THE STATUS AND MAKEUP OF THE U.S. HIGH SCHOOL ASTRONOMY COURSE IN THE ERA OF NO CHILD LEFT BEHIND

by

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(Under the Direction of David Jackson)

ABSTRACT

A spring 2007 nationwide survey of high school astronomy teachers investigated: how many high schools teach astronomy, teacher backgrounds, student demographics, classroom materials and facilities and other facets of the modern course. Comparisons were made to Philip Sadler's 1986 survey and to various states' Departments of Education existing data. This multimethods study included qualitative questions investigating teachers' perceptions about effects from 2001's No Child Left Behind Act (NCLB) on their classes, views of course futures in their schools, and the nation. Other questions solicited recommendations on starting a course, defending it, and what needs to be done to increase the number of courses.

Significant findings include: the number of regular classes are about 3200, totaling up to 4000 when a 'hidden' single-digit-sized classes population is included; fully 20% of all classes may be with 10 or fewer students. A course is found in 2500 schools, 12-13% of all American high schools.

Many of Sadler's numbers are unchanged after 22 years. However, the ratio of male to female teachers has gone from 88:12 to 67:33. Many teachers now come from the bioscience and geoscience majors, not physics. Today are 3-4% more schools offer astronomy than found by Sadler, and nearly twice the number of teachers (3200 now).

Schools with astronomy are more often Passing in Adequate Yearly Progress (AYP) than the national norm. Classes generally reflect racial, gender and ethnic demographics of their schools and the nation.

More than half of all teachers claim no direct effects from NCLB on their courses, most of the rest seeing negative effects, generally dependent on how other science, mathematics and language courses fare.

A growing number supplant conventional planetariums with computer “planetarium” software, currently at the same rate as portables ownership.

Twenty-eight percent of teachers are not ‘highly qualified’ in that they have never had an astronomy course, let alone an astronomy degree.

Teachers are generally more optimistic than pessimistic about the future, but mostly for their own course, not for the fate of courses around the nation. Six-part plans for starting a class and defending it from cancellation are developed for teachers’ use.

INDEX WORDS: ASTRONOMY EDUCATION, NCLB, “NO CHILD LEFT BEHIND”, DEMOGRAPHICS, TEACHERS, STUDENTS, DISSERTATION, THE UNIVERSITY OF GEORGIA.

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CHAPTER 1

INTRODUCTION

Purpose of This Study

Historically astronomy has gone in and out of fashion in the American secondary schools that came into existance late in the 1700's. It was steadily present in secondary curriculums until the end of the 1800's when it virtually vanished. Astronomy had a brief renaissance in the late 1950's, lasting about two decades. Now it is present only in trace amounts, no more than 4% of all secondary schools, and precariously, yet it does exist. Why? In what form? For what purpose?

The purpose of this study is to investigate the influences of the past, the status in the present, and the teachers' perceptions for the future of high school astronomy courses. The look at the past will determine why and how the present course came into existence. The look at the present will create one or more models of its current characteristics--content, teachers and students, resources and facilities, and more. In the present, are there echoes of past historical influences and perceived needs? The teachers' perceptions of what the future holds--what is needed for continuance and expansion of astronomy courses--will be used to create guidelines for other teachers to use to justify, create, or defend astronomy courses at a time when astronomy courses are often the first to go because of high stakes testing or budget cutting.

Research Questions

In this mixed-methods study, information was acquired through a survey of high school astronomy teachers. Some of the survey questions were open-ended, permitting coding of responses which were then examined in qualitative or quasi-quantitative means. Secondly, some survey questions were quantitative, to illustrate the current status, formats, and makeup of astronomy high school courses. Questions, in no particular order, included such things as the backgrounds of the instructors, availability of planetaria, financial support, student demographics, and an analysis of the existence of state standards, among other items.

Finally, as a form of critical action, models of key points that can be used by instructors to keep courses active or create new ones were made.

Following are the research questions at the basis of this study:

1. What is the typical form(s) of a high school astronomy course?

   Sub-questions within this are:

   A. What are the typical kinds of schools that do offer astronomy, in terms of public versus private, block or period scheduling, status in AYP (Adequate Yearly Progress), and existence of planetariums? (And…how many schools are there?)
   B. What are the specifics of the courses themselves? What do they cover, how often are they taught, how many sections, how long is the course in time? What prerequisites are the gate keepers for students who wish to take the course? Does the course have standards set by the State?
   C. What is the background and teaching situation of the typical high school astronomy course teacher, in terms of education (degree level), amount of astronomy training, entry point into the field, longevity, other courses taught, contact with the rest of the field, what do they do for professional development and ‘keeping up’?

D. What is the nature of the student body in a class? How representative is it of the school? How many students take the courses, and are the numbers changing over time? What are the academic abilities of the students taking the class?

E. What curricula and facilities are available to teach the class, including textbooks, curricular packages, the use of the internet, planetarium and telescope availability? How much does the course material cost and where do the monies come from? What are the ongoing problems teachers perceive with the course?

2. What are the raison d'etres for the course? Sub-questions include:

   A. What are the teachers' original justifications or purposes stated for the course's creation? And who created it?

   B. Is there any evidence for historical influences on what the purpose of a course would be during time periods other than the immediate present?

3. What positive or negative effects have the typical high school astronomy teachers seen in their courses from No Child Left Behind (NCLB)? Are the teachers optimistic or pessimistic for their schools and for courses nationwide, and why?

   A. What would current teachers use to defend or justify the course in the present time?

   B. What advice would teachers give to another teacher as to how to set up a course or to increase the number of schools in the whole country that teach astronomy?

Subjectivities and Theoretical Frameworks

As a teacher with a life-long passionate interest in astronomy, I need to be very careful in regards to the creation of the final survey questions. I must be careful not to construct them as leaning pro or con, to allow teachers to generate their own pro or con answers. I would indeed like to see more astronomy offered in the schools but I have to make sure that I allow the respondents to provide the direction in their answers without me pushing them in that direction.

Because of this personal bias, I also need to say that this is somewhat tinged (unexpectedly!) with aspects of a critical theoretical framework, to formulate some actions following the survey. I do hope to be able to create one or more models of characteristics that can be used by teachers all over the nation to incorporate more astronomy courses into the curriculum of school districts. What specific "critical" theory? I'm getting ahead of myself. Let me describe my standpoint by using the arrangement of epistemology, theoretical perspective, methodology, and methods as defined by Crotty (1998).

Epistemologically, this study is very much constructivist. Patton's (2002) fundamental questions for this epistemology are "How have the people in this setting constructed reality? What are their reported perceptions, 'truths,' explanations, beliefs, and world view?" Patton uses constructionism/constructivism as a theoretical perspective, not an epistemology, but Crotty does and I follow Crotty's worldview here.

In Crotty's schema, my theoretical perspective is interpretivist and within this I am primarily within the phenomenology camp. Paraphrasing Patton's foundational questions for phenomenology, I am looking for the meaning, structure, and essence of high school astronomy courses as perceived by the course instructors. Since phenomenology is often defined as getting at "what is the essence of the phenomenon" (Patton, 2002), the 'essence' answers will come primarily from the open-ended questions of the survey.

Yet, this study is also partially an ethnography. Punch (2005) defines ethnography as describing a culture and understanding a way of life from the point of view of its participants, the art of describing a group or culture. Many of the survey questions will be getting an overall description of what a modern astronomy class looks like, albeit not by sitting in many of them in traditional ethnographic style. Who and what are the people making up the class? Where do these classes most often occur? How does this picture vary with other factors? Despite the fact that ethnographies are a qualitative tradition, the ethnographic questions of my survey actually lead towards quantitative descriptions, questions and data on the course. These will be the foundation of the quantitative part of my mixed methods against which the qualitative questions will be compared.

This brings me to the third attribute of my proposal, a critical aspect to my theoretical perspective. In the results section of my dissertation, I hope to have enough of a model to be able to generalize the necessary conditions to keep those existing courses alive and cause the creation of new courses in astronomy. Is it possible to say that my theoretical perspective is that of a critical ethno-phenomenologist?

In the last two levels of Crotty's schema--methodology and methods--my principal methodologies are survey research and grounded theory, because of the mixtures of data sought, with my methods being sampling, comparative analysis of the open-ended questions' answers, and some statistical analysis of the qualitative responses and quantitative data.

CHAPTER 2

HISTORICAL BACKGROUND AND REVIEW OF THE LITERATURE

Astronomy was the mark of an educated man in America, going as far back as 1642 when Harvard University required seniors to take a year-long course (Ornstein & Hunkins, 2004). In reality, many colonial children learned astronomy as a basic knowledge, whether in or out of rudimentary colonial schools. Knowledge of the Sun, moon, tides, directions of the stars and other things were often verbally transmitted knowledge from parents as well as teachers, primarily because it was a necessity of farm, nautical and rural life. (Bishop, 1977).

Astronomy also was a required subject in the first secondary level schools in America in the late 1700's, the Academies. When supplanted a century later by public high schools, a course in astronomy, often subsumed into courses of Natural Philosophy, was also a required subject. These courses were considered a requirement for "training of minds," "mental discipline," and the practical aspects of geography, commerce, navigation and the refinement of a civilized person (Bishop, 1977).

All this went away after 1892, when a small group of powerful educators, primarily college presidents and some high school administrators, met to set the standards for college admission requirements. This "Committee of Ten" included a group for Physics, Astronomy and Chemistry that made only the first and last listed courses a requirement for admission. Though not explicitly stated by the committee members, the removal of Astronomy may have been part of the trend away from "out of date courses like Greek and Latin" to courses that permitted "growth in personal and social objectives." With astronomy no longer a requirement for college admission, schools focused only on the required physics, chemistry and biology courses. By 1930, only 0.06% of all students in the whole country would take an astronomy class. (Bishop, 1980).

During the first 50 years of the past century, tremendous and revolutionary strides were made in astronomy but only boys earning Scout merit badges (after 1911), readers of *Scientific American* and attendees at public lectures would hear about them. It wasn't until the launch of Sputnik I in 1957 that people and politicians would question the value of these earlier "personal and social objectives" over subject content mastery and the "patterns of education" in the United States compared to the rest of the world.

The tremendous explosion of curriculums and reforms were led, again, by the college professors seeking an increase in scientific researchers. This was also the age of the small planetarium built into thousands of schools. But, like the Space Program, these waned after the 1970s with changes in priorities at the national level.

Among those changes was the creation of two sets of national science standards. These standards were not government curriculum mandated, as done in other countries. Nevertheless the two influenced state standards and, likely, the existence of astronomy courses.

The first and astronomically richer standard is the AAAS *Benchmarks for Science Literacy* (AAAS, 1993), (first outlined in generalities in AAAS' *Science for All Americans*, 1989), and continuously managed by Project 2061, a long-term science literacy program. Astronomy concepts considered essential include a general picture of the universe, motions of the sun and moon, star patterns and the movements of planets amongst them, the nature of the stars and the sun, the variety of planets and other solar system objects, and the sophisticated technologies now in use that bring us increased knowledge of everything from subatomic particles in the stars to exotica at the edge of the universe. The historical revolution making the Earth a moving world, from Copernicus to Newton, is especially emphasized.

Noting the extensive lack of personal familiarity with the sky in modern days (and cities with great amounts of light pollution), planetariums are mentioned as useful instructional facilities on several occasions. Certain specific quotes from *Benchmarks* indicate that the goal of these standards is a specific kind of science literacy, that is, to be knowledgeable about the overall picture of science and not necessarily all its domains. Furthermore, it is 'habits of mind' that are necessary, not necessarily all its core subjects. As stated on the Project 2061 Website, (http://www.project2061.org/publications/bsl/online/bchin.htm):

- "*Benchmarks* specifies how students should progress toward science literacy, recommending what they should know and be able to do by the time they reach certain grade levels." (Grades 2, 5, 8 and 12 are their checkpoints and likely form the basis of many state exams for judging the quality of schooling.)

- "Project 2061 promotes literacy in science, mathematics, and technology in order to help people live interesting, responsible, and productive lives. In a culture increasingly pervaded by science, mathematics, and technology, science literacy requires understandings and habits of mind that enable citizens to grasp what those enterprises are up to, to make some sense of how the natural and designed worlds work, to think critically and independently, to recognize and weigh alternative explanations of events and design trade-offs, and to deal sensibly with problems that involve evidence, numbers, patterns, logical arguments, and uncertainties."

- "If we want students to learn science, mathematics, and technology well, we must radically reduce the sheer amount of material now being covered. "

- "The common core of learning in science, mathematics, and technology should center on science literacy, not on an understanding of each of the separate disciplines. Moreover, the core studies should include connections among science, mathematics, and technology and between those areas and the arts and humanities and the vocational subjects."

We use the 1989 date as the year of appearance in our studies further on, for the *Benchmarks.*

The second set of standards was born from the National Research Council and is called the National Science Education Standards (NSES) (NRC, 1996). These are also dedicated towards general science literacy. Its tone is much more systemic, encouraging teacher development and practices over content standards. Indeed, the amount of actual standards in science content is dramatically lower than in *Benchmarks*. There are only seven actual concepts stated for astronomy, dealing primarily with the birth of the solar system, geological processes that changed the earth and brought on biological life forms, the origin of the universe and its early history, and the way stars shine. The Copernican revolution is also emphasized along with other Kuhnian paradigm shifts in science.

There have been three studies that give insight into the status of high school astronomy since Bishop's classic histories of 1977 and 1980. The last significant look was Philip Sadler's short 1986 survey of the field (Sadler, 1992), now considered a classic but dated review of the field. Next is a cursive review of the state of physics classes and its relevance to astronomy by Fraknoi, published in 1996. A study of astronomy begun in 1999 at two-year and non-research oriented four-year colleges was published in 2004 which has many parallels to this proposed study. The three are discussed in more detail below.

The Sadler study, which was brought to the writer's attention well after his survey was substantially created, is a good benchmark for comparisons of this dissertation's results. Sadler, working with colleagues to develop a curriculum for astronomy in high schools, was surprised to find that 11% of Boston's high schools taught stand-alone astronomy courses, a higher percentage than he expected. Names and addresses of the then-11,100 U.S. high school science department heads were obtained from the National Science Teachers Association's (NSTA) National Registry of Teachers to query about the existence and status of the courses around the country. Despite being late in the school year, a post-card survey attempt had a 23% return of the cards and a 15% rate of schools having high school astronomy courses. His study differed from a 1977 National Survey of Science, Mathematics and Social Studies Education study (Weiss, 1977) that found 6% of all high schools offered astronomy.

Sadler followed up with an 8-page questionnaire of 32 questions to the nearly 400 teachers identified in his first survey, questions asking for a general description of the course, other offerings in science at the school, information about the teacher and, because the point of the survey was to find out what curriculum would be desired by the teachers, they were asked about resources and materials they would like. (This current study will ask similar questions except we ask what they *have).* There was a 62% survey rate of return to his questionnaire, 240 responding teachers. In it he found that 41% taught physics and more than 25% taught earth sciences. Thirty eight percent of the teachers taught courses not commonly related to astronomy, like biology. Most teachers got their astronomy expertise from a hobbyist or personal perspective. One-third belonged to astronomy organizations. Eighty percent wrote their own curriculum and only 14% used a commercial text, all at the college level. Females counted as only 12% of all teachers. One section of astronomy was the norm for 57% of the teachers, with an average of 22 students, mostly as a capstone for 11th and 12th graders. Twenty percent of the courses were year long. About 5% of the students, on average, took the class.

Most of the teachers initiated the course; it was not pre-existing before they began to teach it. On average they had taught it for 9 years. According to Sadler, teachers craved better materials, a student workbook , summer workshops and an astronomy education newsletter or association. Teachers also believed they were the only ones in their region teaching the course, thus even neighboring teachers worked in isolation.

Andrew Fraknoi published in 2004 a long-delayed article on a 1999 study of astronomy teaching in community and other teaching-oriented colleges. Like high school astronomy teachers, most do not have doctorates (54% have masters or bachelors degrees) and the number is higher for two-year schools alone, 69% have masters or less. Only 25% have astronomy degrees and 38% have physics degrees, roughly 10% are from the geosciences and almost that many have education degrees. Twelve percent are from outside the normally expected sciences. The number of respondents, 400, was believed to represent 30-40% of the total population of 1200 to 1600 total teachers, similar to Sadler's numbers a decade earlier for high school teachers.

Budgets for materials averaged around $1000-1100 per year. More facilities, such as a dedicated classroom, an observatory or a planetarium were major desires. Yet, about a one-third had an observatory and just over a quarter had a planetarium, a higher percentage than high school teachers. Most community college teachers who were full-time had to prep around their other classes in other subjects. Like Sadler's high school teachers, they often work isolated from any other astronomy instructor anywhere in the same region.

The relevancy to high school astronomy is in its parallelism. Fraknoi's study takes place after the Sadler study but is remarkable for its many similar conclusions and statistics. A problem with the survey is that it was taken over seven years so its validity as a snapshot of the true situation is fuzzier; the delay may not represent the time of the study well.

Fraknoi had produced an earlier survey, this time on physics in the high school, with a much shorter publication delay (Fraknoi, 1996). About the same time as the release of the NSES, the article offers some updated statistics. For example, now there were 24,000 high schools in the United States, 46 million students overall, in 16,000 districts, a substantial increase since Sadler's study. One-third of the high schools had no physics class and physics-trained teachers did not teach many of the ones that existed. Only 20% of the students took physics. The numbers for astronomy courses in the senior high level are presumably smaller; in the US, astronomy is taught more in elementary curricula, and in middle schools, mostly as part of earth science classes. For comparison, a year of high school astronomy is mandated in Europe (Percy, 1996).

One final set of statistics: out of the thousands of planetariums installed during the heady early years of the Space Age, there are now only around 1100 active planetariums in the US, of which only around 350 are in high schools today (Peterson, personal communication). The 2005 directory of the International Planetarian Society (IPS) lists about 275 planetariums that are clearly in high schools, though whether any astronomy course is taught can not be directly assumed (IPS, 2005). That list is not complete; others not listed with the IPS were found on the listing of planetariums on a web page of *Sky and Telescope* magazine. The figure of 350 may well be about right. However, there may also now be over 1000 portable planetariums at all K-12 schools today; since Bishop reported in 1980 that there was almost a one to one correspondence between fixed planetariums and offered courses, one wonders what effect this number of portables has on the existence of a high school astronomy course, and even if high schools are using them. Portable usage probably depends on whether, like a fixed dome, the portable is always at the high school and available when needed, or shared with other schools. Of the IPS listings, 10% were portables owned apparently by the school itself. Portables owned by a district (or area educational organization, such as a museum or BOCES) available on regular loan may help but I hypothesize that it will be of a lower influence on whether a stand-alone course exists.

No analysis of the state of astronomy education has been published since Fraknoi (1996) and Sadler's (1992) studies. No study showing the influences (or lack) of the new sets of standards has been published. After the time of these three published reviews of the field and the introduction of new standards, an era of budget cutbacks and increased high stakes standardized testing began, enlarging in earnest in 2001 with the No Child Left Behind Act (NCLB) and its emphasis on reading and mathematics. Astronomy classes continue to hang on; in some states, the course is even growing in numbers of students taking it. Repeated surveys show astronomy is consistently one of the two top science interests at all educational levels from K through adult (Trumper, 2006). If it is so popular among students, why do so few schools offer it?

CHAPTER 3

OVERALL PROCEDURES AND STRATEGIES

Sampling and Data Collection Procedures

The population chosen was, formally, by a nonprobability procedure called criterion sampling. Nonprobability procedures are normally used when research addresses qualitative problems such as implications and not quantitative questions like 'how much' or how often'. (Honigman, 1982). Since there are both qualitative *and* quantitative aspects to this survey, it becomes necessary that the non-probabilistic sample become large enough to be actually representative of the population. Criterion sampling identifies specific groups or individuals for the study; in this case, the participants were all grade 9-12 astronomy course teachers. The definition of this course is that it must be a fully independent, self-contained course on astronomy, not part of another course that contains some astronomy. Typical course titles might be Astronomy, Astrophysics, The Solar System, etc., but do not include courses such as Earth or Geological Science in which astronomy is mixed with meteorology, environment, general science, and so on. (However, for a comparison purpose, a few of the latter were invited to participate, and did so.)

The spring research participants were gathered from multiple sources. Some of these would be considered truly non-probabilistic, i.e. not truly random. That is because they were a voluntary response group, people who respond to open public invitations to participate. Generally this is not considered the best research design as the persons are more likely to have an extreme viewpoint or eagerness. For example, they may be a minority of the population but very passionate for or against an issue and want or like to speak out, whereas the less voluntary persons may represent the mainstream majority. In this study we call these responders our 'hot' group.

Some of these sources included:

- astronomy and educational associations, such as 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), state and regional association discussion groups for physics, earth science or general science teachers. (More than half of each of the associations' regional groups allowed the message placements.) Sometimes others forwarded our invitation to other groups on their own. The mediums of communication are listserves (internet discussion groups that participate by mail—listserv is actually a specific program for this but it has become a kind of generic term for these communication means and shall be used in this study under that latter definition) or print newsletters of the state or regional chapters of these national groups.
- other groups that have interested astronomy teachers, such as Dome-L for planetarium directors, the 200,000 strong newsletter for the "Starry Night" software program, the newsletter to StarLab portable planetarium operators, and any others that became known.
- some state science coordinators and educators who work with astronomy teachers passed along our invitation.
- NASA, particularly the EPO (Education and Public Outreach) brokers who work with teachers and maintain contact lists. Other EPOs can be found associated with various outreach efforts now required of any NASA-operated space mission, such as Cassini, or

national observatories or other programs with outreach, such as SETI and NRAO and the ASP.

