in the science department, almost certainly driving astronomy to near-extinction in exchange for more science remediation. The current effects have not quite equaled out the slow growth over time in the total number of students and courses—more schools may be offering it than canceling it, but the number of sections in a school and students in each one are decreasing—but by at least 2007 it had become an influencing factor.

On the other hand, there is also pressure to add more years of science to the students' curriculum and already astronomy teachers and courses are becoming increasingly demanded commodities in some states. More teachers will be needed and they will need training and certifications that are limited or do not exist. Without more training programs reaching teachers, and some form of certification, more truly unqualified or out of field teachers may find employment in astronomy classes.

Which pressure will prevail is uncertain. Astronomy survives only on the backs of the enthusiastic teachers, interested students and their parents, and the sufferance of administrators who appreciate the subject, as long as the school's AYP status is not Fail.

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* "Middle and high schools must offer more rigorous coursework that better prepares students for postsecondary education or the workforce." TRANSLATED: Tougher and more basics-focused courses in middle and high school.Â NCLB measures educational status and growth by ethnicity, and helps to close the achievement gap between white and minority students. NCLB requires schools to focus on providing quality education to students who are often underserved, including children with disabilities, from low-income families, non-English speakers, as well as African-Americans and Latinos.Â There's little doubt that the No Child Left Behind Act will be reauthorized by Congress in 2007. The open question is: How will Congress change the Act? The modern u.s. high school astronomy course, its status and makeup, and the effects ofnNo Child left behind. Astronomy Education Review, 8(1), 010107-1-010107-8. This is a book specifically for people interested in the makeup field. It displays the different forms of makeup that one can do. It speaks about the different effects to learn as well as guided tips to be successul in the makeup industry. Nagami, S., & Tsuji, K. (2011). The relationship between university libraries' collection for sports and their students' sports performances. Online Submission, - Many Athletes have b