Then there were people invited directly through email (and in a very few cases, through our personal knowledge of their existence). Some lists were given to us from astronomy-related conferences, others by publishers or other persons. Some were found as we (myself and others) did searches on the Internet, clicking on numerous links to amass more names. Other sources for this essentially randomly selected group, which is nicknamed the 'cold' group, include:

- Lists of planetariums, which were easily obtained from several sources such as the *Sky and Telescope* magazine website, the International Planetarian Society (IPS), and several American regional planetarium groups. We also found lists of high school astronomy clubs with contacts.
- During our solicitation periods we occasionally received lists of people to contact directly.

All in all, the spring survey started with over 600 names, evenly split between 'hot' and 'cold' groups. With an initial estimate of between 2500 and 3000 possible teachers from a national listing called the National Registry of Teachers, this represented 20-25% of the population. According to Tuckman (1999), one must have at least 10% of a small population to be able to trust that your conclusions will have reliability (for larger populations, Tuckman claims, size is not of importance).

Finally, snowball sampling -- having surveyees recommend other people to survey -- was also used in order to gather more teachers. This added another 50 or so teachers.

Actual Data Gathering

The first persons contacted were a group of 16 to be subjects of phone interviews; eleven accepted the invitation. These persons were purposely picked for a variety of characteristics: rural or urban, private or public, geography, school sizes, and so on. Their interviews were recorded and their demographic data (such as year they started teaching) and key sentences in the qualitative responses were transcribed into a Microsoft Excel^{tm} (hereafter referred to as simply Excel) worksheet. Their responses were used to polish the proposed survey instrument, to add new questions or proposed checkbox answers, to delete others and to convert as many questions to 'clickable' answers, such as checkboxes, one-choice-only radio buttons or drop down menu selections. The interviews took place at the end of January through mid-February 2007.

The revised survey was made into a programmed Webpage and a version in Microsoft Word^{tm} (hereafter called the Word version or the Word file). It was tested for technical glitches, misspellings, missing answers, and non-functionalities both by colleagues and a 'pre-pilot' group that consisted of four persons who came from our personal knowledge of their astronomy-teaching existence or the non-responding interview invitation people. Small changes were the only result of their testing our procedure.

Over a period of 8 weeks, groups of persons who responded to the listserv announcements were formally contacted with an approved invitation letter. The letter contained a Web address to go to for doing the survey by their choice of survey instrument, Web-form or Word file. The first group of 50 invitees was used as a pilot study, to gauge responses and validate procedures in a realistic manner. The pilot teachers were selected from all the different responding groups obtained from the aforementioned sources over a period of a few months. As there had been some time lag between contact and survey start, we sent out emails to alert them to the upcoming start, a technique recommended by the authors of a survey tutorial website called SuperSurvey (2007). Then, seeing that the system was working, we sent out weekly batches of invitations, inviting the remaining ‘hot’ group members, then the ‘cold’ group members, then any persons we learned about through snowball recommendations or other means. Each week we also sent out a reminder message to the non-responders of the previous week, to catch people who may have been away, on spring break, or too busy to catch the message the first time. This reminding doubled the responses overall.

Finally, during the last week, we sent out a Last Chance message to all non-responders, adding in an offer, if they replied, with a small incentive, a set of small publications from *Astronomy* magazine. Incentives are known to help increase response rates and it worked. We also put up an anonymous, one-question non-responder web form where people could tell us why they were not doing the survey, which added and confirmed reasons that were given to us in email from some people who responded negatively to our invitation.

The majority of the ultimately more than 260 responses would be from the Web-based form on a uga.edu website. The form automatically generated a text file saved in a password protected area that was downloaded weekly and saved into Excel spreadsheets. The form also generated two emailed copies that went to two of this writer’s email accounts which were saved, one online and one on the personal computer. The program also generated a Webpage, again in a password protection area, to which each new responses was appended at the bottom in order of response. This Webpage made reading the responses easier while the Excel spreadsheets were easier to use in data analysis.

About 15% of the responders elected to do the Word files either because of their own personal inclinations or because they could not put in the time to do the Web form in an uninterrupted sitting.. The Word versions, which read as identically to the Webpages as the technologies allowed, were Protected Documents, that is, the text could not be changed but answer boxes could be typed in or selected with checkboxes or drop-down selections. Word files can also be exported out into spreadsheets, which were then combined with the week's downloaded delimited text files/Excel spreadsheets.

No one selected a straight ASCII text version or asked for a postal mail survey.

Because of astronomy teacher workload considerations and the timing of this study, the initial Web-based study needed to be done prior to end-of-school-year activities such as finals and standardized testing, and potential teacher burnout. Too late in the spring and there will be less response. Too early in the school year amd teachers are likely to be buried in start-of-the-year minutia; November and December are too filled with holiday interferences. Late winter, early spring seemed the best time, and most of the survey responses were acquired during the period of late February through mid-April. Some late responses, post-official survey, were received even to early June.

Following the data collection, each original spreadsheet of data was copied to a new one which was then used to 'clean' the data. Occasionally the comma-delimited data would be found in a new or different column—despite the programming, commas inside quote marks were not kept as text but broke the data into columns not planned for. This was a big problem in the qualitative questions. Sometimes it was the form of the answer; we expected whole numbers but got ranges. Sometimes a responder would select "none" and then proceed to indicate actual responses as well--we would delete the 'none' response, and so on. A person at a clearly identified private school would select ‘public’ as a choice. These “oops” factors were corrected using our best judgment and were made in as limited a fashion as possible. We moved to another worksheet all the ‘unusuals’ such as responses from non-American schools, teachers who actually had never taught an astronomy class, and others that didn’t fit the specified criteria. Finally, then, we made ‘working copies’ in which we could do our counts and analyses.

There were 237 usable surveys when the process was finished. Seventy were from the cold group, at a general response rate of about 24%. The rest were from the ‘hot’ group which responded at a 60% rate. Overall we had about a 40% response rate.

The Survey Instrument

The survey instrument had five main sections, corresponding roughly to the research questions plus basic contact information and a place for getting recommendations of other teachers or schools to contact and for any additional comments the teacher wished to make.

The survey contained 55 questions, several of which had sub-questions or fill in forms for extra details. Overall there are 17 questions that are numerical-quantitative in nature, such as ‘year teacher first taught’, ‘number of males and females in class’, ‘school size’, and so on. There are seven open-ended qualitative questions.

Twenty-two questions can be considered categorical-quantitative questions. They get textual answers which are then sorted or classified in some way and then the counts are analyzed statistically as well as discussed for content. Primary among these are the questions concerning keeping up with astronomy, astronomy education or other educators, what other courses do teachers teach, etc. An example of this question, excerpted, is shown in Figure 1. The larger blank areas were fill-in forms that expanded to fit the answer. The checkboxes, and often the answers given in the blank forms, could be tallied and used statistically.

What ways do you use to keep up with the latest news in the science of astronomy? (Check all that apply and fill in appropriate boxes):

astro/science magazines (which?)
newspapers
news magazines like Time
.
.
.

Figure 1. A sample categorical-quantitative question.

There is one categorical-qualitative question ("any other unlisted, or prominent secondary gripes?"), and there are eight questions that are categorical-mixed, that is, they are used both in a qualitative way to develop meaning and descriptive analyses and in a quantitative way for statistics. Examples of the latter include the majors of the teachers, reasons they no longer teach astronomy, and the effects of NCLB on the teachers' astronomy classes.

Counting categorical and numerical data together, there are 39 quantitative and 8 qualitative questions in this multimethods study, and eight that can not be binned as purely one or the other.

The Word version is listed in its entirety in Appendix A.

Data Analysis

The qualitative and quantitative questions require different techniques of analysis. The general procedures for each shall be discussed separately, and then specific procedures for the various survey questions will follow.

Qualitative Questions

One group of questions had to do with the teachers' perceptions on the effects of NCLB on their courses, followed by two questions on their perceptions of the future of astronomy courses, at their school and for the nation. The second group of questions had to do with prescriptive advice that could be given to fellow teachers, on starting an astronomy course, on defending or maintaining one in the face of NCLB or other forces that may wish to terminate the course, and finally what they feel needs to be done on a national level to increase the number of astronomy courses in high schools.

The initial process for the qualitative questions was to code the responses to the open-ended questions using grounded theory techniques developed by Strauss and Corbin (1997). The techniques for analysis were much the same for all six of the questions. Each sentence in an answer, regardless of grammar or size, was given a code word or phrase indicative of the sentence's type of advice, effect of NCLB, attitude, etc., whatever area (question) the respondent was addressing. In some of these questions, though, it was usually only necessary to code the single group of sentences if they all pertained to the same theme. This coding was done in each of the ten spreadsheets of data, in new within-spreadsheet worksheets which had been prepared by copying the entire working spreadsheet to a new worksheet, thereby keeping the original data untouched. Extraneous data columns were removed, the column being examined then duplicated next to the original column, and then the sentences coded in the duplicate column's spreadsheet cells using ALL CAPS, the code being put at the beginning of the sentence. When complete, the column was copied to a Word file as a table, the table converted to text, a paragraph mark put before each code phrase so that each sentence became a paragraph on its own, and the paragraphs were sorted alphabetically by the code phrases so that similar codes were put together. The sorted data were then grouped under some title; these might include ‘teacher-to-teacher’, ‘justifications’, ‘finding support’, ‘curriculum ideas’, and so on. Larger groups may be split into smaller ones, or smaller ones collapsed into larger groups. No presupposed groupings were used; each grouping would appear when a ‘critical mass’ of similar answers would make themselves noticed.

A small example to illustrate the procedure, from one of the smaller spreadsheets, for the advice question. The original data from three responders, with codings, is in Figure 2a.

ASTRONOMY TRAIT It's the final frontier.
COURSE DESIGN Bill course as 'extension' of material in more basic course - don't duplicate material. CLASSROOM STYLE Make 'hands-on' with activities and planetarium time, OUTSIDE ACTIVITIES Schedule at lease 1 'Star Party' star-viewing evening with local astronomy club/organization. COURSE LEVEL Don't make it too difficult. Aim for challenging, but doable for average student.
COURSE LEVEL Astronomy can be taught at a range of levels. Make sure of the audience that the course is intended for. It could be introductory science, up to college level. STANDARDS State Standards need to be covered. STUDENT NEEDS Specific needs of students need to be addressed. COURSE LEVEL And the course's position in the overall scheme of science in the school needs to be examined.

Figure 2a. Original coding data sample.

Each of the inside-the-sentence CODINGS were then separated by a carriage return, and the whole group sorted alphabetically (Figure 2b).

ASTRONOMY TRAIT It's the final frontier.
CLASSROOM STYLE Make 'hands-on' with activities and planetarium time,
COURSE DESIGN Bill course as 'extension' of material in more basic course - don't duplicate material.
COURSE LEVEL And the course's position in the overall scheme of science in the school needs to be examined.
COURSE LEVEL Astronomy can be taught at a range of levels. Make sure of the audience that the course is intended for. It could be introductory science, up to college level.
COURSE LEVEL Don't make it too difficult. Aim for challenging, but doable for average student.
OUTSIDE ACTIVITIES Schedule at lease 1 'Star Party' star-viewing evening with local astronomy club/organization.
STANDARDS State Standards need to be covered.
STUDENT NEEDS Specific needs of students need to be addressed.

Figure 2b. Sorted coded sample.

One can now see that there are several phrases/sentences of the same code, and there are a number of groupable themes within. In particular, there is a single item on astronomy itself (ASTRONOMY TRAIT), five codes on classroom design (CLASSROOM STYLE, COURSE DESIGN, COURSE LEVEL, OUTSIDE ACTIVITIES, STUDENT NEEDS), and one on justifications (STANDARDS).

Finally, the grouped data from all the spreadsheets/Word files were combined into one Word file. Related subgroups were merged, then the file might be broken up into multiple files depending on broad themes. These files were then examined and writing commenced.

In addition to discussion of the responses, simple statistics could be done on most qualitative questions in that the sizes and numbers of groups or themes could be counted. Furthermore, two questions on the attitudes of teachers had a categorical question attached, with a Likert-like scale ranging from optimistic to pessimistic. These attitudes could be analyzed quantitatively and then used as subgroupings for the open-ended question responses.

Quantitative Questions

The quantitative questions were analyzed differently. Sometimes numerical data was simply used in simple descriptive statistics, generating means, medians and standard deviations, proportional amounts, and straight counts. Sometimes, statistical tests can be used to see how groups or factors were related. These included t-tests, to compare groups with means and standard deviations, and Chi-squared tests to see if two sets of categorical variables were independent. When outside ‘gold standards’ were available, tests of proportions or Chi-squared tests would be done. For some questions, we had data from the literature, from the National Center for Educational Statistics, from the Sadler survey, and from the National Registry of Teachers (NRT).

The last item, although not used for the spring survey to find teachers, is a mailing list/subset of teacher names and data maintained by the National Science Teachers Association. Their June 2007 listing indicated the existence of about 1947 grades 9-12 teachers who claimed to teach astronomy. This list, an Excel spreadsheet, also contained budget data, school geographic type (urban, rural, suburban) and school type (public, private, religious), among other data. This list would be used for a future postal survey but for this spring survey it is a source of statistical data. When the list was cleaned of non-high schools, there were only 1296 unique institutions and 1713 total teacher names; this is henceforth named the 'uniqued' NRT list.

For all statistical tests mentioned, the alpha value is always 0.05. Results were determined variously with the programs SPSS^tm^, Excel with statistics plug-ins, XLSTAT^tm^—a more powerful Excel add-in, and StatView^tm^.

Specific Survey Questions

At this point, it is necessary to discuss the various survey questions individually and briefly indicate how they were used and analyzed. Available response choices are indicated in italics. The questions may not always be contiguous to each other in the survey as displayed.

In the first of the several survey question figures that follow (Figure 3a), the information seen was needed mostly for internal use. Identifying information was removed when put into aggregate databases and pseudonyms were used when the information was needed for more explicit discussion. Internally, it was also needed for communication, confirmation and clarifications, and to be able to send any incentives.

Your name:
Email address:
Phone :
Today's date: as MM/DD
High school name:
City State (e.g. GA): Zip
Public or Private? *Public private*
How many students are in the school?
On Block Schedule or Periods? *Block periods other(explain in box at end of survey)*
Status on most recent AYP (adequate yearly progress) report :
Pass Needs Improvement Fail Don't know Not applicable

Figure 3a. Survey questions: basic contact and school information.

Public/private, block/periods/other, and AYP status are all questions for basic descriptive statistics. In addition, they showed up in matrices to see, for example, whether block or periods or other daily scheduling formats were more common among public and private schools. The number of students was used to determine school size characteristics (means and standard distributions) against AYP status and for Chi-squared comparisons of class demographics of gender and racial/ethnics against school demographics. AYP is a categorical variable for studies concerning minority school types. The teacher name was used to generate teacher gender statistics which in turn was compared with undergraduate majors and against past national studies. Of course, the number of schools (public and private) by state comes from the state response. In general, the data was needed to begin to answer research question, “What are the typical kinds of schools that offer astronomy?”

The date of response (compared to the date of invitation) was used to determine “how quick or slow the responders were”, a datum needed for a methodological validation test of quick/slow versus hot/cold.

The question in Figure 3b, appearing in the survey as a table, has two identical rows, for the first/primary astronomy course and for any other second course in astronomy.

Please fill in the table below about your astronomy course(s) (they must be regular courses, not part of some other course):

Course Title Content Course Length Course Frequency
Your general course *Title put here*
Content choices: *stellar astronomy solar system astronomy stellar and solar together*
Course Lengths: *year long semester long other (fill in the box)*
If Other->
Course Frequency: *every year every semester every fall semester every spring semester irregularly other (fill in the box)*
If Other->

Figure 3b. Survey questions: course description and parameters.

Simple counts and statistics were done to generate a consensus model of the courses being offered, including information such as how many are semester-long versus year-long, how often they are offered, titles, content choices. Some of the data were also used in categorical matrices, such as course type versus course length or frequency. A similar analysis of any second courses taught was made.

The first question in Figure 3c was used in determining the average number of sections per teacher and sometimes the average number of students in the class. Both of these were tested with t-tests or tests of proportions against state Department of Education (DOE) data and Sadler's values. The number of sections helped indicate how much a "full time astronomy

How many sections are offered at a time? _____
What are the requirements or prerequisites to take the class?
Are there state standards for this course? *Yes No Don't Know*
Is astronomy a required course in your school/system? *Yes No*

Figure 3c. Survey questions: numbers and requirements

teacher" the respondent was. This, along with 'how many other instructors', a later question, went into the study of the isolation of the teachers. When numbers such as "1-3 sections" were indicated, a middle value ("2") was used in statistical studies. Requirements were analyzed in a number of science courses versus math courses matrix, with exceptions qualitatively discussed. 'Standards' and 'required?' were simple counts though an analysis of standards was used to determine how many teachers can pull standards from state lists, or not.

As college majors and teacher certifications are not necessarily related and majors are more diverse, the next pair of questions (Figure 3d) were expected to give insights into what would be a more reliable proxy--the college interest or the state certification process—as for whom gets to teach the astronomy class. Also, a count of the types of majors and the number of astronomy courses taken ought to give insight into the amount of need for teacher training in astronomy. Because Sadler reported on these factors, and about what other courses astronomy teachers also teach, these data were needed to compare this study to his study. The last question in Figure 3d was analyzed with straight basic statistics to learn the entryway into teaching astronomy.

INSTRUCTOR INFORMATION - I want to know more about you as your school's astronomy teacher.

Please fill in this table about your educational background and how many astronomy courses you have had. (leave blank if the degree is not applicable to you):

Degree	Majored in	Number of astronomy courses taken
Bachelor's		
Masters		
Doctorate		

What area specialization is your teaching certificate?
What got you into teaching astronomy? *Got into it in college, planned to do this.*
Kids asked me to teach such a course.
Administration asked me to teach one.
I was teaching something else and I wanted to do this.
Stepped in for/another teacher gave me the section
other (fill in the box). Other->

Figure 3d. Survey questions: instructor backgrounds.

What year did you first teach an astronomy course in any high school (e.g. 1950)?
When was the last time (year) you taught a high school astronomy course (e.g. 1951)?
If you did not teach in the academic year 2006 - 2007, explain why you no longer taught astronomy after the time you listed in the previous question (i.e. you retired, moved, course dropped, etc.), otherwise, leave blank:

Figure 3e. Survey questions: when did the teacher teach astronomy?

The first and second questions in Figure 3e together were used to determine teacher longevity which was also one of Sadler's statistics. From these were generated the codes C (currently teaching), CT (course was terminated), P (retired or former teacher), F (future teacher beginning next year) and C1 (currently teaching in first year). These became filters in the analysis, especially when determining who counted in the AYP studies. Also, the year that the teacher started to teach the class was used as one variable in the historical influences/course purposes study. Reasons given for why teachers no longer teach should be insightful towards understanding influences on teacher retention and whether AYP had an influence on their status as no longer teaching astronomy.

What other courses do you regularly teach? Check all that apply: *Physics* *Chemistry* *Earth Science or Earth/Space Science, Geology or GeoSciences* *Math* *Environmental Science* *Physical or Integrated Science* *Biology /Life Sciences* *Research Course* *Other:->* How many other astronomy instructors are at your school?

Figure 3f. Survey questions: who teaches astronomy and what else do they teach?

In addition to basic descriptive statistics, the questions in Figure 3f were directly analyzed by test of proportions to how today's teachers compare to Sadler's of 20+ years ago. The number of other instructors was used to generate values of the average number of teachers in the school and then compared to Sadler, NRT and DOE values, determining how isolated teachers may be compared to those of other sciences.

The three questions of Figures 3g and 3h may look the same but are slightly different. They concern how teachers keep up with the science of astronomy, the field of astronomy education, and with other astronomy teachers. These questions, qualitative yet categorical, build the picture on teachers professional development. Additionally, the details became key sources

What ways do you use to keep up with the latest news in the science of astronomy? (Check all that apply and fill in appropriate boxes):

astro/science magazines (which?)
newspapers
news magazines like Time
NASA education programs
NASA Websites
Websites other than NASA (list:)
Astronomy programs (like Hands On Universe, Micro-Observatory, etc., list here:):
Listserves (list:)
Science/Education association newsletters/magazines/updates
Mentors or other personal relationships
Astronomy books
Attending Conferences
Attending astronomy-related workshops
astronomy clubs
I don't keep up with the science.
Other:->

What ways do you use to keep up with the field of astronomy education? (Check all that apply and fill in appropriate boxes):

astro/science magazines (which?)
NASA education programs
NASA Websites
Websites other than NASA (list:)
Astronomy programs (like Hands On Universe, Micro-Observatory, etc., list here:):
Listserves (list:)
Science/Education association newsletters/magazines/updates
Mentors or other personal relationships
Astronomy Education Review
Attending Conferences
Attending astronomy-education-related workshops
astronomy clubs
I don't keep up with the field
Other:->

Figure 3g. Survey questions: keeping up with content and pedagogy.

In what ways do you network with other astronomy educators? (Check all that apply and fill in all appropriate boxes):

Astronomy programs (like Hands On Universe, Micro-Observatory, etc., list here):
NASA education programs
Attending Conferences
Attending astronomy/education-related workshops
Giving workshops
Science/Education newsletters/magazines/ association updates
Listserves (list:)
Mentors or personal relationships
astronomy clubs
I don't keep up with other educators
Other:->

Figure 3h. Survey questions: keeping up with educators.

of material for the critical action part of this study, particularly how to start a new astronomy course and resources that can be used.

The question in Figure 3i has more meaning than just simple statistics as to which groups astronomy teachers belong. These were also needed to eliminate selection effects, since NSTA, AAPT, NAGT and NESTA regionals were used in the obtaining of some of the names of potential survey respondents. These were also used to see if the same percentages found by Neuschatz and McFarling, (2001) [hereafter referred to as the 2001 AIP Survey] concerning memberships holds here, and whether national or regional associations are the better venues to provide teachers with the training they may wish, and where they can find other local astronomy teachers. Thus we generated basic statistics though, because of selection effects, they may not be representative. The memberships were examined not only with tests of proportions but also with ratios of the memberships' sizes of the national groups themselves. The 'Other' question ought to generate further useful groups for astronomy teachers to join.

To which science or science education organizations do you belong? Click all that apply:

None NSTA AAPT NESTA NAGT
State/regional science teachers assn State/regional physics teacher assn
State/regional earth science teachers assn
ASP AAS Planetary Society US Planetarium associations IPS
AAE Other:->

Figure 3i. Survey questions: organizations where astronomy teachers belong.

The following questions pertain to just your general course---
Over all time, what is the average enrollment of your astronomy classes?

The enrollment trend is *growing steady declining* .

In your most recent general class, using actual numbers, not percentages, what was the:

Class Enrollment ___________

Gender Mix: Male ________ Female ________

Grade Levels: 9th graders ____ 10th graders _____ 11th graders _____
12th graders ________

Ethnic/Racial: White ____ African American _____ Asian ______
Hispanic _____ Other _________

Please check that your numbers in each section above add up to your "class enrollment" number!

Figure 3j. Survey questions: student and class demographics.

The data generated from the questions in Figure 3j was the richest for class and student demographics. Class characteristics were checked for some high schools against their school demographics, using the National Center for Education Statistics (hereafter referred to as NCES) as the source of the school demographics data except for school sizes and class data which were provided by the teacher. Using Chi-squared tests, we determined if the class reflected the school numbers. The sums of all of the astronomy students' gender/ethnic class counts were compared via tests of proportions against national ethnic/racial makeups from the most recent census, and also compare against physics classes as measured by the AIP. Sums of the numbers of students in the sections and the school were used to compare to Sadler's percentage of students taking the class, and against NCES statistics of the same sort. The grade levels counts were used to determine if astronomy is a capstone or introductory class by the numbers in each grade. The racial/ethnic counts were used to determine if the class is a low minority, representative of the average demographic, minority or high minority class, which was also used to see if minority levels have any influence on the school's AYP status. The enrollment trend descriptor was studied with basic descriptive statistics to see if enrollment, which has been increasing over the past decades, is still increasing. It was then compared against the trend noted by looking at the all-time average of past classes to the current class enrollment, to see if the numbers match the descriptor trend. When class enrollment values were given as a range, the middle of the range is used in these statistical studies.

The academic abilities of the students in this class is generally *High Average Low Mixed*

Figure 3k. Survey questions: student abilities.

The question in Figure 3k was here to see if this was a good proxy for the kind of course offerings, such as general or capstone or for low achievers.

What course book, or curriculum from commercial or other sources, do you use?

Figure 3l. Survey questions: book and curriculum materials

A list of textbooks and other curricula materials was generated from the question in Figure 3l as part of the sources of materials that all teachers can use who may need source material for a class, part of the critical action aspect of this study.

What access to planetariums do you have? (Choose ONE)

Your particular school owns and operates a fixed planetarium.
You use a fixed planetarium elsewhere. → *(*how many visits do you get per course? *)*____
You can use a portable planetarium. → *(*how often, per course?___ Whose is it? *(school, district, someone else's?))*
No planetarium is available to you.
Other situation, explain here:

Figure 3m. Survey questions: planetarium availability.

Basic descriptive statistics were done on the the questions in Figures 3m and 3n, and usage comparisons were made between planetariums owned and planetariums borrowed or existing elsewhere (not owned). As the existence of a planetarium had once a nearly 1:1 relationship with the existence of a course, this study examined whether this holds with portables or other sky presentation devices. We also compared our sample with the IPS directory to see if it was representative. Similarly, for the next question on telescopes, basic statistics indicated how many and what kinds of telescopes are used by the classes.

What access to telescopes do you have? (Choose ONE):
Have its own observatory at the school.
School owns some small telescopes. → (How many?_______ *)*
Use someone else's
Have no telescopes.
Other->

Figure 3n. Survey questions: telescope availability.

How much do you usually spend per year for equipment, supplies, and materials (e.g. $1000)? ________

Then, choose one of the following answers for your primary source of funds:
This is explicitly budgeted for astronomy.
Comes out of the general department funds.
Comes only upon my request when needed from the school administration.
Comes out of my own pocket only.
Grants are my major source.

Figure 3o. Survey Questions: Budgets

Basic budgetary statistics derived from the questions in Figure 3o were compared to those of the NRT budget values.

Choose one of the following as your biggest problem, wish or need that you have for your astronomy teaching:
funding
time
more space
supplies
math or language prep of students
attitudes of students
no problems
Any other unlisted, or prominent secondary, gripes?-> _______

Figure 3p. Survey questions: teachers needs and wishes

In addition to basic descriptive statistics, the question in Figure 3q enables a comparison of today's teachers' wishes with Sadler's.

What should be the primary purpose of an astronomy course? Choose one:
1. *All educated persons should know this and be able to pass the knowledge on to others, like their families.*
2. *Develop minds, thinking skills, imagination.*
3. *Teach skills students can use in life.*
4. *Master this content, just like mastering the content of any other course.*
5. *Integrate many facts, processes, and sciences together because of its broad, multi/interdisciplinary nature.*
6. *Increases awareness/literacy of how science works, improve attitudes towards science.*
7. *Increase appreciation for Earth, sky or our place in the Universe.*
8. *To empower the student, to show the world is predictable and they can learn about the world through science.*
9. *Other ->*

Figure 3q. Survey questions: purpose of the course.

The answers' order is chronologically arranged from historical purposes found in the literature. This data was key not only for determining an overall understanding of why the course should exist and what purpose does it have, but also for this study's interest on whether teacher's time of training influences their stated purpose. During the 40+ years covered by teachers (as given by the date of when they started teaching the class), there were three key educational paradigm shifts, two times when national standards were introduced, and once when the No Child Left Behind Act was enacted. Dividing the data into time periods when these were introduced (plus one additional year to allow time for introduction into teaching programs), the number and proportions of the answers were checked and compared with chi-squared and tests of proportions at the various time period boundaries. As this study is especially interested in what happened when NCLB was enacted, that boundary is paramount.

When (year) was the course first offered at this school (e.g. 1950*)?*
Did you create the course (choose one answer)?
Yes. The justifications I used are written below:
No but the justifications I heard to make it are listed below:
The principal justification was (Choose one):
Students demanded a course, showed high interest.
I or the original course creator personally wanted to do it.
The administration asked me to do teach it.
Reason is unknown.
More/second courses were wanted by science-interested students.
Electives wanted by administration for students who had trouble with standard science courses.
Factors external to the school pushed for it.
Other justifications (fill in the box):
If you need to explain anything further, or tell to whom the justifications were given, explain here:

Figure 3r. Survey questions: reasons to create courses.

How a course comes into existence and who made the course may be key to increasing the number of courses. The justifications in Figure 3r were compared against who created it. It turns out that the year it was introduced was difficult to determine in many cases and this variable was not utilized.

The six purely qualitative questions in Figure 3s were analyzed as discussed above in the qualitative section and were the primary sources of data for the prescriptive results to be given to teachers who wish to start a new, or defend an existing, course. The two questions within regarding the teacher's perceptions of the future of the astronomy course in their school and in the nation were analyzed not only with basic statistics but were also used as filters of the answers for each of the attitudes.

If you should have to defend or justify the course at some future date, what arguments would you use? Why?

What advice would you give to those who would wish to start an astronomy course at their high school?

What, if any, positive or negative effects have you felt in the astronomy course from the No Child Left Behind Act? Why do you feel this way?

Answer this question: "I am *optimistic* *somewhat optimistic* *neutral* *somewhat pessimistic* *pessimistic* about the future of my astronomy course in my school."
Now, explain why here:

How do you feel about the future of High School astronomy course offerings nationally? "I am *optimistic* *somewhat optimistic* *neutral* *somewhat pessimistic* *pessimistic."*
Now, explain why here:

What would have to be done to increase the number of astronomy courses in the US?

Figure 3s. Survey questions: qualitative questions on attitudes, creating, defending courses.

If you have any other comments you wish to make, clarifications or expansions of earlier questions, do so here!

FURTHER CONTACTS:

Can you point me to any other astronomy HS teachers? If so, please give as much information here as you can for contacting them.

Can you point me to a school(s) that used to have a course but no longer does? Or in which an attempt to create a course was made but was unsuccessful?

Figure 3t. Survey questions: Comments and new contacts for snowball sampling.

The first question in Figure 3t was a general place for respondents to say other things on their minds or to expand on other answers. Our snowball sampling data came from the last two questions; though the very last question was not utilized for this study, it will be used in a later one.

Methodological Analyses

It is known that there can be a difference in survey data and results between persons who respond earlier versus those who respond later (Tuckman, 1999) and also persons who are from ‘voluntary response groups’—those that answer public announcements seeking people versus those who first hear about the survey directly from the surveyor. The data for both national and local course future attitudes were analyzed in a series of four multiple linear regressions with the dependent variable being the attitudes of optimism to pessimism, against dates of invitation (and, separately, dates of response), response lag time, and hot/cold group membership. The survey is checked for geographic validity by comparing state counts of responses with national lists of planetariums, the NRT list and overall state populations.

It is also known that late responders often do mimic non-responders (Krathwohl, 1997) and non-response must be checked to ensure internal and external validity of the survey results. This is done by direct query of survey responders, an anonymous survey webpage for non-responders, and the multiple linear regressions above.

CHAPTER 4

ANALYSIS OF QUANTITATIVE DATA

This analysis of the spring 2007 High School Astronomy Survey begins with a look at its primarily quantitative questions, and the categorical questions that can be answered in both descriptive and statistical ways. This chapter examines the data in terms of larger to smaller scales, first the schools that have astronomy courses, then the courses themselves, followed by the teachers and their students. The analysis will end back at the broader picture, first comparing these results to the last great survey, the 1986 Sadler study, and then end trying to determine exactly how many teachers and classes of astronomy are in American high schools.

Data from seven states' Departments of Education (DOE) were also obtained for which several comparative studies are done to validate the survey results. Adding in survey information, case studies can be made on these seven states.

Two categorical questions, on how the teachers view the future, are discussed in the chapter on qualitative questions, as they relate more to the qualitative questions than to the material here.

The Schools' Parameters

The number of usable school surveys are 237. The most responses from any single state was from Pennsylvania with 26, followed closely by Wisconsin with 22. Georgia is sixth most with 13. There were responses from 40 out of 50 states. Is this a representative pool of respondents?

Table 1 shows the 10 biggest counts of schools per state in the uniqued NRT 2007 listing—these are not the total number of schools in the state but should be all in proportion to the real numbers--and the Top 10 from this survey's response pool.

Table 1
Highest Counts of Schools in This Survey and in the National Registry of Teachers

2007 Top 10 States in NRT	Number of NRT's 'Uniqued' Schools	Top 7 States, This Survey	Number of Survey Respondents
CA[a,b]	88	***PA***	26
NY	82	***WI***	22
PA	80	*TX*	16
OH	63	***OH***	16
IL	61	***MI***	14
MI	58	*GA*	13
FL	48	**CA**	10
WI	46	VA	8
WA	45	**WA**	8
MN	43	AZ	8

[a,] *Italicized states are those with 5% or more of the total number of schools,*
[b] **Bold are states common to both lists.**

While the ranking positions differ some, two out of the three NRT 5-percenters appear on both lists. Six of this survey's ten highest responding states are also in the NRT top ten.

The schools are mostly public, 87% (n = 207), the remainder being private schools, at 13 % (n = 30). How representative is this? There are two sources to which these values can be compared.

First, figures from the National Center for Educational Statistics (2005a) indicate our survey is only slightly higher in private school by about 1 percent. NCES lists 22,180 public high schools in total, and 2704 private ones. However, there are about 1700 'other' high schools that include vocational, special education, and alternative high schools, which drops the count to

20,760 ‘regular’ high schools. This makes the public/private ratio to 88:12. One can claim that this survey pool is generally representative of the national frequencies of public and private schools, just from this. However, the values can also be compared to the NRT list which has 23% of schools as private-nonsectarian or Catholic (*n* = 300). This is higher than the national average. For reasons that shall be seen later, the NRT list is not always representative.

In terms of school regional characteristics, the whole NRT list is split 46% suburban, 24% urban, and 30% rural, 1% unknown (all numbers in this paragraph may not sum to 100% because of rounding). By comparison, NCES (2005b) lists for all schools [elementary and others included] 41% suburban, 30% city (= urban), 22% rural and 8% others considered ‘town’. If the 8% is assumed split by the same proportions, this becomes 44% suburban, 33% urban, and 23% rural. The NRT list is more rural and less urban than NCES values.

It is worthwhile to see if the survey’s responses are representative of the both the NRT and NCES distributions. First, schools/teachers in common between this survey and the NRT were located. Thirty-nine persons were found who had responded in the spring who are also on the NRT list. There were additionally 11 other schools that were on both lists but not with the same persons. These 50 were examined for the distribution of geographic location and type of school. It was found that 70% of the subset were public schools, 30% private, more of the latter than the whole NRT list, and much higher than the same percentages nationwide or in the main survey. Also, the geographic distribution of the 50 were 52% urban, 38% suburban, and 10% rural. This subset of the spring survey respondents distribution is much more suburban and urban, and much less rural, than the overall NRT list or the NCES values as well.

However, the whole pool of respondants was then checked, obtaining locality information from the school information search engine at the NCES website. Though the NCES actually have more categories, it was possible to 'bin' the schools into suburban, rural and urban categories. Data was found for 230 of our schools, and the breakdown was 104 (45%) suburban schools, 66 (29%) urban, and 60 (26%) rural. This is actually quite close to the NCES values mentioned above and not that far off from the NRT values. It would appear that the sample of 50 common schools was not representative of either the pool or the NRT, but the pool of respondents in toto are quite representative of the population. Rural schools were not undersampled and there is not so high a predominance of urban schools as initially indicated by the smaller sample.

The sizes of surveyed schools depends on whether they are public or private. There are 202 public schools on the survey list with usable school size data. The average is 1581 students (*s.d.* = 867), the median slightly smaller at 1525 students. Private schools (*n* = 30) average 734 students (*s.d.* = 560) with a median of 615.

According to Table 5 in the NCES 2005b report, the average public high school has a size of 1249 students. This was based on 15,409 public schools in 2005-2006, using data from states. There were 19,028 regular secondary schools in a comparable 2004-2005 list (NCES, 2006), but this includes schools with grades 7 and 8, dropping the average size to 815, the data coming from schools themselves. According to the NCES School Year Report, 2003-2004, as reported in a webpage at the National High School Center (2006), the average high school has a size of 768 students. It is unreasonable to think that in one year the average high school size nearly doubled. For this study the value of 800 students will be our standard for the average size of a U.S. high school. As to the number of 'regular' high schools, there appear to be between 18 and 20 thousands. Our standard will be a middling value, 19,000.

Consequently, the surveyed public schools with astronomy courses average about twice the size of an average high school. There was no national average of size for private high schools but given that in 2004, about 1,307,000 students were in private high schools and there were 2700 private high schools in 2001, this generates an average private high school size of 483 students. Thus, even the surveyed private schools are nearly twice as large as the average private school size

The overall size of all public high schools on the NRT list (n = 980) is 1029 students with a standard deviation of 802 students, and a median of 868. This is about two-thirds the size of the survey's findings and one-third larger than average U.S. high school value though the median is a lot closer to that value. Private schools are much smaller, at an average of 349, standard deviation of 370, and median of 241. If the private schools are proportionately smaller to the same extent as the NRT's public schools, then they should really average 536 students, still lower than our size determination. So the size values of the NRT list is proportionately about 30% higher than the national average. This further indicates that the NRT schools are not as representative of the entire national school system as one could wish; it is getting its school data from the smaller schools in general.

The combinations of comparing this survey to the national figures and the NRT list indicates that our pool is representative of the national statistical pattern and somewhat representative of the NRT schools, but the NRT is not entirely representative of the national pattern. This should generate confidence that this survey's respondents represent school types on a national level.

Schools' AYP Status and Sizes

AYP stands for Adequate Yearly Progress and is a measure of compliance with high stakes testing and No Child Left Behind. All teachers were asked what was their school's AYP status. Some of the respondents are not currently teaching, indeed may have retired. Taking all the above into account and filtering the results only for currently teaching public school teachers yields 114 schools with a Pass grade, 30 Needs Improvement, 5 with a Failing AYP, 17 Don't Knows and 16 Not applicable and 5 No response. Removing the Don't Knows, Not Applicables and No Responses makes our survey values as 77% Pass, 20% Needs Improvement and 3% Fail.

How does this compare to national AYP percentages isn't an easy question to answer. The NCES (2007a) figures for 2005-2006 indicate the national percentage of schools that failed is 26, that 14% Need Improvement, meaning that 60% Passed AYP. The year before the pass rate was 73% of all schools. But this is the number for all schools. Would high schools be different?

A spot check on the Web found specific information on high schools for the same year in several states. California had 64% passing, Georgia had 63% pass, NC passed 48% of its high schools for an average of 58%. Their respective comparable figures in the NCES table were 47%, 65% and NC 49%, an average of 54%. It would appear that on an individual school system or individual state basis, the numbers may not always follow national trends but the overall averages do seem to indicate that the percentage number of high schools passing should be similar to the state's all schools percentage. It will be assumed that the national trends should follow suit.

Therefore, the number of high schools with astronomy are more likely to be schools that Pass AYP, at a rate even more than the national percentage of schools that passed. 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 national averages.

A follow-up question would be whether school size has any effect on a school's AYP status. Table 2 indicates the size statistics for schools in this report broken down into school type and AYP status. At first glance, it appears that schools that do not pass AYP and yet teach astronomy are slightly larger than schools that Passed AYP. Indeed

Table 2
Sizes of Schools Teaching Astronomy by Type and AYP Status

school type	average	std dev	median	number
private	734	560	615	30
public Pass	1566	934	1500	132
public Needs Improvement	1642	752	1700	32
public Fail	1708	719	1600	6
public other	1520	727	1500	32

histograms (Figures 1a, 1b, and 1c) of the counts show that Needs Improvement schools, in units of 100's, have a slightly higher peak value in school size than the Pass schools.

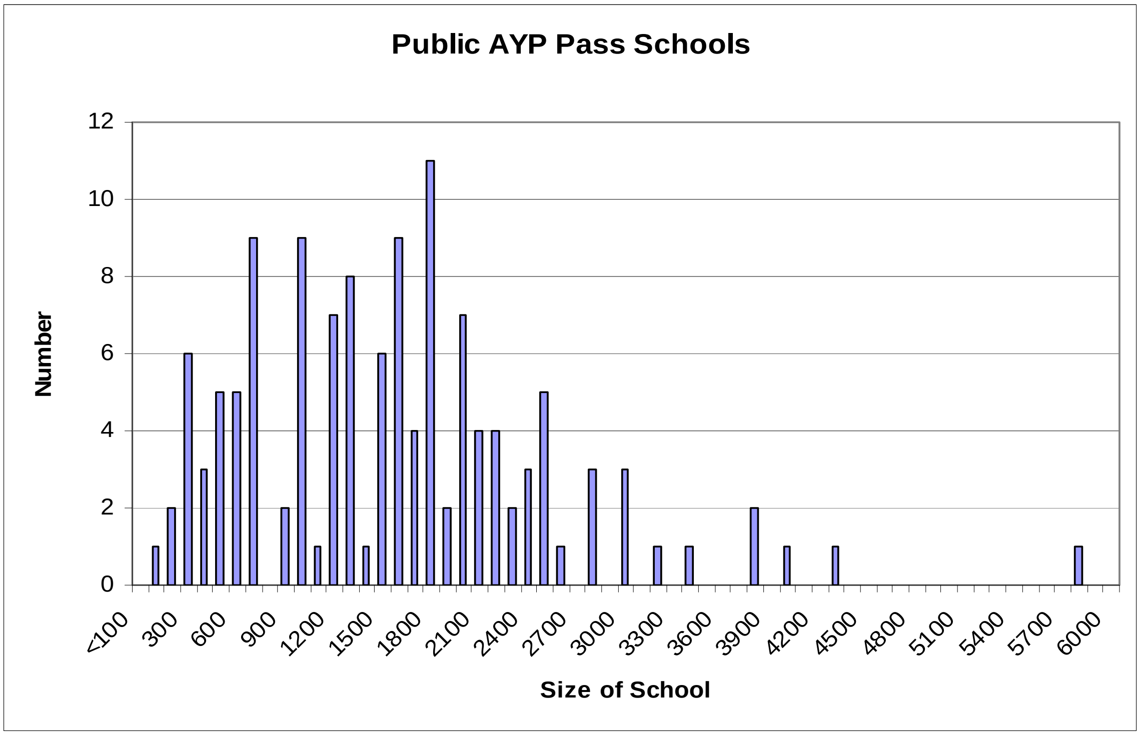

Figure 4a. Number of AYP Pass schools per school size.

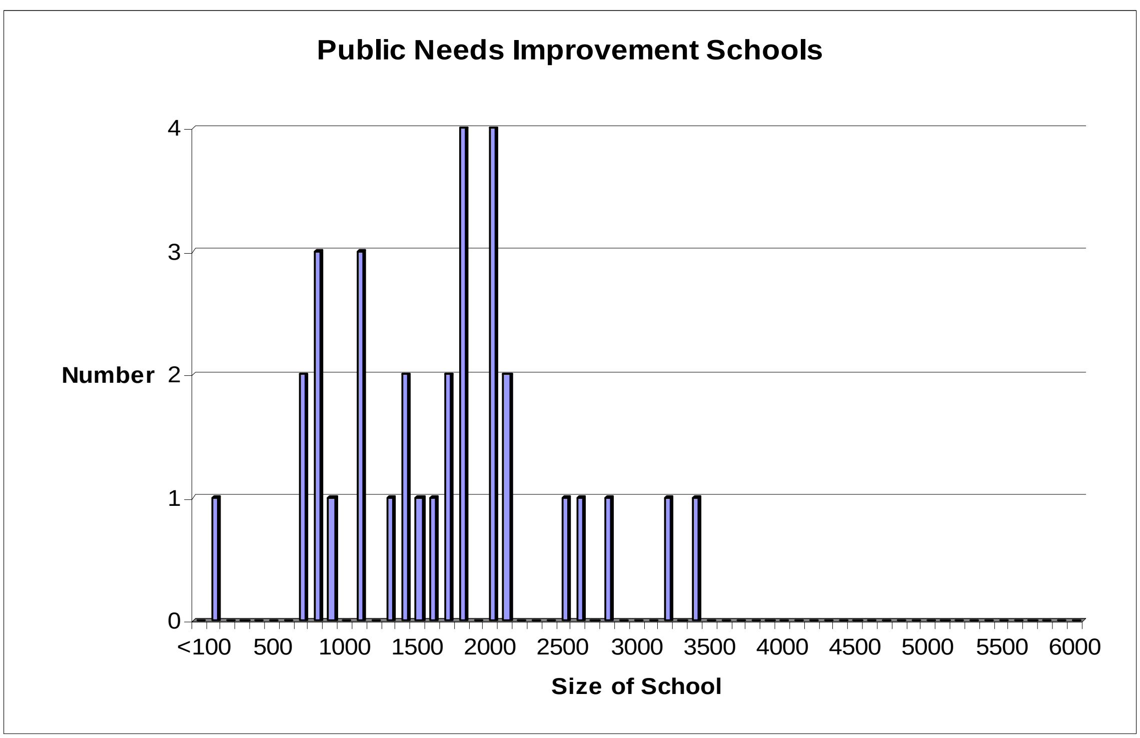

Figure 4b. Number of AYP Needs Improvement schools, by school size.

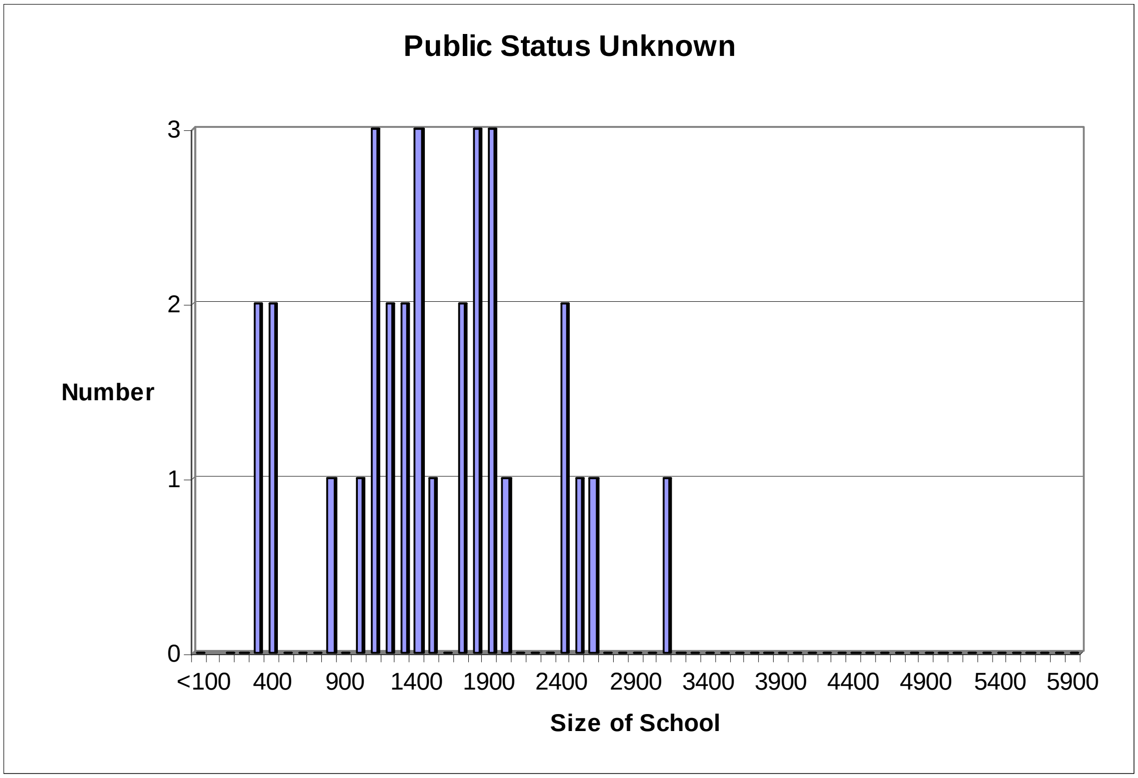

Figure 4c. Number of Other public schools, by school size.

However, t-tests with df = 1 comparing Pass versus Needs Improvement, and versus Other, and versus private schools (the Fail group is too small for this test) show no statistical difference between the sample groups (Table 3). The Other group consists of schools that selected "Don't Know," "Not Applicable" or left the AYP field blank.

Table 3
T-test Results on School Type/Size Groups

Test groups	***p***	***t***
Pass vs. Needs Improvement	0.468	1.107
Pass vs. Other	0.420	1.289
Pass vs. Private	0.104	6.018
Private versus all public	0.129	4.867

Thus, for public schools, it can not be said that size matters in terms of AYP, that there are significant differences in sizes between schools of differing AYP types.

This then supports the contention that these percentages hold for all public high schools and that public high schools with astronomy are thus more likely to be Pass schools than the norm. This gives support to studies that say that electives like astronomy are cut out when a school does not pass AYP (NSTA Reports, 2007; Hunt, 2006). Speculatively speaking, this could give support to the argument that to help a school pass AYP, electives such as astronomy can actually help but it can also mean that schools that pass AYP have the luxury of offering an elective like astronomy.

The number of schools having the same size or fewer students to the average American high school is only 23% (*n* = 31) of the Passing schools, 12.5% (*n* = 4) of the Needs Improvement (NI) schools, 18% (*n* = 6) of the Other schools, and none of the Failed ones. Calculations for the first quartile point Q1 for Pass, Needs Improvement, and Other schools render similar values, ranging only from 900 (Pass) to 1100 (NI and Other). The Q3 is 2000 students, remarkably, for all three groups. A look at the graphs indeed shows few schools above 2500 students. This thus further concludes that public high schools that teach astronomy are most likely to be not only larger than the average U.S.high school but they generally range from 2 to 4 times that national average, and they are passing AYP.

How large is large? The NCES uses three definitions of a "Large High School" which are a school greater than 900, 1200, or 1500 students, apparently varying with different purposes. (NCES, 2003). Large means different things to different institutions as well; for example, New York City uses a definition of greater than 2000 (Stiefel, et al, 1998). However, the NCES' lowest number can be compared directly with a table on the size of high schools (NCES 2003) that states that the number of high schools 900 students or greater nationally overall should be 28%. In this study's Pass group it is found that 77% are Large Schools; the Needs Improvement group contains 78% and the Other group 79%. Fail schools have 83% of their schools as Large Schools. These similar values further corroborate that size doesn't matter for AYP status.

An addendum to this size discussion: because earlier in this discussion it had been noted that the 230 schools had been binned into the three geographic locality types, it can be shown now that there are certainly size differences because of the locatlity and type of school. In the public school venue, the Urban schools are slightly larger than Suburban, with medians and averages of 1897/1850 and 1744/1600 students, respectively, but rural schools only 40-60% their size, 1030/720. In the private sector, the schools are even smaller though the suburban and urban schools are again comparable to each other and rural schools are again about half their city counterpart sizes (711/658 and 846/502, and 440/440 for rural, respectively).

The percentage also varies with location. The NCES Large School figures are 44% in central cities, 37% urban fringe, and 9% in rural districts. Large schools are not distributed evenly, and high schools with astronomy follow the national trend, even leaning more towards urban schools than most Large Schools do. No matter how you slice it, schools with astronomy classes tend to be large.

The Courses' Parameters

Purpose

Why should a course be taken, or offered? What is its purpose? Has it changed because of No Child Left Behind?

Historically, the reasons why a course in astronomy should be taken by a student has changed. Eight major purposes were stated or implied during various periods of American history. The purposes, in chronological order are listed in Table 4, and placed in a timeline and referenced in Appendix B.

Table 4
Historical Purposes for an Astronomy Course, In Chronological Order

Purpose description	(Survey code)
All educated persons should know this.	(educated)
Develop minds, thinking skills, imagination,	(mental improvement)
Teach skills students can use in life	(skills)
Master this content, like for any other course.	(mastery)
Integrate many facts, processes, and sciences together.	(Multi-Interdisciplinary)
Increase awareness/literacy of how science works	(science literacy)
Increased appreciation for Earth, sky and our place in the Universe	(appreciation)
Empower the student, to show the world is predictable and learnable	(empowerment)

The working hypothesis is that there should be shifts in purpose during major educational changes and that teachers should be most affected by the purposes in vogue during their time of training. The time periods covered by these teachers, who began as far back as the 1960's, include the Space Age/Cold War push for science education, the first and second institutionalizing of national 'standards' (even though there is no true national curriculum) following the introductions of the AAAS/Project 2061 Benchmarks of Science (1989), then the National Science Education Standards of 1995, and then the 2001 No Child Left Behind Act.

Overall, for the entire pool, only three have substantial numbers of tallies. By far, appreciation of the universe is the largest vote getter, 82 out of 226 teachers. Next highest with 36 votes is mental improvement, which is representative of the philosophy from the latter part of the 1800's. Close behind with 33 is the multi/interdisciplinary aspects of the course, an influence of the 1970-1980's. A distant fourth place is science literacy. All the raw counts are in Table 5.

Table 5
Number of Teacher Course Purposes per Time Period

	Purposes									
Time period	educated	mental improve-ment	skills	mast-ery	multidisci-plinary.	literacy	Apprecia-tion	Empow-erment	other	number of teachers
Post-NCLB	7	12	1	2	13	10	20	8	2	75
G2 = Post-NSES	3	16	1	3	12	5	36	5	6	87
G3 = Post-Bench-marks	2	1	0	0	4	2	13	3	2	27
G4 = Pre-Bench-marks	2	7	0	1	4	5	12	1	5	37
G5 = Cold War /Space Age	0	0	0	0	0	0	1	0	1	2
Totals	14	36	2	6	33	22	81	17	15	226

“Other” was the choice of 16 respondents. Out of them, 12 directly stated that their choices were a combination of the other 8 given choices. One should have been listed as one of the given choices; it was the same as one of the choices. Three of the other six were more poetic combinations of purposes.

Table 6 is much more informative because the counts of each time period are represented by percentages (the G5 time period and the Other listings are dropped). Figure 5 illustrates these proportions in terms of cone heights.

Table 6
Purposes for an Astronomy Course, by Proportion Within Each Time Period.

	Purposes							
Time Period	educ-ation	mental improve-ment	skills	mastery	multidis-ciplinary	literacy	appre-ciation	empow-erment
Post-NCLB	9.6	16.4[a]	1.4	2.7	*17.8*[a]	13.7	**27.4**[a]	11.0
G2 = Post- NSES	3.7	*19.8*	1.2	3.7	14.8	6.2	**44.4**	6.2
G3 = Post-Benchmarks	8.0	4.0	0.0	0.0	*16.0*	8.0	**52.0**	12.0
G4 = Pre-Benchmarks	6.3	*21.9*	0.0	3.1	12.5	15.6	**37.5**	3.1
Total	6.6	17.1	0.9	2.8	15.6	10.4	38.4	8.1

[a]**Bold is the highest percentage** in each time period, the *italicized are the second highest proportions* and the underlined are third highest

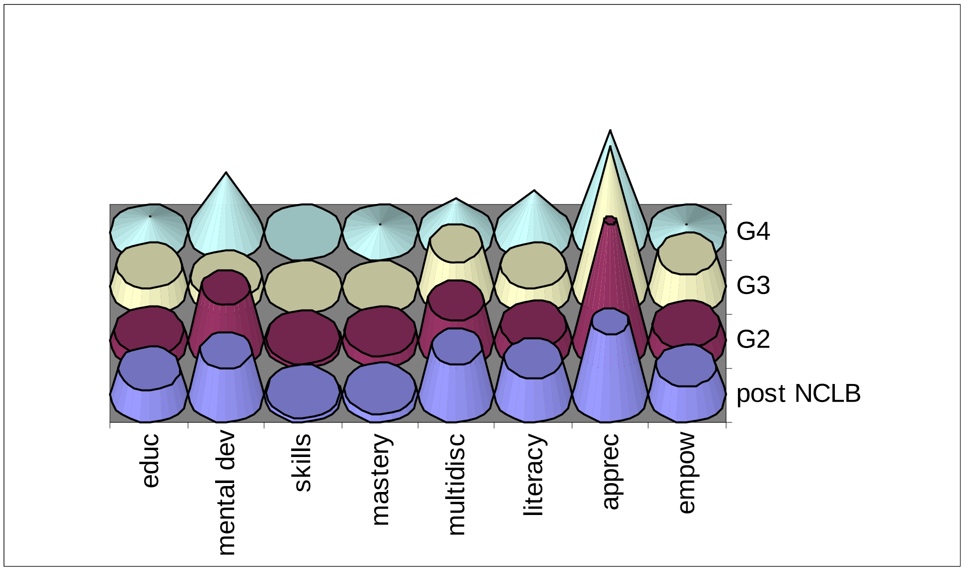

Figure 5. Relative numbers of different purposes for an astronomy class, by time period.

At first glance, most purposes do not appear to be varying much over time. When the detailed proportions are inspected, there are several shifts noticeable at some borders between time periods. ‘Literacy’ only makes the top three way back at the earliest time period, before standards were introduced; it reigns along with ‘appreciation’ and ‘mental improvement.’

When *Benchmarks* are introduced, ‘appreciation’ dominates, it contains the majority of counts. ‘Multidisciplinary aspects’ supplants ‘literacy,’ which makes sense since the multidisciplinary aspect didn’t make many waves in pedagogy before then and ‘empowerment’ supplants ‘mental improvement.’ This is perturbing because ‘literacy’ is what one might expect from teachers who were trained after *Benchmarks* became part of the pedagogy, as science literacy is a major concept behind the *Benchmarks,* not before. In fact, there is little change when the NSES gets introduced a few years later, primarily a comeback to prominence for ‘mental improvement’ and the halving of ‘empowerment’ purposes.

There is at least one large shift as one moves across the NCLB introduction boundary. “Appreciation’ retains a lead but it drops significantly in proportion. “Literacy’ makes a strong comeback as well as 'all educated persons show know this'. These might be expected when accountability is suddenly a major expected outcome.

A Chi-squared test should indicate if the changes are statistically different. However, the overall counts table (Table 5) has more than 20% of its cells with values of less than 5 and a number of zero values, therefore a Chi-squared test can not be made on the raw counts as a whole. The two small-total purposes (skills and mastery) were eliminated as well as 'others' and time period G5, leaving a 4 x 6 contingency table. The results of the test were a Chi-squared of 15.65 and a probability of p = 0.406. The variations are not as statistically different as they are visually.

As this study is concerned with the time period of NCLB, a better test might be to collapse this into pre- and post-NCLB time periods. Table 7 has the raw counts for that test.

Table 7
Counts of Teachers' Stated Purposes for an Astronomy Course, Before and After No Child Left Behind is Introduced.

	Purposes						
Time Period	Education	mental improvement.	multi-disciplinary	literacy	appreciation	empowerment	totals
Post-NCLB	7	12	13	10	20	8	70
Pre-NCLB	7	24	20	12	61	9	133
totals	14	36	33	22	81	17	203

Table 7 is next converted to a table of proportions (Table 8) and a statistical test of proportions was done on each pre/post pair.

Table 8
Percentages of Teachers' Stated Purposes for an Astronomy Course, Before and After No Child Left Behind is Introduced.

	Purposes					
Time Period	education	mental improve-ment	Multidi-sciplinary	literacy	appre-ciation	empower-ment
Post-NCLB	10%	17%	19%	14%	29%	11%
Pre-NCLB	5%	18%	15%	9%	46%	7%
z-statistic	1.437	0.159	0.670	1.244	2.350	1.257

The z-critical value is 1.97 and there is a statistical difference for the 'appreciation' proportions. It drops dramatically after NCLB is introduced. All the other values, while not different in a statistical sense, clearly show that other purposes become larger, the greatest changes again being in 'educated', and 'literacy', purposes clearly in mind when accountability is now a major expected outcome.

One can conclude that descriptively the overall proportions are fairly constant over time but the recent NCLB introduction has caused the leading purpose for an astronomy course to drop dramatically, with the other, more 'accountable' purposes gaining.

Content, Course Length, Frequency

What is taught in these astronomy classes, and how much time is given for a course? The answers were put into a set of matrix tables (Tables 9a-c) comparing content versus time length. Choices for content were Solar System Astronomy, Stellar Astronomy, or Both. (Teachers added a few Unknowns). Courses are usually semester or year long, but some other types appeared in the Other option given to respondents

Table 9a

Course Content and Durations for Private Schools

Semester	Year-Long	Other	Totals by Content	Course Content
3	0	0	**3**	**Solar system only**
2	0	0	**2**	**Stellar Astronomy**
13	9	2*	**24**	**Stellar and Solar System**
1	0	0	**1**	**Unknown**
19	**9**	**2**	**30**	**Totals by Time**

* Durations include 1 trimester and 1 two-trimesters.

Table 9b

Course Content and Durations for Public Schools

Semester	Year-Long	Other	Totals by Content	Course Content
6	1	2*	**9**	**Solar system only**
8	11	0	**19**	**Stellar Astronomy**
95	67	13**	**175**	**Stellar and Solar System**
3	0	1	**4**	**Unknown**
112	**79**	**16**	**207**	**Totals by Time**

* “9 weeks” and “half year”

** quarters, ‘9 weeks,” half semester, 2-trimesters, “marking period” and unknown durations

Table 9c
Course Content and Durations for All Schools

Semester	Year-Long	Other	Totals by Content	Course Content
8	1	3	**12**	**Solar system only**
10	13	0	**21**	**Stellar Astronomy**
109	73	14	**199**	**Stellar and Solar System**
4	0	1	**5**	**Unknown**
131	**88**	**18**	**237**	**Totals by Time**

In both private and public high schools, semester-long courses rule. Private schools use them 63% of the time (n = 19) whereas public high schools use them less, 54% (n = 112). The other 46% of the public high schools split between mostly year-long (n = 80) and for Other (n =16) durations. The latter are predominantly times of approximately the same length but labeled as quarters, 9 weeks, half semesters or marking periods. A very few schools use trimesters or did not say what their course durations were. At the private schools, the split among the remaining durations is similar proportioned, 8 year-long and 2 other periods.

The overall number of schools on traditional periods outnumber the schools on block, 51% to 41%, but in public schools periods wins over block only by 48% to 44%. Private school numbers are 77% versus 23%. Eight percent (8%) of all schools are still on some other schedule, such as trimesters, quarters or 9-week marking periods.

When courses are taught on a semester basis, periods are slightly more common, 72 versus 50. When taught on a yearly basis, periods barely get past block structure, 45 versus 36. When taught on other durations, such as quarters or trimesters, it is almost exclusively a form of block, 11 out of 18 schools.

Teaching both stellar and solar system astronomy in the same course is by far the most common descriptor used. In private schools, this situation exists for 24 of the 29 schools, which corresponds to an 83% of all private schools. The public schools are comparable, 176 (out of 204), or 86%. It would be safe to conclude that the majority of all schools teaching high school astronomy teach the universe in one single course, and it is slightly more likely (55%) to be a semester-long course.

Some schools do specialize the ‘general’ course into just solar system astronomy, or just stellar. Solar system classes are found in 11% of private schools and 4% of public schools, but stellar astronomy class numbers are closer, 9% public versus 7% private. Stellar courses by raw count easily outnumber the solar system classes, 21 to 12. One can conclude that if a single astronomy course is offered, and it is specialized, it will mrore likely be a stellar astronomy course, which has about a slightly better than 50-50 chance at being year-long (13 year-long versus 10 semester-long). If the first course is a solar system course, it is almost exclusively done on a semester-long basis.

A small percentage of courses are not run on either a semester- or year-long basis. This 7.6% group consists mostly of schools on a 9-week/half semester/quarter/”marking period of 9 weeks” basis. The few others are durations of a trimester (12 weeks) or 2 consecutive trimesters.

Examining the course frequency gave unexpectedly confusing results. For private schools offering semester-long courses, the most popular frequency is yearly (n = 10). The choices “every semester” and “fall semester” were chosen 3 times each. It is probably safe to say that a semester-long course is most often taught in the fall semester every year but rarely in the spring. Year-long courses are only offered yearly, all must start in the fall.

Public schools offering semester-long courses are even more confusing. An equal number (*n* = 33) offer it every semester, and every year. The spring-only and fall-only choices are equally matched as well, *n* = 6. One might conclude that about 2/3rds of the students can take it in the fall, but only 1/3rd of all students have a chance in spring. Given the vagaries of observing weather during the first three months of the calendar year, this is the most likely scenario. The great majority of the year-long courses are offered yearly (*n* = 54). A very few listed themselves as every semester but it seems unlikely that a course would start in January and end the next December.

There are a few other course frequencies noted. A few were simply irregular, one was every 3rd semester, one was by the trimester, one every trimester, and one school listed it as in “alternate years” and one stated it was offered 2 out of 4 quarters. Enrollments play a small factor, sometimes the course is offered but doesn’t make but this seems to be only in a few schools.

It seems safe to conclude that if offered yearly, it will be offered every year; if offered as a semester length, it will be offered virtually every fall by all, and up to half of those schools may offer it in the spring as well.

This situation then allows those schools with fall-only courses to offer a second astronomy course if they wish. Examining the course frequencies for the 36 second-course titles given us, 17 of them (47%) are offered yearly and 6 others are offered every spring.

The remaining approximately one-third are schools where second courses are offered every semester (2 times) and those that offer it as year-long second courses yearly (in the fall, obviously) but only when there is enough demand (3 times). The remaining choices run the gamut of: every trimester, every spring trimester, every year but the quarter varies, irregularly, a trio of second courses in one school offered on rotation through the fall semesters of three years, every other year, and in the summer.

Course Names

Table 10
Alternative Course Titles for First Astronomy Courses, Besides "Astronomy"

Geoscience or Space Science Course Titles	Physics or Astrophysics Names
Earth and Space Science (2)	Advanced Physics-Astronomy
Earth Space Systems – Other, Astronomy	Astrophysics/Atmospheric Physics
Topics in Earth and Space Science-Astronomy	Astronomy-Astrophysics
	Astronomy and Modern Physics
Honors Earth Science – Astronomy	Physics-based Astronomy
Astronomy/Geology	Astrophysics
Space Science I	
Space Science (no number) (2)	Observational and Topical Astronomy Titles
Astronomy and Space Science (3)	Observational Astronomy
Physical Earth Science	Planetary Astronomy
	Naked I Astronomy
Astronomy by Any Other Name	Planets
Astronomy 1 (10)	Solar Astronomy
General Astronomy	Introduction to Planetariums
Introduction to Astronomy (10)	
Astronomy I-IV	Physical/Integrated/General Science Titles
Astronomy Level I	Integrated Science 1
Astronomy, Regular and Honors	Physical Science – Astronomy
Astronomy Elective	
Exploration of the Universe	Advanced(!) First Course Titles
Astronomy College Prep	Honors (5)
Introductory Astronomy	Advanced Astronomy
Astronomy A and B	Junior /Senior Astronomy

It is interesting to look at what the courses are named. Simplistically, 74% call the course "Astronomy" regardless of the content area. The rest use other titles; the alternative names are shown in Table 10. The titles show up only once except for those with numbers following in parentheses.

Nearly half use a truly astronomical alternative, with fully a third of all schools using "Astronomy 1" or "Introduction to Astronomy." The only other large category is that of names in the course areas of geosciences or space sciences, where 13 schools use titles involving Earth or Space. The number of physics-related titles used is only six.

Few schools are able to offer a second astronomy course, overall only 15%. Most of those numerically are in the public high schools, as might be expected (n = 27 versus n = 9 for private schools). On a percentage basis, however, private high schools are more likely to offer a second or follow-up course, 24% versus 11%.

The next question is, "what are the titles/topics of those follow-up courses?" As might be somewhat expected, the leading title was … "Astronomy II," in six of the 36 listings. Some of the titles repeat those of the table above, such as Earth and Space Science, or Honors Astronomy. The "Logical" and "Higher Level" groups clearly dominate numerically, and there is a similar relative distribution between Geoscience and Physics titles (giving support to the idea that more people and interest in astronomy is now coming out of the Geoscience camp instead of the traditional Physics), but there are at least a glimmer of hope in how many schools follow-up with real science research courses.

Table 11.
Course Titles for Second/Follow-up Astronomy Courses

Logical Follow-up Titles
Spring Astronomy
Introduction to Astronomy II
Astronomy 2/3
Astronomy II (6)

Topical Astronomy Follow-up Titles
Galactic Astronomy
Stellar Astronomy I
Planetary Astronomy

Research Based Course Titles
Astronomy Research (Uses NASA data sets)
Research in Science
Astronomy – Advanced Level Independent Study
Senior Research in Astronomy

A Higher Level…of Astronomy Titles
Junior/Senior Astronomy
Accelerated Astronomy
Honors Astronomy
Advanced Topics in Astronomy
Advanced Astronomy (4)

Geoscience/Space Science Related Titles
Astronautics
Space Science 2/3
Earth Science
Level I Earth/Space (short astronomy unit)
Earth and Space Science (2)

Physics Related Titles
Modern Physics (quantum and relativistic physics and cosmology)
Cosmology and Particle Physics
Earth, Space and Physics

Sounds Like a First Course…Titles
Introduction to Astronomy

Prerequisites

What does it take to get into an astronomy course? For 26% of the responding high schools….nothing, there are no prerequisites (n = 62).

Of the remainders, the most favored requirement was one science course completed, preferably with a C or better but sometimes at least a B (n = 38). Next comes one math course, with similar requirements (n = 27). Usually it is Algebra 1 or Geometry, but sometimes the one class has to be Algebra 2 or Trigonometry. Overall, 54% had a math, science or math+science requirement (Table 12a):

Table 12a

Prerequisites for an Astronomy Course.

Number of Sciences	No math	1 math course	2 math courses
No science	62	27	6
1 science	38	15	---
2 science	22	5	---
3 science	10	1	---

While passing a certain number of courses is a de facto grade requirement, 11% of the courses had explicit grade level prerequisites, mostly having to the student be a junior or senior. Five schools had sophomore requirements and only one made it a senior-only course. Nine of those junior/senior requirements were JUST grade level. Eleven others were grade level plus some math or science requirement (but not both). Sometimes the science course had to be concurrent. Two schools in one state (New York) also required Junior/Senior status plus passing the Regents Exam with a certain minimum amount.

There were 10 other requirements that did not fit into either science/math or grade level requirements. They reflect an interesting spectrum from extreme passing marks to extreme failing marks, and things in between (Table 12b):

Table 12b

Miscellaneous Prerequisites For Taking Astronomy Courses

Pass 4 science classes	Be in Algebra 2 or trigonometry
Pass 3 College prep classes	Complete all core science classes
An "A" grade in your previous English, math and science course + pass the state high-stakes test.	Be in physics with C or higher
Pass freshman science OR be a junior	One science plus pass the state's high-stakes examination
Pass Honors chemistry	You had to have a 60 or less in Earth Science.

Bottom line: to take astronomy, most schools require at least some previous science class, a lesser amount require just some math class, a minority require at least one of both, or at least upperclassman status. But one in four schools require no prerequisites.

Class Enrollments

What is the average class size? A tabulation of how large the current section sizes was made. The statistics are as follows (Table 13a-b):

Table 13a
High School Class Section Sizes

	Durations					
	Public High Schools			**Private High Schools**		
:	Semester	Year	Other Durations	Semester	Year	Other Durations
average	22.6	23.3	21.4	17.9	15.7	6.5
S.D.	7.2	6.4	7.5	6.4	6.0	6.4
median	23.5	23	23	17	15.5	6.5
count	110	70	18	19	6	2

Table 13b
Class Section Sizes, Overall Summary

	Public High School	Private High School	All High Schools
Average	22.7	16. 6	22.0
S.D.	6.9	6.8	7.2
median	23	17	22
count	198	27	225

There is little difference among public high schools, whether semester, year or trimesters or any other course duration. The average class size is about 23 students. It is six students smaller in the private high schools. The sizes of astronomy class sections for the two private high schools on other time-scales are dramatically smaller.

What trend does the size of student enrollment have? The five-years-apart High School Transcript studies of the National Center for Education Statistics has shown a small but relatively steady trend from the 1980's up through the 2001 release, rising to 2.5% of all students. The raw numbers of students taking astronomy may be growing simply because of an increasing population. An increasing percentage would indicate that more students have found some reason to take an astronomy course. The Condition of Education 2007 (NCES, 2007b) gives the value to be 3.3% of all students, in 2004-05. Compare this with physics (35%), chemistry (60%) and biology (over 90%), values also given in the Condition report.

It is also possible to add up all the students of our teachers in the survey and all the students in the school and derive a minimum percentage of students taking the course. The survey counts up 9307 possible students out of a total estimated population of 345,277 students. This is 2.7% of the enrollment…but any other instructors' student counts are not known, just those who were surveyed. Given the average number of teachers per school of 1.31 (calculated in a later section) and assuming the average number of sections and class averages holds for them, this raises the percentage of all students that take a high school astronomy course to 3.5%.

This survey investigates this trend with two parameters. First, teachers were given a choice of selecting "growing," "steady" or "declining" as a descriptor of their perceptions of the trends of enrollment in their astronomy classes. Elsewhere they were asked to give the average over time of their section enrollments, and the actual enrollment of their most recent class.

A matrix of trend descriptors and course type is given as Table 14. (The Course Descriptors are described in the next section). The results look encouraging. The Steady descriptor leads in the three largest groups, the U, M, and A courses, by 2 or 3 to 1. The second highest numbers are in the Growing descriptors for U and M. Overall, Steady leads by a nearly 2:1 factor over Growing, which in turn is 3.5 times greater than Declining.

Table 14
Trends by Course Descriptor and Course Type

Course Type	**No trend term**	**Declining**	**Steady**	**Growing**
(U)pper Grades	13	14	92	49
(L)ower Grades	0	1	3	4
(M)edian Grades	1	2	21	12
(A)ll Grades	2	2	6	2
No enrollment numbers given	2	1	3	3
Grand Totals	18	20 (9%)	125 (58%)	70 (33%)

But to check the respondent pool, data from those schools that provided both descriptors, averages and current enrollment numbers were examined. Only 183 schools gave all three data. On that basis, using the percents from the table above, it should be expected to find 60 growing, 106 steady and 16 schools with declining enrollments.

In truth, when comparing the actual numbers against the stated trends, our respondents are overly optimistic. The actual counts of schools enrollment trends using enrollment numbers compared with the descriptor counts are in the Table 15 below.

Table 15
Trend Comparisons, Descriptors and Actual Enrollment Numbers

Source of count	Declining	Steady	Growing
Descriptors	20	125	70
Enrollments	73	72	42

The 125 Steady descriptors actually include only 47 with numbers equal in average and current enrollments. Forty eight more of these schools' enrollments were not Steady but Declining, which was not balanced out by the 16 schools that were listed as Steady but actually grew.

The Growing schools numbers dropped from their stated 70, and 60 expected; only 25 had numbers that matched their descriptor. Twenty-one were not Growing but Steady, and ten were headed in the opposite direction.

Declining school numbers were the only ones on target with the stated trend. Twenty were originally claimed, 16 expected and 15 actually matched their descriptors. Four schools said to be Declining actually were Steady and only one school was Growing.

It may appear that the enrollment trend in astronomy has reversed its recent decadal behaviors, at least since 2001. This may give evidence that some outside factor has affected the number of students taking astronomy or there may be also have lower individual class sizes but more students in more schools overall. As shall be seen further, there is a hidden mass of teachers and students that may affect this number and trend. What may really be happening is that there is overall growth, but a peak in classroom average sizes just prior to 2001 and overall growth is still overcompensating for shrinking class sizes.

Course Existence Factors

Why does the course exist in the first place? To answer that question, respondents were asked who created the course, themselves or someone else. Then they were to give one of eight possible answers, two of which were 'Unknown" or "other." (Blank answers were included as Unknown in the analysis.) It is also probably safe to say that if the 'creator' answer was blank, i.e. unknown, it wasn't the teacher who did it. Tabulations are in Table 16.

Table 16
Justifications and Course Creators

Justification	Teacher created	Someone else created	Unknown creator
Students demanded a course	9	8	0
Personal interest in creating a course	41	12	2
External factors	0	1	0
Easier electives	18	10	1
Administration wanted one	12	5	2
More/advanced courses wanted	13	15	1
Subtotals	**93**	**51**	**6**
Reasons unknown	27	18	1
Other reasons	15	22	1

By a factor of nearly 2:1, current courses have been created by the teachers surveyed. If the justification given does not depend on who created the course, the numbers should be proportional. Some are, especially when the "unknown creator" is added to the "Someone else created" numbers, since someone *had* to create the course even if that person was not known to the current teacher! But the number of 'personal interest" numbers for "Someone else" is too low by a factor of two. This more likely reflects a lack of personal knowledge of the previous teacher, whether because the course had been on a hiatus or went all the way back to the Cold War doesn't matter. The number of "students demanded a course" for either forms of course creation are low and belie a common bit of advice to use student demand to "drum up business" for a course. It can't hurt but it is not a primary tool for *creating* a course, historically. That doesn't necessarily hold for *supporting* an ongoing course.

What seems to be the primary tools for course creation are: personal interest of the teacher, and an administrative desire for more science electives. The latter is evenly split between wanting more advanced or second courses, or wanting easier courses. For current teacher created courses, "personal interest" alone accounts for 44% of the number of courses offered, compared to "easier/advanced courses"/"administration requests" combined (46%). The same categories less balanced, 23% and 59%, respectively, for courses created by someone else. Since it appears that the 'someone else' is often an administrator, this indicates more readily how teacher and administrator viewpoints on creating an astronomy course differ.

All other justifications are minimal. For example, although it was suggested that some external influences might cause a course to be created, such as local cultural backgrounds (i.e. Native American cultures, rural dark skies, space industries), this seems to be a non-issue. Two teachers mentioned the Cold War being a reason for the building of their planetariums and one said it came into existence when a dome was donated to the school but otherwise no other external factors are mentioned.

There were places where more detailed answers on the justifications could be written, free-form. It is of interest to look at what new justifications may have been found (Table 17), and how often more detailed answers explaining the six primary reasons were used.

The two biggest 'others' are related to the various needs for additional courses, not 'first courses ever', and planetariums. It is a surprise to see how the latter is such a popular "other" reason are in this study. Though the number of planetariums has decreased over the years, and some respondents elsewhere comment on the closing of planetariums or observatory domes, it is possible even for half-time planetarium directors to cause a high school astronomy course to come into existence, or keep one going. If a community feels the planetarium is valuable, there

Table 17
Details on Justifications.

General Justification / Specific Justifications	Course created by teacher	Course created by someone else
Need more courses:		
Senior electives beyond Bio, Chem. Physics	3	--
More non-bio electives	2	2
More electives, general	4[a]	--
Lower level electives	3	4
Second chance courses	1	--
Demand for a more contemporary science course	1	--
More Non-AP courses	2	1
Need for an integrated course	1	--
Need for a completion or culmination course	2	1
Totals	**19**	**8**
External factors		
Cold War	--	3
Dome donation	--	1
Keep students who take astronomy elsewhere, taking their scores to other school	--	1
Totals	**0**	**5**
Planetarium existence		
Have planetarium in school	10	--
Have planetarium they use in district	4	--
Recent rebuilding/addition of planetarium	4	--
Enlarged role of plm. Director job	1	1
Totals	**19**	**1**
Course upgrade or renewal	4	1
Totals	**4**	**1**
State or district objectives or requirements	2	4
Totals	**2**	**4**

Table 17 (continued)

General Justification Specific Justifications	Course created by teacher	Course created by someone else
Science topical course needs:		
A way to get more earth science course credit	2	--
Splitting larger course Earth Science into 2 or more topical courses	2	1
Fulfill physics requirements	--	2
Expansion into honors level course from regular course interest	1	--
Totals	**5**	**3**
Proposals for special purposes	2[b]	
Totals	**2**	
Other		
Principal was an astronaut	1	--
Student interest	5[c]	1
Fulfilled a grant requirement	1	--
Response to flagging science interest	1	--
Qualifications of teacher better suited to astronomy	3	--
Accommodate special needs	--	1
Students can do real research		1
Equivalent in value to Bio, Chem, Physics	1	--
Totals	**12**	**3**

Note: some teachers list more than one "other" justification, hence the numbers do not match the previous table. Plm = planetarium
a – 1 - need for more diverse course offerings and to improve ACT scores, 1 – need for more quarter (course duration) science courses to fill schedules, 2 – general *b* – One school justified a course as needed to make the school into a Natural Science Academy. Another justified the course to make the school into a science magnet school. *c* – One teacher used his/her physical science students higher interest in astronomy over physics and chemistry units to create a new course, another teacher found there was high interest in alternative science courses in general.

will almost certainly be a course regardless of AYP status. It is very odd, and without explanation, that all the planetarium comments are from teachers who created a course, and none from planetarium instructors who inherited a facility.

The aforementioned 'external factors' appear to be primarily a factor for older, long-existing courses.

A few of the 'other' reasons bear close reading for people who need to justify their courses or course initiations. Creating special schools of science is one way to get an astronomy course going. If all science courses are losing enrollment, an astronomy course might reverse that trend. Splitting longer courses into several smaller courses seems to be a valuable possibility, especially in Earth Sciences and Physical Sciences, but not Physics. Finding a course in hiatus and updating it seems a good way to get one step ahead as well.

Standards and Required Status

If a course is to be viable it needs to have standards (this is shown more fully in the qualitative questions to be examined later on). Almost all states have standards—somewhere—that include astronomy concepts. There are many standards at the elementary and middle school level, and at the national level. High schools are a different story. For example, it is known that Georgia's Performance Standards (GPS) at the high school level have precisely one astronomical standard in any course, and there are no standards for a specific astronomy course at the time of this writing, though an effort to make them was later initiated post-dissertation writing. There used to be standards for a course, though, under the Quality Core Curriculum (QCC), the previous set of standards. Some teachers in Georgia stated they are using the old QCC standards anyway. Exactly where the standards are being drawn from for Georgia or any other high school in any other state, though, is beyond this study.

Only a few teachers in the survey said there were specific state standards for an astronomy high school course. Despite that, quite a few states in the survey seem to have enough standards for their course, but whether that was from a course-specific listing or pulled together from other course standards can't be determined. Unfortunately, the survey question did not apparently distinguish well between the two options of actual astronomy course standards versus pulling standards from various other courses.

Twenty-seven states in our survey (about two-thirds of all the states with at least one respondent) list at least one teacher claiming to have state standards behind their courses. Several states clearly must, as there are comparatively large numbers of teachers making the claim. Five specific states, Texas, California, Florida, Illinois and New Mexico had both a large individual number (3 or more) of respondents claiming to have standards for their courses and more than 50% of the total number of respondents from the state. Pennsylvania, Wisconsin and Michigan were at the 50% mark and with five or more respondents with claims.

Of the 237 schools being studied here, only 7 were found that stated that astronomy was a required course, only two of these were private schools! The rest were public high schools. The sizes of the seven range from 57 students to 3200 students so size is no clue as to why they are required classes. But three were in Pennsylvania, three in the Midwest, and only one in the south, Florida. This bears re-examination in any future surveys.

Characteristics of the Students

Who takes the astronomy class? To answer this, teachers were asked to give the enrollment counts for their most recent astronomy class by grade level, by gender, and by race/ethnicity.

Class Levels

First the values at the grade level are examined. For those schools that provided grade level numbers, they have been categorized into four groupings:

- Upperclass Course (U) are those where the highest and second highest enrollments are junior and/or senior levels.
- Underclass courses (L) are those where the highest and second highest enrollments are freshman or sophomore levels.
- All Levels (A) are represented by all four grades at roughly similar counts.
- Median Classes (M) are those where the highest two levels are sophomore and junior, or are courses population by three sequential grades (9,10 and 11, or 10,11, and 12) in which all three are relatively equal amounts or the third 'outside' level is at least comparable to the second highest. For a median class, it might have a representation of, for example, 15 seniors, 12 juniors and 8 sophomores. An Upperclassmen course might have 15 seniors, 12 juniors and 2 sophomores. Those last two sophomores clearly are an exception for perhaps some brighter than average pair of students whereas the median class has a flatter distribution where juniors and sophomores are more equally distributed. Therefore the two sophomores don't change this into a Median Class.

The number of students by grade level from 225 schools is available. The distribution of courses is listed in Table 18.

Table 18
Number and Percentage of Schools by Course Level Type

Course Type	Number of Schools	Percentage of the Survey (based on 225)
U	168	75
L	8	4
M	36	16
A	12	5

Clearly most of the high schools use the astronomy course as a capstone course and very few use it as a replacement for a general, introductory or integrated science course for students before they proceed into the usual biology, chemistry and physics sequence. The number of schools that may use the course as a general elective for all or most of the school, the M + A groups, are a substantial second place, 21%.

Student Abilities

The impressions of student abilities by the teachers do not show much. The upperclassmen courses and the Median courses show essentially the same percentages of perceptions of academic abilities, with average and mixed being the highest values. Combining the All classes and Lowerclassmen numbers shows that the perception is that there are fewer higher ability and average students and more lower ability students in those groupings. As there is usually some algebra and science critical thinking skills required in most astronomy classes, the lower grades of high school will see fewer students with enough prior knowledge, hence a perception of less ability (Table 19a)

Table 19a
Ability Descriptors by Course Type

Ability	**Upperclass**	**Median Class**	**Underclass + All grades allowed**
High	28 (19%)	6 (19%)	2 (11%)
Average	64 (43%)	15 (48%)	5 (26%)
Low	7 (5%)	0 (0%)	4 (21%)
Mixed	36 (32%)	10 (32%)	8 (42%)
Unknown	1	0	0
Totals	146	31	19

Looking at the abilities across the various minority status categories, no differences between the Low Minority and the Minority/High-Minority categories are found (these are defined just below). The only different group is the "Representative Diversity" group that which mimics the national average demographics by race and ethnicity. This category is lower in the high ability percentage and more average. Average is average—to be different is to be different (Table 19b).

Table 19b
Ability Descriptions by Minority Status

Ability	**High-Minority/Minority**	**Representative Diversity**	**Low Minority**
High	6 (18%)	4 (8%)	25 (25%)
Average	13 (39%)	30 (63%)	31 (31%)
Low	3 (9%)	2 (4%)	5 (5%)
Mixed	11 (33%)	12 (25%)	40 (40%)
Totals	33	48	101

In short, this question generates no great new or useful information but the analysis is included for completeness.

Gender and Racial/Ethnic Demographics

In regard to gender, the counts given for male and female students were added up: there were 4230 males (53%) and 3739 females (47%). A 2005 AIP study (Hehn and Neuschatz, 2005) indicated that female physics students numbered 47%. Female astronomy students number the same. Nationally, the nation is 49% male (U.S. Census Bureau, 2000b) so there may be a small gender gap in astronomy courses.

Racial/ethnic demographics were examined as well. Besides a general interest, it is also of interest to see how astronomy is faring in 'minority' schools. But what definition should be used for the term 'minority school'?

The most recent census figures (U.S. Census Bureau, 2000) give the following data for overall national racial demographics: White 75%, African-American/Black 12%, Asian 4%, and Others (including Native Americans, Pacific Islanders, Bi- or Multiracial) 9%.

The ethnic descriptor Hispanic can include members of any race. The overall percentage of Hispanics in the United States is now 15%. However, the distribution of all races and Hispanics is not even throughout the whole 50 states. Table 20 indicates our survey counts and percentages with tests of proportion results.

Table 20
Racial/Ethnic Demographics for Survey Students, and Results of Test of Proportions

	Race/Ethnicity				
	White	African Americans	Asians	Hispanic	Other
Number	5662	571	278	609	178
Percentage in Survey	77%	8%	4%	8%	2%
z values	0.757	1.899	0	3.024	3.774
p values	0.45	0.06	1	0.003*	< 0.001*

* = statistically different at alpha = 0.05.

Tests of proportions between this survey's student counts and the census values indicate that there is a small statistical difference between the Hispanic and Other counts; there are apparently fewer in astronomy than expected, the reason is unknown.

This is dramatically different from studies of physics classes. The 2005 AIP study by Hehn and Neuschatz (2006) has 36% White, 23% African American, 48% Asian, and 24% Hispanic. Tests of proportions *p*-values are all less than 0.001 for each group. Astronomy classes are far more reflective of the national population than physics classes.

Are there any differences because of a school being a 'minority' school? First needed is a definition of a 'minority' school! The only definition that all states and the federal government seem to agree on is that any school that is 50% or more "non-white" is a minority school. The classification is further refined by the terms "high-minority" and "low-minority." In general, a high minority school is also any school that is 50% or higher non-white, because the number of schools that have those percentages equal the fourth or highest quartile of minority schools. The logical definition would therefore be that a low-minority school would be that of the first quartile or those with the least percentage of non-whites. The NCES uses: 0-6%, 6-20%, 20-49, and 50 and higher for four different 'minority' level groups.

A common, alternative definition of minority school, delineated for example by the Washington State Government (2006), is one in which one racial or ethnic sub-group is 20% higher than the (usually, local or district) normal percentage. This would mean any school that is 32% African American or 35% Hispanic (using national figures) would be a minority school even if most of the students are still White.

Table 21

Definitions of Different Levels of 'Minority'

High minority (H)	Any school 50% or higher non-white total or individual subgroup
Minority (M)	Any school 35% or higher non-white total, or 35% Black or Hispanic, or 25% Asian or 29% Other
Representative Distribution (No code letter, or Rep.)	Any school that is between 15% and 35% non-white or no subgroup is higher than the 'minority' percentages
Low minority (L)	Any school 15% or lower non-whites.

A school that reflects national figures should be considered a demographically representative school. Given that the first quartile values are about 20% lower than national parameters and high minority definitions fall near the start of the fourth quartile values, 25%

higher than national parameters, that the second quartile to median range is only 10% different, this study uses the following definitions (Table 21):

When the ethnic/racial demographics are given by the respondents, their classes were then coded into these four groupings. The results are interesting (Table 22a).

Table 22a
Number and Percentage of Different Types of 'Minority' Schools

Type of minority status	Number	Percentage*
H	27	13%
M	14	7%
Rep.	61	29%
L	111	52%
Unknown	24	

*Percentage is derived after removing unknowns.

Logan, Oakley and Stowell (2006) used NCES data to create a table in 10% bins of the percentage of white students who go to school in various levels of minority existence. Using the same definitions as above, their data would give the following percentages of schools with those amounts, followed by this survey's percentages alongside (numbers do not add up to 100% because of rounding) (Table 22b):

Table 22b
Proportion of Schools per Minority Status Level, This Survey versus National Values

Type of Minority Status	Minority Share	Logan et al value	This survey
H	51% or greater	11%	13%
M	35% to 50%	10%	7%
Representative	15% to 35%	25%	29%
L	0% to 15%	54%	52%

Proportion tests (Table 22c)on all four minority status groups fail to give any statistical differences.

Table 22c
Proportion Text Results Comparing This Survey and National Values for the Number of Different Minority School Types

	Minority Types by Code			
Test values	H	M	Rep.	L
z	0.986	1.543	1.425	0.619
p values	0.324	0.123	0.154	0.536

The 2003 Condition of Education report (NCES, 2003) gives five unequal brackets ranging from minority percents of 0-15%, up to one of 75% and more, for the school year 1999-2000. Adapting it to our nomenclature (interpolating between the bracket values) the L group is about 50%, Representative is 19%, Minority 9%, and High Minority 22%. The NCES is much higher in percentage than Logan et al. for the high minority values, and lower for the Representative values; however, these NCES brackets are wider than Logan's finer ones so this study will use Logan's values.

It can be concluded that the differences are not significant and that the survey population is representative of all schools. This further strengthens our various conclusions.

The schools that are minority or high minority are interesting to examine. There are 41 schools in those groups together. Examining the class makeups indicates that 10 of them are made a minority (or high-minority) school by no particular ethnic or racial component but by their overall higher than mean numbers. Out of the remaining 31 schools, 16 (50%) are due to Hispanics being more than 35% of the class. Nine schools (28%) are due to a larger number of African-Americans, five (16%) by Asian groups, and one by Other.

These schools were filtered out and examined separately. They are located all over the country but the largest number of schools were in Texas (6), with California (3) and New Mexico (3) the next highest states in count. The sample is far more public (29 to 2, or 14.5:1) than the survey's 208 to 29 (7.3:1) ratio but that probably may be expected. The Pass versus Needs Improvement ratio is smaller, 17 to 7 or 2.4:1 versus 4:1 amongst the whole survey. Fail schools are represented as 29% of the minority schools whereas minority schools as a whole were 20% of the survey's entire pool.

One final check: are the demographics of the classrooms similar to the schools'? School racial/ethnic/gender data were obtained for 11 schools, those of the people who were first interviewed before the survey was put on the Web. School totals from the teachers generally corresponded with the numbers obtained from the Web. Because the class numbers could be quite small, it was possible only to do minority/not-minority and male/female comparisons.

For gender, Table 23a has the given class values, the school values and the statistical calculations for the eight schools had both school and class numbers. Only one out of eight classes has a statistical difference (more females than expected).

Table 23a

Gender Demographics in Selected Schools

Class male	Class Female	Class size	School Males	School Females	School total	*p* values	Chi-square values
10.5	10.5	21	690	711	1401	0.945	0.005
15	9	24	739	745	1484	0.214	1.549
15	15	30	919	977	1896	0.867	0.028
10	22	32	802	712	1514	*0.014	6.061
8	8	16	1084	1038	2122	0.931	0.008
70	70	140	1957	1838	3795	0.710	0.138
25	25	50	1623	1571	3194	0.908	0.013
20	30	50	1606	2386	3992	0.973	0.001

*p is significant.

Racial and ethnic comparisons are in Table 23b. It is possible to only test White versus Non-White (Minority) because of the small numbers of students in the classes. Here only one out of 10 classes is statistically different from the school demographics.

It can be stated from this sample that the class demographics are probably not greatly different overall from the schools' demographics in our survey.

Table 23b
Racial/Ethnic Demographics for Selected Schools

Class Whites	Class Minorities	School Whites	School Minorities	*p* values	Chi-square values
10	4	769	219	0.564	0.333
15	6	1165	236	0.147	2.099
20	4	1336	148	0.274	1.198
18.5	11.5	1312	584	0.372	0.798
24	0	439	62	0.066	3.390
28	4	1322	192	0.975	0.001
3.5	4.5	1405	717	0.179	1.804
112	28	3340	455	*0.004	8.514
17	38	1523	2469	0.269	1.223
43	2	851	50	0.746	0.105

**p* is significant.

The next question to examine is "Is there any correlation between AYP status and minority school status?" Both pieces of data were supplied by 66% of the survey's schools and the counts shown in Table 24.

Table 24

Counts of Schools of Different AYP Status by Minority Status

Status	Low Minority	Representative	Minority	High Minority
Pass	66	38	6	13
Needs Improvement	13	7	3	5
Fail	1	3	1	1

Again, because of low cell counts in the table, this has to become a 2 x 4 matrix on minority status level versus Pass/Not Pass for a proper statistical test. Since NCES figures indicated that there was a 60-40 split in Pass/Not Pass for the nation, a Chi-squared test was performed, with the expected values below (Table 25a).

Table 25a

Expected Proportions of AYP Pass/Not Pass by Minority Status*

	Minority Status			
AYP Status	Low Minority	Representative.	Minority	High Minority
Pass	48	28.8	6	11.4
Not Pass	32	19.2	4	7.6

*Not Pass = Sum of Needs Improvement plus Fail counts

The Chi-square value equals 24.78 ($df = 3$, $p < .001$). This survey pool of schools does not follow national norms. Examination of the individual cell Chi-square contributions indicates that the differences are almost entirely with the Low Minority and Representative groups (Table 25b). Minority and High Minority schools are very close to the U.S. norms for Pass/Not Pass rates. Individually the Pass rates are (L) 82.5%, (Rep.) 79%, (M) 60%, (H) 68%, and the aggregate Pass rates are Minority (66%) and Non-minority (81%).

Table 25b
Chi-Square Cell Values for The Test of AYP Status and Minority Status

AYP Status	Minority Status			
	Low Minority	Rep.	Minority	High Minority
Cell Values AYP Pass	6.75	2.939	0	0.225
Cell Values AYP Not Pass	10.125	4.408	0	0.337

More minority schools are on year-long courses, the opposite of the entire pool of responding schools; the ratio of schools on periods versus block is similar to the pool. A larger percentage, 84%, of the classes are upperclassmen oriented, versus the pool's 75%.

Between these three facts (AYP rates, course durations and grade levels), one might conclude that minority schools could do better at AYP if they are on semesters rather than years.

Facilities, Classroom Materials, Operations and Budgets

Textbooks and Curricula

The teachers were asked what textbook or commercial curricular packages they used. They reported many titles. The textbook most often used is Astronomy Today by Chaisson and McMillan (*n* = 51), nearly a quarter of all teachers. At least three editions are being used, 3rd through the current 5th. Second most often used is Michael Seeds' Foundations of Astronomy, 21 teachers. When explicitly stated, all editions from 4th to (current) 9th (except edition 5) are in use. Others with double digit counts are Comins & Kaufman's Discovering the Universe (*n* = 15) with editions 5, 6 and 7 (current) mentioned, and Arny's Explorations: An Introduction to Astronomy (3rd and the current 4th editions, *n* = 11), Cosmic Perspective by Bennett et al, (at least one 3rd edition in use, current is 4th – 2007, *n* = 10) and Astronomy, a Beginners Guide to the Universe by Chaisson and McMillan (4th edition mentioned, 5th out in 2007, not possible to know if it is being used at this time) with 10 users. Everyone of these is a college text, with readabilities generally grades 14 and up, and rarely as low as grade 12. (Edition information and readability are all due to Bruning, 2007, and personal communication).

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 Hewitt et al's Conceptual Physical Science.

Table 26a lists other titles named from one to five times (the citation research is left to the reader for these and all the following titles) include:

Table 26a
Textbooks Used in High School Astronomy Courses

21st Century Astronomy (Hester et al.)
Astronomy – The Cosmic Journey (Hartman & Impey)
Astronomy, a self teaching Guide (Moche)
Astronomy, the Evolving Universe (Zeilik, 8th edition at least)
Astronomy: Journey to the Cosmic Frontier (Fix)
The Cosmos: Astronomy in the New Millennium (Pasachoff & Filippenko)
Discovering the Essential Universe (Comins)
Dynamic Astronomy (Dixon, 1984!)
The Essential Cosmic Perspective by Bennett et al (abridged version of the Cosmic Perspective textbook).
In Quest of the Universe (Kuhn and Koupellis)
Understanding the Universe (Seaborn, 1998)
Universe ([Freedman and] Kaufmann)
Universe (Snow and Brownsberger)
Universe Revealed (Impey and Hartman, 2000)
Voyages Through the Universe (Fraknoi, Morrison and Wolff)

Schools that used a textbook tallied 178, despite many complaints that there weren't any good high school astronomy texts. That still may be so; many of the above are used at the college level. 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 doesn't list them) are college level, so the situation hasn't changed much.

A number of titles were also mentioned as supplemental or lab or activities books (Table 26b). These are rarely mentioned more than once.

Table 26b
Supplemental Titles Used in Astronomy Courses

Apollo 13
Astronomy through Practical Investigations
Blind Watchers of the Sky (Kolb)
Cartoon Guide to Physics
Conceptual Astronomy 1 (Adkins)
Contact
Contemporary Activities in Astronomy: A Process Approach (Huff & Wilkerson)
Cosmos
Cosmos Reader (Sagan)
Elegant Universe (Greene)
Galileo's Daughter
Lecture Tutorials in Astronomy (Slater et al.)
Light This Candle
Mysteries of the Night Sky
Nightwatch (Dickenson)
On the Shoulders of Giants
Peer Instruction for Astronomy (Green)
Pocket Guide to the Sky (Oceana)
Study Guide and Notes for Astronomy (Pitman)
The Nearest Star (Pasachoff)

"Curriculum materials" spans a wide net. By far the most used materials appear to be from the Harvard-Smithsonian Center for Astrophysics *Project Star*, 30 users. Materials from Hands-On Universe were mentioned 11 times, and the ASP's *Universe at Your Fingertips* mentioned 6. Mentioned repeatedly but less than the aforementioned include SETI's *Voyages*

Through Time, StarLab materials, RBSE/TLRBSE materials, SPICA and Harvard *Project Physics*.

Table 26c lists some interesting one-time mentions:

Table 26c
Other Curricular Materials Used in Astronomy Courses

Kinesthetic Astronomy (Morrow and Zeilik)
Golden Valley Radio Telescopes
Night Sky Networks
Tzec Maun remote observatories
Adler Planetarium's Quasar research modules
The Wright Center
Harvard's MicroObservatory

Various NASA Education and Public Outreach offices, websites, and programs are mentioned heavily, at least 15 times. 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 stuff is derived from the Internet.

Planetariums and Telescopes

Just as books, test tubes and pendulum bobs should be standard equipment in science, chemistry and physics classes, lanetariums and telescopes should be primary tools to teach astronomy. These are a bit more expensive than test tubes and pendulum bobs. Planetariums can be part of the school, or may have to be traveled to, within the district or beyond. Fixed domes go back as far the 1930s but came into strong demand in the Space Age. But portable planetarium units were too new on the scene when Sadler did his study (even though he is the primary promoter of them—most today are his StarLab portables). It is of interest to see what effects from portable planetarium units are now visible and how they compare to fixed units. As Bishop stated, back in the 1970's and earlier, if there was a planetarium, there was a course. As to observatory domes and scopes, you have them or you don't.

Teachers were asked if their school owned a fixed planetarium operation that they could use anytime, if they used a fixed planetarium elsewhere (and if so, how often). Did they use a portable planetarium and if so, how often and who owned the unit? Did they not use a planetarium of any kind, or was there some other option that was not listed? (The "Other" category proved to have some new information, and a lot of choices that really belonged with the given choices.)

The final tabulation is in Table 27 ("plm" is an industry standard abbreviation for "planetarium"):

Table 27
Planetarium Ownership (Number, Percentage)

Owned plm	Used plm elsewhere	Used portable	None	Other	Unknown
62, 26%	57, 24%	28, 12%	60, 26%	26, 11%	2, <1%

The proportion of 'Own planetarium' is quite high! If this sample were scaled up to an estimated 3000 schools with astronomy, there would be 900 high school planetariums in the country! This is three times what is known to exist. This survey clearly oversampled this part of the population. Several planetarium directories were used but most of those listings went out in the sixth to tenth (last) weekly batches of survey invitations, yet two-thirds of the count came before those invitations were sent out.

Only two 'Owned' schools reported usage statistics, and those were 'every day' and '15X per course'.

Of those that used a planetarium elsewhere, 36 of them only use it once per course. Only once did a school use another facility as many as six times and then only because it was within a nearby former high school building. Nine reported using it 2 to 4 times per course, and one said weekly. The majority did not report usage amounts.

It is interesting to see how many portables showed up in the sample. From the International Planetarian Society directory it was known that about 10% of the high school planetariums listed are actually portable units. The proportion is higher here, about 15% overall; out of the 28 "Used portable" listings, 8 are owned by the school which makes the percentage of portables equal to 11% of total of "owned plm" + "owns portable." Six others are borrowed from the district while 8 are from NASA, universities, museums or others that operate a lending service. The origins of the other six are not known.

Twenty-six of the portables-using schools reported usage rates. These can be as indeterminate as "as much as I want" to a numerical peak around 20 days per course. Several appear to use it for an extended, single time, such as "1st 1, 2, or 3 weeks of the course" and various multiples of "5 days" that appear so often. When borrowed from a district or some other source, the average usage days are smaller; Out of 14 appearances of 1, 2 or 3 days of usage, 10 were when the portable was not the school's own. This usage rate is much less likely to be seen in school-owned planetariums, only 2 schools out of the 9 reported such low usage. One can conclude that ownership at the school of a portable unit does imply it is used and possibly at the similar rate to a fixed planetarium (where the astronomy class does not normally meet in the dome).

In the "Other" were found numerous references to field trips, with the implication in some, and the explicit statement in others, that these were to other planetariums, and were no longer a good option. There were 12 such statements, 5 mentioning irregular usage if at all, and 7 mentioning that the expense of a field trip had become too costly. These statements go neither into "used plm elsewhere," where field trips clearly are still done, nor into "none."

There were 14 remaining "other" categories of which 3 are a mix of the regular choices (portables, fixed, use planetarium elsewhere) and 9 are a new choice, the use of sophisticated computer software, so-called "planetarium software," on large screen projections, televisions or monitors, or interactive boards. All of these project the night sky, provide accurate planetary system motions and can be used by students as well as instructor. The primary choice is the computer program *Starry Night*. Also mentioned are *Voyager 4* and *Stellarium*.

On the other hand, telescopes do not appear to be too much of a difficulty. Out of 235 reporting schools, 152 have one or more portable telescopes, and 17 have their own observatory dome. Only 24 have no telescopes whatsoever, while 42 use someone else's, or some other situation.

Of the schools with portable telescopes, 35 schools detailed their inventories totaling 54 telescopes. The most common size (and rate of reporting) are the eight inch telescopes (13 schools, 21 instruments) followed by six inch telescopes (6 schools, 12 instruments). No other sizes were in double digits or as many schools as this last one. Maximum was a 14 inch, the minimum a two inch. The average number of telescopes is just over 3 per school (3.22) but the median is 2). Scopes and their numbers are listed in Table 28.

Among the "Other" scope answers, 17 (half) are the teachers using their own telescopes. Five schools also have solar telescopes, seven use local observing clubs or observatories. Four reported using remote telescopes, notably the Tzec Maun project, Perth Observatory (great because it is day here but night there!) and the Telescope In Education consortium telescopes. Two reported a combination of dome and portables but without sizes or other information, two reported large usage of binoculars, and one stated that their 65 cardboard telescopes should count. (The numbers here add up higher than the numbers above because some schools have multiple answers).

Table 28
Number and Frequency of Telescopes in a School

	Number of scopes							
	1	2	3	4	5	6	7	10-20
Number of schools having this many telescopes	35	48	31	7	10	11	4	6

Budgets

Planetariums, telescopes and simple star charts all cost money. Teachers were asked how much money they are given for their astronomy course(s) for supplies, and the principal source of the monies. There was a choice between explicitly budgeted for astronomy, drawn from the general department funds, given only when request made to the administration, grants, and personal funds. There were 232 useful replies.

Table 29 lists the number of schools for each source of funds and is divided into units of 100’s until $2000 is reached, after which it is in units of $500 and then $1000. Funds coming out of the department outnumber all other categories together, 128 designations, or 55% of the schools. Second largest source of funds are monies explicitly given to astronomy, 55 schools or

24%. Money from the teacher's wallet, from requests to administrators, and from grants are all about equal, 15-17 schools, or about 7% each.

Table 29
Budget Amounts and Sources of Funds for Astronomy Teachers

Dollar Level	**Budgeted for Astronomy**	**Departmental Funds**	**Teacher's Wallet**	**Requested from Administrations**	**Grants**
<$100	2	4	3		
100's	3	14	4	3	1
200's	11	24	2	2	
300's	6	14	1		
400+		8			
500+	7	27	2	3	1
600+		1			
700+	3	5			
800+		1			
900+	2				
1000+	5	7	2	1	
1100+					
1200+	2	2		1	
1300+					
1400+					
1500+	1	4			
1600+	1				1
1700+					
1800+	1				
1900+					
2000+	4	3		1	4
2500+	2				
3000+		1		1	
3500+	1	0			
4000+		1			
4500+					
5000+		2			1
6000+	1	1			1
None/other/ varies/unknown	2	9	3	4	6

Table 30 lists the median values in hundreds for those with known budgets which are greater than zero:

Table 30
Median Values for Different Sources of Funds

Source	Range of the Median	Top two budget amount levels by count
Budgeted	$500’s	11 schools-$200s, 7 schools-500’s
Department	$400’s	27-500’s, 24-200’s
Teacher	$200’s	4-100’s, 3-<100’s
Administration	$200’s	3 each, 100’s & 500’s
Grants	$2000’s	4-2000’s

Both Budgeted and Departmental funds mimic each other’s distributions after the 500 dollar level up to the $2000 level. Each has 4 or 5 ‘hits’ at $2500 or above with the highest budgeted amount at $14,000 and the highest departmental largesse at $9000.

While a few teachers spend $1000 of their own funds on the students, most top off at $500. Grants, though rare as the means of support, are generally fairly high, as much as $8000.

Our survey shows that astronomy classes generally get 200-500 dollars for expenses, with a handful of rare cases that are primarily new planetariums or successful grant-getters. If the money isn’t explicitly budgeted or at least the department isn’t supportive, the administration is no more beneficent than the teacher’s own wallet.

The NRT mailing list has codes for a variety of unequally distributed discretionary fund levels, and 893 of the uniqued listings have known budgets. The peak (mode) of the NRT is the $155-249 bin, 26% of their schools report these amounts, but the next three levels are very close at about 19-22% each (levels are $250-329, $330-449, and $450-1249!). Fully one-third (74) of our astronomy teachers fall into the highest of these ranges, with an approximately equal percentage (13%) in the $155-259, $250-329, and the $1250 and over ranges. While the peak of our teacher's moneys are higher than most of the NRT's teachers, there is a higher percentage of the astronomy teachers at the very lowest rungs of money (below $150) than in the NRT, 22% versus 11%, respectively.

Table 31 provides the percentages for the various groups and the results of a test of proportions. Every single budget group is statistically different. The survey teachers are more numerous on the very low and very high ends of the table, and deficient in the middle values.

Table 31
Comparison of Survey Budget Distribution by Percentage with National Registry of Teacher (NRT) Categories

	Budget Ranges in the NRT					
Percents and Statistical Test Values	<$154	$155-249	$250-329	$330-449	$450-1249	$1250 and up
This Survey	0.22	0.13	0.13	0.04	0.34	0.14
NRT	0.105	0.255	0.21	0.194	0.22	0.017
*z**	5.319	4.067	2.785	5.522	4.108	13.492
p values	<0.001	< 0.001	0.005	< 0.001	< 0.001	< 0.0001

Other Needs

Given money, what are the teacher's greatest need, wish, or gripe? There were seven categories, and the teachers came up with several more. Not all of them would be solvable with funds. The frequencies are listed in Table 32 along with a comparison to those listed in the 2001 American Institute of Physics survey of physics teachers.

Table 32
Teachers Most Listed Needs or Gripe (If Any), with Survey and AIP Equivalent Rankings.

Need or Gripe	Number of Teachers	AIP rankings
Time	42	labs 2/lessons 5
Other	38	scheduling 7/admin. support 8
Student attitudes	36	6
No Problems	34	--
Student preparation	31	4
Funding	30	1
More space	12	3
Supplies	10	--
No response	5	--

The largest request was for 'more time' (n = 42). The next highest was 'Other Gripes or Needs', with 38. 'Student attitudes' and 'preparation' are not far behind, and 'funding' is about equal with 'student prior preparation' before coming into their classes. However, elsewhere there were many comments regarding need for 'professional development'. This would be incorporated into future research lists (it isn't on the AIP list at all).

In general, other than more space or supplies, the wishes of the teachers are spread fairly evenly across the choices.

Comparison to the rankings of the AIP physics teachers in 2001 shows the astronomy teachers are reversed in their needs. Funding doesn't rank as high with astronomy teachers as it does with physics. Attitudes and administrative support and scheduling are not important to physics teachers (but physics is not an elective as often so scheduling or administrative support for a required class should not be as much an issue). Only in wanting more prep time and bemoaning student preparation are the physics and astronomy teachers comparable.

One gains great insight into the teacher's worlds by examining the comments made under Other and some of the other choices, most notably the attitudes (Table 33). (All were mentioned once unless followed by a number). The biggest issue seems to be how students are selected to be put into astronomy courses, or a related complaint, the affects of counselors who don't understand the teacher's program. Student abilities and attitudes are a big issue here as well as above, as well as administrative attitudes. It appears that, for the most part, astronomy teachers feel misunderstood by administrators, students and others.

Table 33
Detailed and Grouped Teachers Gripes, Wishes and Needs

Counselors and scheduling. (13)

- Not recognized as a lab credit, counselors steer students away.
- Course was cancelled when chemistry became required, enrollment dropped.
- Block scheduling was a major setback to teaching astronomy.
- Counselors should not put low ability students into astronomy class when they have no interest.
- General scheduling conflicts and issues (4).
- Counselors steer students to astronomy, generating complaints he is 'stealing' students from other teachers.
- Competition for electives limits enrollment.
- Too much domination by Biology, Chemistry, Physics.
- Not enough enrollment.
- Astronomy should be required.

Other (11)

- Students not learning how to use scopes.
- Lack of clear dark skies (4).
- Course cancelled because the teacher left – nobody can take over it (1).
- No money for field trips to dark skies or observatories (4).
- Money to bring back program that brought elementary and middle school students to planetarium.

Students (11)

- I have problems generating student interest. (2)
- Students don't have necessary abilities (5).
- Students lack prior physics knowledge.
- Students like problem solving abilities that come from algebra, physics.
- Student attitudes are inconsistent; some want 'gut', others want more.
- Math abilities = student attitudes.

Table 33

Things desired (11)

- Want a planetarium. (2)
- Good textbook (3).
- LCD projector.
- Space for a portable planetarium.
- Space in a storeroom near the roof.
- Finding online labs.
- Finding good labs.
- Need modern PC lab.

Administration woes (9)

- Administration too focused on state standards and graduation tests, doesn't support astronomy.
- Can't require night observing sessions. (4)
- It took six years to get a StarLab portable planetarium!
- Astronomy teaching staff is considered most expendable.
- Administration doesn't understand what astronomy is, or is not. (2)

Personal (5)

- Wish I had more enrollment so I could teach only astronomy.
- Want more access to astronomers, I am teaching out of field.
- Too many core courses, I can't find room in schedule to teach astronomy (2).
- Too tired to do night sessions.

Teachers

As Butch Cassidy said to the Sundance Kid, "Who ARE those guys?" These are very educated people, very heterogeneous, and almost without exception, NOT astronomers. Many have been teaching the class for a long period of time.

Time in Service

Longevity of teachers teaching an astronomy course: the median time length is seven years, the average is 9 years. Eighty five percent of the pool were actively teaching this year (less than 1% were teachers preparing to start the next year, 15% were no longer teaching (P)).

Out of the 200 teaching (Code C) this year, ten percent were in their first year (C1) but 3% knew their classes were going end this year (CT).

If you get past year four, then there is relative job security for years 5 through 20. There is a sizable number of people who have been teaching past the three decade mark. Since it is known through other variables in the survey 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.

Those teachers surveyed who no longer teach the class do so for any of a variety of reasons -- retirement, moved, course cancelled. The longevity values for these people are slightly less, an average of 6.7 and a median of 6.5.

For a comparison, in the Condition of Education 2003 (for the academic year 1999-2000), the average overall longevity simply for teaching in a public school science teacher was 15 years, and 12 for the private school science teacher.

Education and Training

All teachers today must have a college education, a Bachelor degree in something. Those with their highest degree being only a bachelors are 13% of the pool. Interestingly, 79% of the teachers have a Masters degree (n = 187 out of 237). A very small number (n = 19) have doctorates. This last represents only 8% of the whole survey respondent pool and only 10% of the masters degree holders. A survey by the AIP in 2001 had physics teachers' highest degrees as Bachelors (35%), masters degrees (60%) and doctorates (5%). Astronomy teachers do better in getting graduate degrees by comparison.

The Condition of Education 2003 has 46% of public high school teachers with a Masters degree, 35% of private schools. Astronomy teachers are doing much better, but…

How much astronomy have they had? Not much. The number of astronomy courses taken at all degree levels is in Table 34 below. (Some numbers may represent credit hours instead of numbers of courses—the data is taken at face value.)

Table 34
Number of Astronomy Courses Taken in College by Teachers, by Degree

Number of courses taken…	**…Getting Bachelor's Degree**	**…Getting Masters Degree**	**…Getting Ph.D.**
"A few"	---	1	---
0	67	82	13
1	75	26	2
2	35	30	2
3	22	18	1
4	13	7	1
5	7	5	
6	2	6	
7		2	
8	5	3	
9	1	2	
10	3	2	
11		1	
12	2	2	
15	1		
16	1		
24		1	
"many"	3		

Sixty-six (28%!) have taken no astronomy at the undergraduate level! If 'qualified teachers' have to be found not only in core courses but electives, a lot of teachers are NOT qualified.

At least, though, 72% have had at least one course. Of those who gave an actual number which was greater than or equal to 1 (n = 168), the average number of courses is 2.65. The number lowers to 1.89 courses when the entire pool is considered. More people (75) took just one course than any other number of courses, about half of that number take two courses (*n* = 35) and three courses are taken by 22. The few clear astronomy majors or aficionados have taken 5 or more (up to 16 courses) and are also *n* = 22, less than 10% of the pool.

At the masters level, things are slightly better. 3.5 courses were taken by the 104 teachers who took at least one course. All 187 masters degree holders together, average only 1.96 courses. A high number, 82 teachers (44%), took no astronomy courses.

At the doctoral level, most did not take any astronomy (13 out of 19). Of those that did, the average is 2.16 courses, but it is less than 1 course for the whole pool of Ph.D.'s.

The subset of those BS/BA degree people with no astronomy courses who also went on for a higher degree were examined to see if they added any astronomy courses at the masters levels (*n* = 61). It was a nearly even split. Thirty-three did not take an astronomy course at either level but 28 went from none to something. A few actually got a masters in astronomy.

Biologists ought to be teaching biology, a non-physicist in a physics course is an immediate "not highly qualified." The training (i.e. majors) of high school astronomy teachers doesn't occur in astronomy departments.

It is a bit tough to get a clear understanding on the undergraduate majors because so many teachers have double majors that cross traditional lines. Starting this analysis with just those who indicated a single major, and combining similar majors with somewhat different titles together, Table 35a finds a shift from the traditional origins of astronomy teachers.

The sciences clearly dominate (65%), which is encouraging. The highest origins for high school astronomy teachers, though, are from the biosciences, followed closely by the geosciences. Physics, physical science/broadfield, then chemistry make up much of the rest. Many of the 39 Education-based degrees (16%) are at least coming in with specific science

Table 35a
Numbers of Teachers in Various Undergraduate Major Areas of Study

Area/Major	*n*	Area/Major	*n*
The Sciences (155)		Education (39)	
Astronomy/Astrophysics	6	Science Ed/ Secondary Sci Ed.	14
Physics	19	Earth/Geo Science Ed	14
Physics and Astronomy	5	Other sciences education	5
Physics or Astronomy + some other major)	8	Education/General Education	6
Chemistry	15	Secondary or Elementary Ed.	3
Chemistry + another major	3		
Biological/various Life sciences	31	Other (28)	
Biology + another major	4	Math or Math Ed	6
Other science or technology (aviation, aerospace, forestry, Meteorology, soil science Etc.)	9	Math and some science (double Major)	9
Physical Science/Broadfield/ Science/General Science	16	Humanities (Art, History, Social Studies, Home Econ., Accounting, Anthropology, Communication Arts)	13
Geology/Geoscience/Earth Science/Earth & Space Sci	28	Miscellaneous	15
Various Engineering (w/ or w/o Physics/chem/math double major)	11		

domain education degrees (like Geoscience Education) or science education degrees that commonly require a substantial amount of undergraduate science courses. The remaining 19% come almost equally from mathematics (or math and science double majors), from the humanities, and from miscellaneous degrees that don't fall into the three main groupings. But the astronomy-major teacher is only 8% of the pool, 16% if you include pure physics teachers as well. The aforementioned AIP survey indicates 22% of their teachers have physics degrees of some kind, and 11% have a physics education degree, for a total of 33%. An NCES 2005 report on bioscience teachers indicates that 61% have a major or minor in biology, though there is no information given about biology education majors (NCES, 2005c).

The situation appears much better in Table 35b for the 'highly qualified' front when one gets to the masters level. More teachers went out for astronomy-related or science education degrees and some have two masters. Geoscience is still far more the degree of choice than straight physics (physics without astronomy or space).

Table 35b
Numbers of Teachers in Master Degree Major Areas of Study

Area/Major	*n*	Area/Major	*n*
Sciences (67)		Pedagogical Education (44)	
Astronomy/Astrophysics/Space Physics, Physics and Astronomy	14	Teaching/Education/General Education	26
Geosciences/Environmental Sciences	15	Curriculum/C&I/C&D	8
Physics, or physics + math, computers, or another science	8	Secondary Education	6
Biology/various biological sciences like Zoology	14	History of Education	1
General science/Science/Physical Sciences/Broadfield	8	Elementary Education	1
Other sciences (physical chemistry, Chemistry, Electrical Engineering, Natural sciences)	8	Reading Education	1
		Educational Psychology	1
Education (107)		Leadership and Support (13)	
Science Specific (50)		Administration	2
Secondary Science/Science Education	30	IT/Ed. Tech/ Classroom Tech/Media	8
Astronomy Education	2	Ed. Leadership	1
Physics Education	7	Professional Development	2
Physical Chem. Ed./Chemistry Education	2	Other (10)	
Geoscience/Earth-Space Science Education	5	Math	2
Biology Education	1	Humanities (history of science, religion, communications, anthropology, archeology, city planning, family resource management)	8
Math Ed or Math and Science Education	3	Miscellaneous	
		Divinity, MBA, and others	5

Out of 184 masters degree holders, the science/education ratio changes; 36% hold science degrees and 57% hold education degrees. 47% of the latter are in science domain/education degrees, equal to 27% of the whole pool. If you consider those with science degrees or science education degrees together as ‘highly qualified’ then 63% are so labeled, about the same as the undergraduate percentage. Only 7% of the masters pool have an astronomy masters degree, comparable to the undergraduate majors. That goes up a single percentage point when including the two astronomy education masters recipients, reflecting the lack of such programs.

The nineteen doctorates fall into six science doctorates (two in geoscience, only one in astronomy), eight education degrees (science education has the most, 3), and two in miscellaneous (divinity and dentistry). The one astronomy Ph.D. accounts alone for 5% of the doctorates, there are no astronomy education degrees. Science drops to 31% and science plus science education drops to 47%.

Another way to see who is doing the teaching is to look at the certifications they hold. Teachers can have none (although that’s usually only in private schools) up to as many as they can earn. Certifications are less wide in scope than college majors. Our 237 teachers fall primarily into 8 groups, summarized in Table 36:

Table 36
School Certifications Held By Teachers

Certification	*n*
Earth/Earth & Space	70
Physics	54
Biology/Life Science	49
Broadfield/Science/All Science/Composite/Unified	40
General/Integrated Science	31
Chemistry	30
Math	29
Physical Science	17

Converted to percentages, fully 29% are certified in Earth-Space Science, surpassing Physics by 6%. Only in this compilation are Biology Life-Science certificate holders in third place, unlike in the college majors rankings.

Given that 65% have majors in sciences, the data was examined for those who also had a science certification as well. One hundred fifty out of 215 teachers had both a certification and a major in a science, or 70% of the pool. This compares well with the 1999-2000 year data in the Condition of Education 2003, where 73% had both major and certification. In biology, the comparable numbers are 75% have certification and 16% have neither certification nor a major or minor in biology (NCES, 2005c).

There were only 10 teachers in this sample with no certification, and 8 for which there is no information. Seven people claimed certification in astronomy but no programs on that have been actually found. It bears investigating. Twenty-two other certification areas, none with more than four teachers were also found, mostly in education or miscellaneous non-science/non-education.

The traditional home of astronomy, physics, therefore has lost much ground to the geosciences. Even the biological sciences are the background area for as many or more teachers than physics! There appears to be very little done for astronomy education as its own area, the astronomers aren't doing nearly as much as physics education programs, or those of chemistry or math or geoscience teacher preparation. Only in the certification area does physics get accorded even second place.

Gender

Seventy-eight female teachers can be positively identified, at minimum (sometimes just initials are given and there is no way to say what gender they are). Female teachers are 33% of this population. Compare this with the AIP physics teacher study of 2001 where 29% were female up to 31% in 2005 and 53% female among biology teachers (NCES, 2005c).

Their majors are, like the pool, quite varied, mostly 1 person per major. However, certain groups of majors had large counts. There were 15 biological science majors and 10 geoscience majors. There were only two astronomy and 3 physics majors among them (and 2 with a dual physics and astronomy major). The biology and geoscience-derived teachers count for 25% of the whole pool and 30% of the females. On the graduate level, those numbers follow the same proportions and are specifically 5, 2, 1, 0 and 1, respectively.

The largest graduate majors for females are science education (11) and education in general (10) , the two leading categories just as in the general population of the survey and in the same, slightly over 50% for both together, percentage.

Clearly women are coming from the biological sciences and geosciences and that is the cause of their higher presence overall.

Entry Into The Astronomy Course

Finally, how did these teachers actually get into teaching an astronomy class? They were asked to pick from five categories plus "other." The results (Table 37) are:

Table 37

Frequencies of Teacher Entry Paths Into Teaching Astronomy

Reasons given	n
I was teaching something else and I wanted to do this	64
Other	58
The administration asked me to teach this	46
Got into this in college, planned to teach astronomy	34
Stepped in for/another teacher gave me a section	22
Kids asked me to do/teach this	13

Among the Other listings, several comments had large numbers of people saying the same thing, the largest being “Astronomy was a personal interest” (22 people). Two similar comments “left another astronomy related job to do this” and “involved with many science/space groups” together have 11 teachers. Filling holes in course offerings or expanding interest from extant general courses accounts for 10 more. Six others teach because it came with the job of being a planetarium director. Other repeated comments include “a change of profession” (2), extended my interests to the students (3), assisted in a planetarium (2) and “I wanted to learn this myself” (3). Four people got into teaching astronomy after attending workshops with groups like Hands-On Universe.

Because of the high count on personal interest and “I wanted to do this,” clearly the strongest way to get a course started is with the teacher’s own motivation.

How Much and What are They Teaching, and With Whom?

How many sections of astronomy in general are taught by a teacher? In this sample, there was data for 231 teachers. The breakdown is in Table 38:

Table 38
Number of Astronomy Sections Taught by a Teacher

Number of classes	Number of teachers	Percentage	Total number sections taught
1	126	55	126
2	58	25	116
3	33	14	99
4	5	2	20
5	8	3	40
8	1	<1	8

Eighty percent of all teachers do not teach this class as anything but a single or double section, a bonus on top of their other main teaching subjects. Twenty percent or less can be said to teach astronomy ‘full time’, like a math or physical education teacher might do their subject all day long. In fact, looking deeper at enrollment numbers, sections, and whether on block or periods, one could only be reasonably sure of 36 teachers, or 16% of this pool, are ‘fulltime astronomy teachers’.

If they aren’t teaching astronomy, what are they teaching? Their other courses are listed in Table 39.

Table 39
Frequency of Other Courses Taught by Astronomy Teachers

Courses taught	This survey’s number	Percent (of 237 teachers)
Physics	92	39
Earth Science	83	35
Physical Science	63	27
Other	51	21
Chemistry	46	19
Biology	44	18
Envir. Sci.	24	10
Math	15	6
Oceanography/Meteorology	14	6
Research Course	8	3
Unclassifiable	4	2
None!	1	<1

Among the Other choices: the two largest are Planetarium Director (or staff) 12 times, and Meteorology (alone) for 9 times. Meteorology is sometimes tied to an oceanography class (2 times) and oceanography is mentioned alone 3 times. The only other courses mentioned more than once were AP Physics, Genetics, Electronics, and Integrated Science.

How isolated are the teachers? They were asked to say how many other instructors of astronomy are in the school (Table 40).

Table 40
Number of Other Astronomy Instructors in Each School

No other instructors	1 additional	2 additional	3 or more additional	("2 or 3")
159	57	10	5	2

68% of the teachers teach alone, and 24% work with a single partner. Only 8% have a team of 3 or more. This works out to be 1.31 teachers per school. The NRT value is 1.32. State figures will be examined later on.

In this sample of teachers who have at least one more astronomy instructor in the department, 60 are in public schools and 11 in private schools. The proportions of none/one or more partners are comparable; 30% of the public high schools have multiple astronomy instructors while 38% of the private high schools have this status. No relationship was found between the number of extra instructors and school size; the averages vary but for public schools it is always 1500 or higher, and private schools 7-8 hundred. The only exception is that the few schools with 3 additional instructors averaged 2100 students. That increase did not hold for four extra instructors.

Professional Development and Affiliations

Keeping Up With Science

How do the teachers keep up with the science of astronomy? The number of teachers out of 230 that responded to each of a set of choices are in Table 41a. Without any doubt, astronomy teaching would be in a disastrous state if NASA's education budget were to vanish. Similarly, the two largest circulation astronomy magazines, *Sky & Telescope* and *Astronomy*, form the bulwark of keeping up with the rapid changes in astronomy. The printed word is still a great way to keep up, not only through magazines but also books and newspapers. Conferences, workshops and NASA programs are key.

Table 41a
Number and Percentage of Teachers Reporting Ways They Keep Up With Current Astronomy

Choice	**Number**	**Percentage of Teachers Mentioning This Category**
NASA Web pages	193	84
Astronomy/science magazines	181	79
Books	152	66
Non-NASA web sites	123	53
Newspapers	121	53
Conferences	113	49
NASA Educational programs	106	46
Workshops	104	45
News from associations via newsletters and magazines	88	38
Individual communications	71	31
Astronomy Programs	70	30
Clubs	62	26
Listserves	52	23
News magazines	48	21
Other	28	12
Don't keep up	1	<1

Let us examine the categories in some detail:

Magazines

Sky and Telescope is the leader, with 98 (54%) of the votes, with *Astronomy Magazine* right behind with 87 (48%). Many teachers get both. In descending order of importance (votes) are *Discover* (30*), Scientific American* (27), *Mercury* (15), the no longer published *Night Sky* (9), *Science News* and *Science* (7) and *Stardate* (6).

A few others mentioned two or three times are *Popular Science, Nature, Planetary Report, Reflector, Physics Teacher, New Scientist,* and *National Geographic*.

Non-NASA Websites

The most popular website is <spaceweather.com> (23, 19%) which monitors aurora, solar activity, the solar wind and the near-Earth environment. Right behind it is <space.com> (22). The Astronomy Picture of the Day, often used as a warm-up or introductory activity in classrooms, was third highest with 17 mentions. *Sky and Telescope's* <Skytonight.com> is 4th with 10 votes.

Websites that had two to nine votes also included <Badastronomy.com>, <skymaps.com>, <astronomy.com> (the website of the magazine), <nineplanets.org>, Jet Propulsion Laboratory, <stardate.org>, UCAR (University Consortium for Atmospheric Research) which includes the Windows to the Universe website, the SOHO solar observatory in space, <Heavens-Above.com> for satellite predictions, <Hubblesite.org>, and the European Space Agency. There were numerous websites named once, with no particular patterns. They are not listed in this work.

Listserves

Listserves rarely have high numbers of users in this category. The largest is a planetarium listserv, Dome-L with only 10 (19%) users here. The Hands-On Universe list, for participants of the program's workshops, had 7 members and a parallel list for Teacher Leaders for Research Based Science Education (TLRBSE, also listed with a new acronym ARBSE and plain RBSE) had 5. There are a number of NASA informational and news lists together totally 8 persons mentioning them.

Astronomy Education Programs

Despite giving examples, this listing had a series of computer astronomy programs listed as well. Excluding these, the leading education program mentioned is the HOU (Hands-On

Universe) program, with 31 mentions (44%). Only the TLRBSE list even approaches it, with 8 votes. The Starry Night computer program has curriculum, videos, and other materials such a listserv newsletter and it received 6 mentions. Minor numbers of repeated votes went to Project Star, Project CLEA—a computer simulation operation out of Pennsylvania, Space Explorers, the ASP's ASSET list to teachers and Hands-On Astrophysics.

Other

The 28 options given are rarely mentioned more than once. Keeping up through personal observing got the most (4) votes. Public lectures (3), public television (2) and taking courses (2) follow.

Keeping Up With Pedagogy

How do the teachers learn about or keep up with astronomy education, the pedagogy, the techniques?

Table 41b

Number and Percentage of Teachers Reporting Ways They Keep Up With Current Pedagogy

Choice	**Number**	**Percentage of Teachers Who Mention Category**
NASA Web pages	113	48
NASA Educational programs	109	47
Conferences	106	45
Workshops	94	40
News from associations via newsletters and magazines	84	36
Astronomy/science magazines	66	28
Individual communications	61	26
Astronomy Programs	54	23
Listserves	42	18
Non-NASA web sites	37	16
Don't keep up	28	12
Clubs	27	11
Astronomy Education Review	26	11
Other	17	7

The choices were similar to keeping up with the science, minus books and news-magazines and papers, but adding *Astronomy Education Review*. 235 teachers responded and their choices are listed in Table 41b.

Once more, NASA is the key vehicle for teaching astronomy teachers techniques and pedagogy, and also educational conferences and workshops.

One more key way of pedagogical education are the newsletters and magazines from educational associations. Individuals and specialized astronomy programs bring up the rest.

A larger percentage of teachers do not try to acquire pedagogical training, 12%, than didn't bother with content.

Listserves, clubs, and non-NASA websites have little to give for pedagogy.

Magazines

Once more, a virtual tie between *Astronomy Magazine* (22, a 9% of the teachers) and *Sky and Telescope* (21). A strong third is *Mercury*, a magazine known for covering astronomy education historically (10). No other journals or magazines had numbers even this high. Those with more than one 'hit' include *Discover, Scientific American, The Science Teacher, Stardate,* and the late *Night Sky*.

Websites

For pedagogy, 32 names were given, not one of them with more than two mentions. While similar to the keep up with science list of titles, there are a few more education association listserves. Otherwise, nothing stands out. Pedagogy is not a prominent feature of the educational internet.

Programs

By far, the leading vote getter is the Hands-On Universe program, with 24 votes (10%). The TLRBSE/ARBSE/RBSE systems have the next highest count, 14. The only selections given 3 or more votes were Project Star, CLEA, and the ASP in general.

Listserves

The planetarium listserv Dome-L leads with $n = 10$. The TLRBSE/RBSE lists account for 6 recommendations. Two lists out of the University of Arizona Association of Astronomy Educators also have six total. The ASP ASSET list stands at 4.

There were no clear recommendations for "other" choices. Collaborations, summer seminars, summer research, teachers groups and educational associations were the main ideas of interest.

Keeping Up With the Community

Table 41c
Number and Percentage of Teachers Reporting Ways They Keep Up With Other Educators

Choice	**Number**	**Percentage of Teachers who mention category**
Workshops	107	46
Conferences	106	45
Individual communications	93	40
Giving workshops	56	24
NASA Educational programs	52	22
Don't keep up	44	19
News from associations' via newsletters and magazines	37	16
Astronomy Programs	37	16
Clubs	37	16
Listserves	35	15
Other	21	9

Finally, how do the teachers keep up with other astronomy educators? 232 teachers replied, they don't …much. Table 41c indicates the paucity.

Workshops and conferences are as much for social interaction as pedagogical contact. Most others just keep in touch with a few folks they know, directly. Listserves don't qualify for satisfying the human need for communication. Quite a few satisfy that need by giving workshops, not only attending them. The largest number so far indicate they work in isolation, $n = 45$, or 19%, nearly one in five.

Generalizations

It is interesting to examine all the choices across the three questions (Table 41d). The number of teachers contributing is fairly consistent.

Table 41d
Comparison of "Keeping Up" Resources

	Keeping Up with (Number of)		
Resource Choice	**Astronomy**	**Pedagogy**	**Educators**
NASA Web pages	193	113	
Astronomy/science magazines	181	66	
Non-NASA web sites	123	37	
NASA Educational programs	106	109	52
Conferences	113	106	106
Workshops	104	94	107
News from associations via newsletters and magazines	88	84	37
Individual communications	71	61	93
Astronomy Programs	70	54	37
Clubs	62	27	37
Listserves	52	42	35
Other	28	17	21
Don't Keep Up	1	28	44
News Magazines	48		
Books	152		
Newspapers	121		
Astronomy Education Review		26	
Giving workshops		56	

Some broad recommendations and generalizations can be made…

Teachers keep up with science using NASA Web Pages and Astronomy/science magazines. Another large source of content information –only-- are other internet Websites. Books and newspapers are very effective in keeping up with the latest astronomy news. Unfortunately, the online professional journal *Astronomy Education Review*, a good source for pedagogical research findings, isn't well known enough for value to high school astronomy teachers.

Conferences and workshops are consistently multi-useful and popular, for keeping up with people, pedagogy and science. NASA educational programs are useful in the same way, except it is not as 'social'. Ditto for association news magazines and newsletters.

People keep in contact more individually than by any other method outside of workshops and conferences, notably through personal relationships or email. In fact, learning new science or pedagogy is as much an individual thing as conferences and workshops.

Use of specialized astronomy programs, particularly Hands-On Universe and the Research Based Science Education programs are principal sources for science and pedagogy.

For a reason that can't be figured out, teachers get a great deal of content knowledge through association with clubs, nearly twice what they would get from the social aspects of working with other astronomy enthusiasts!

Teachers keep up with the content very strongly, but not with each other. Listserves are equally as effective, or ineffective, for keeping up with any of the three areas.

Organizations

In what groups do these high school astronomy teachers associate? In this pool the answer isn't without bias. Since much of our voluntary responders answered advertisements placed with permission on listserves belonging to local/regional groups of the NSTA, AAPT and NESTA, this can not expected to be a random sample. The non-voluntary responders were partially selected from planetarium lists, so a higher percentage of planetarium memberships should be expected than a random pool as well.

Still, it is interesting to see who responded, and what other groups were mentioned as associations the teachers find useful for their instructional purposes (Table 42). Out of 229 teachers, it is found…

Table 42
Professional Organizations Memberships of Astronomy Teachers

Major groups		State/local groups		Astronomy associations	
NSTA	127	Science regionals	106	ASP	35
AAPT	41	Physics regionals	31	Plm regionals	26
NESTA	18	Earth Science reg's	17	IPS	21
NAGT	2			AAS	9
		Other	26	AAE	3
None	27			Planetary Soc.	27

If it were to be assumed that high school teachers were pulled equally out of the memberships in proportion to their size, then they should be in the ratios of NSTA:AAPT:NESTA:NAGT as 55,000:10,500:7000:1400. Reducing the NSTA membership to the number of our study, 127, the numbers should then be 127:24:16:3. The Earth Science groups follow the model but there are nearly twice the representation for AAPT (Physics Teachers) than the study should have. Yet…

The 2005 American Institute of Physics study indicated that 36% of its members belonged to NSTA, 22 percent to AAPT and 54% to neither. No statistical test is needed to indicate that our proportions are nowhere near those numbers. The survey has 25 teachers who belong to both (17%), 102 who are just NSTA (72%) and 16 that belong to AAPT alone (11%). Since our high school astronomy AND physics teachers are clearly a minority now, it stands to reason that our NSTA representation would be higher than for just physics teachers, and our ”none” correspondingly smaller.

When just those teachers who claim to teach physics are looked at, the numbers are NSTA only--30%, AAPT only--18%, both groups 24% and neither 28%. Again, our ‘neither’ is half the AIP’s study, with NSTA membership (only or in combination with AAPT) at 54% and AAPT (only or in combination with NSTA) 42%. Again there is more representation made up by NSTA members as the AAPT percentage is about the same as AIP’s number.

The low membership in the AAS and AAE indicates either how poorly they do their part towards astronomy education at the high school level, or how poorly they are perceived (if at all) by this population. The Planetary Society and the ASP are far better positioned in astronomy education here than the larger professional astronomer and astronomy education associations.

Other groups mentioned included quite a few local astronomy clubs or societies, the International Dark Sky Association (IDA), AAVSO, Astronomical League (an amateur association), AAAS, NCTM, a variety of science education research associations, a diving group (DAN) where weightlessness is ‘practiced’, several other educator groups (agriculture, marine science, local earth science groups) AIAA, NABT, CAP, ASCD, the National Space Society, a modeling physics group, and a couple of local astronomy teacher groups.

Comparison to the Sadler Study

At this point it is possible to compare this study with the Sadler study. It turns out that his study holds up very well today, except for a few key factors. He states that his number of teachers for these statistics are very comparable to ours, 240 versus 237. The critical value for all z statistics in the tests of proportions to follow is 1.97.

Sadler's average class size was 22, ours is 22.7. He says his classes consisted primarily of 11th and 12th graders with a small number of 10th graders. Without specific numbers one can only say that this study's numbers are similar. He claims 5% of the school population gets to take a course, which does not jibe well with 1980's NCES values of about 1%. This survey finds 3.5%.

Sadler's study has 57% of the teachers teaching one section only, this study has 55%. It also has more two-section teachers, 25% versus 18%. Tests of proportions done on these two values indicate that the former are not statistical different ($p = 0.66$) but the latter is just barely statistically different ($z = 1.990$, $p = 0.046$). Apparently over time, the number of teachers teaching two sections has grown.

He has 65% of all courses being half a year (semester or equivalent). This study is a little less, 55%, and this difference is statistically different ($z = 2.289$, $p = 0.022$). His average high school size was 1200, ours over 1500.

The majority of the teachers in Sadler's study started the course but he provides no number. The same claim holds for us, 136 teachers who created it to 91 who inherited a course. The teachers had been teaching the course an average of 9 years and as much as 20. Our average is also 9, our highest is near 40 years.

Teachers still think they are about the only one in their region, even if they aren't.

Like Sadler, this study asked what other courses were taught by them. Here, and only here, do the physicists reign. Right on their heels were the geoscientists. One significant change has occurred and one artificial one. The term "General Science" has gone out of fashion. It is presumed that all of those are folded into the "Physical Science" course. This survey also did not break out Earth Science from Geology, as Sadler did, so his values have been combined. The percentages are listed in Table 43 (which is Table 39 repeated with the addition of Sadler's percentages) and shown in their original course names in Figure 6. All the tests of proportions come out statistically not different (p = .12 or higher) except for Environmental Science (z = 19.1, p < .001) and Oceanography/Meteorology (z = 2.05, p = 0.04). Physics, math, chemistry, etc, still are about the same now as nearly 25 years ago.

Table 43
Comparison of Krumenaker and Sadler Proportions of Teachers' Other Courses Taught

Courses taught	Krumenaker (N)	Krumenaker (%)	Sadler (%)
Physics	92	39	41
Earth Science	83	35	28 + 14 (Geology) = 54
Physical Science	63	27	13 + 14 (Gen. Sci.) = 27
Oceanography/ Meteorology	14	6	12
Other	51	21	---
Chemistry	46	19	21
Biology	44	18	17 + 8 (advanced) = 25
Environmental Sci.	24	10	8
Math	15	6	10
Research Course	8	3	---
Unclassifiable	4	2	---
None!	1	<1	---

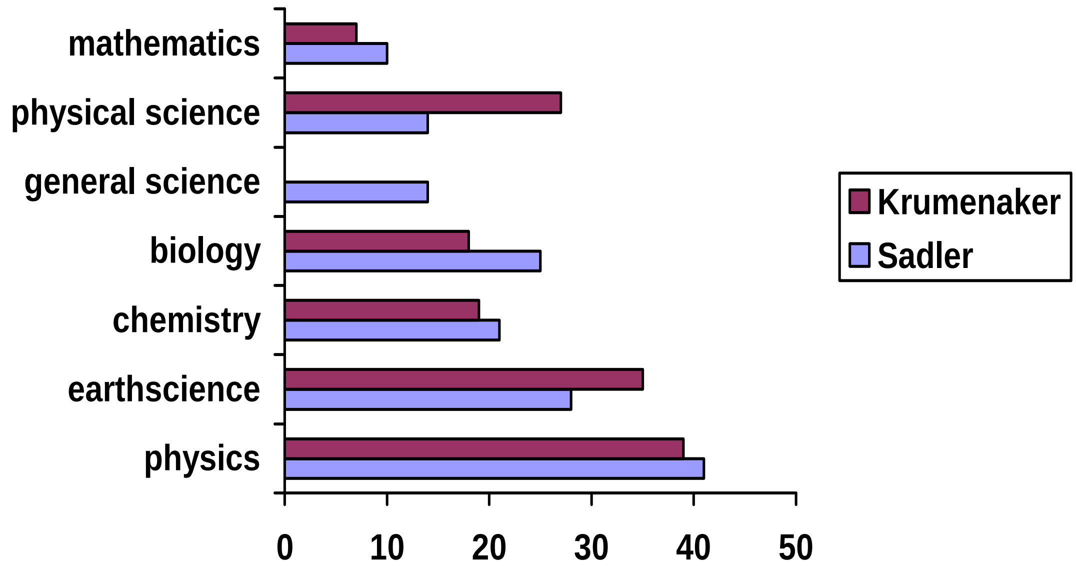

Figure 6. Percentage comparisons of other courses taught in Sadler and This Survey

The four major changes over two decades include:

- Sadler had a gender ratio of 88:12 males dominating. Today it is 67:33. The number of teachers he estimated at 1760, this survey has almost twice that.
- Sadler's teachers' desires or needs were, in this order, a student workbook, better materials (activities and programs), summer workshops, an astronomy education newsletter or association. Our teachers desire more time, and better student attitudes and preparation. There is still a need for student workbooks, or rather, today, student texts. There is great dissatisfaction with those that are out there. Workshops exist but they are not as known as the providers would like; many comments plead for professional development activities. There is a newsletter, really a professional journal, the *Astronomy Education Review*, but it is fairly new (only five years old) and a lot of teachers in the pool hadn't heard about it.

- Instead of *AER* which didn't exist then, the Sadler study had magazines as the predominant venue of news. *Astronomy* magazine read by about 70% of their teacher sample, and *Sky and Telescope* by 60%. The numbers have dropped for both (as shall be shown in the next section. Statistically, there is no difference for *Sky and Telescope* (z = 1.34, p = 0.18) but for *Astronomy*, the drop from 70 to 48 percent is statistically different (z = 5.24, p < 0.001). *Scientific American* was third then at about twice the percentage it is now (a statistical difference of z = 2.35 and p = 0.019. This survey has no mention of *Natural History*; NASA publications would not be considered a magazine in this survey, and *Planetary Report* was a reported readership of 10% back in the 1980's and isn't mentioned often enough by our teachers to get a good count or statistic.
- Sadler's teachers claim that only 14% of them rely on 'a commercial text' whereas 75% of ours mention one. But both groups complain that all the texts are college-level, so there is still a need for a high school text after all these years.

There is one last value needed to check. Sadler concluded that 9% (1318 schools with astronomy divided by 15,359 schools) of all high schools offer astronomy (up from the 1977 NSF Survey's 6%). To answer that question, it is needed to find out how many schools teaching astronomy there are in the country, today.

How Many Schools and Teachers Are There Really?

Early in this study, the number of students that had been given credit for astronomy classes in 2000 was calculated to be about 74,000. That was obtained by using AIP data of 931,000 students taking physics that year. That's 35% of all students (approximately, including AP). So astronomy's 2.8% that year (from NCES data) equals 74,480 students in the whole country. Guessing that a class size of 30 for a maximum per section, that's just under 2500 sections. Now some schools are lucky enough to have more than one section of astronomy but most don't. So one could estimate that there are at around 2500 astronomy teachers in high schools in the U.S. and also that many classes, at least, and schools. Given this survey's actual average number of students per class section of 23, then about 3217 classes must be given.

It was hoped that the NRT list would bring a more accurate cross-check or value. But a distressing piece of information was learned; (Stull, personal communication) the NRT only includes about 20% of all American schools and teachers. Given the just-over-2000 teachers on the obtained copy of the NRT, it is possible that would mean there are in fact nearly 10,000 high school astronomy teachers in the United States. This is far higher than the estimate given earlier in this analysis that there could be around 3000 such teachers. Whether the NRT sample is representative of the nation as a whole, or it just happens to include nearly 2000 of our estimated population without significant gain from the rest of the schools list can not be ascertained. It is possible to say that the 1296 unique schools in the NRT list is only about 8% of the 18,435 high schools reported by the NCES and Betterschools.org (2005).

Table 44
Comparison of the Number of Schools Reported by Several States Departments of Education (DOE) and the National Registry of Teachers (NRT)

State	NRT	DOE	DOE/NRT
TX	29	93	3.2
GA	14	≥43	≥3.1
OK	15	29	1.9
WI	46	≥79	≥1.8
NM	20	24	1.2
NC	19	≥28	≥1.5
MI	58	38	0.7

However, a comparison of DOE data versus the NRT list indicates that the NRT consistently undercounts the DOE data only by a factor of two (Table 44).

Leaving out Michigan, the state data averages at least 2.1 times as many schools as the NRT indicates. With Michigan it drops slightly to 1.9, but since the NRT knows of more teachers than the state does, clearly the state data is flawed in this regard. Consequently, our 1296 uniqued schools should be multiplied by around 2, giving 2600 schools. There were around 1700 teachers for that school list, yielding an estimate of 3400 teachers.

The actual average number of astronomy classes taught is 1.77 classes per teacher. Divided into the newly determined number of classes, this might mean that there are only 1800 teachers of HS astronomy! This number is clearly too low as this study has lists totally above two and perhaps as many as three thousand teachers. Other average classes taught estimates have been lower than ours, 1.2 to 1.5 sections per teacher. Our sample totals have a very non-normal distribution; it is very skewed. The median value for these 232 teachers is…1…the 116th number out of 126 on a column, very nearly 2. But with a median of 1, the number of teachers is 3200.

An old unpublished study from the AIP statistics division (Neuschatz, private communication) indicated that about 2.5% of teachers of physics in 1987 also taught astronomy. These teachers had an average of 1.4 classes in astronomy. This translated at the time into 450 physics teachers teaching about 620 astronomy classes in public and private high schools across the nation in that year. But the survey only referred to AIP members that year. In the 2001 AIP survey there were an estimate 23,300 physics teachers. That would predict 582 of them would also teach astronomy. If Sadler's proportions hold today, there should be at least over 1400 such teachers. This is probably the real lower limit. One would calculate from the survey sample a number of about 1500 such teachers. With so many teachers coming from other areas, using just physics is almost meaningless now.

So it is possible to conclude that the number of classes/teachers are around the mid-3000s. But this would be true only for full classes. It is hypothesized that there may be up to 1000 'one-class-only' teachers out there that are generally working in isolation, and getting most of their information and pedagogy on their own, and through their 'day job', whatever other subject they are teaching. Despite other representations indicating a pool that is representative of high schools and high school teachers, it is conclude that this survey is undersampling the one-class teacher population.

The survey's "Work alone" and "Single class teachers " numbers for the states of Georgia, Wisconsin and Texas are very close. With these three states having 16, 20 and 27 percents for small single digit classes, one may expect that counts of the number of high school astronomy teachers may have fully missed about a fifth of the actual population. That is, there is a large pool of single class/work alone/very small class size teachers that are 'hidden' from most surveys and the NRT.

This gives good reason to believe that the approximately 3200 classes are only 80% of the real number. It would be necessary to multiply the count by 1.25 in order to know exactly how many astronomy classes there really are. This gives a total of approximately 4000 classes with very little change in the number of students.

All the estimates and their methodologies of calculating are in Table 45.

Table 45

Comparisons of Values of the Total Number of Classes/Teachers of High School Astronomy in the United States from Each Method of Calculation

Method of Calculating Number of Schools/Classes	Value to the nearest 100	Too High/Low
Survey Class size divided into year 2000 student number data from NCES	3200 classes	
Reduced by 1.77 to find number of teachers	1800 teachers	Too Low
Times 1.25 to add in 'single digit classes'	2300 teachers	
NRT scaled up by 5	10,000 teachers	Too High
Uniqued NRT scaled up by 5	6500 schools	Too High
Uniqued NRT scaled up by 2, then by 1.3 teachers per school	2600 schools / 3400 teachers	
Our sections per teachers median (1) into our 3200 classes, x 1.25	4000 teachers	
AIP physics teachers only, at Sadler's proportions	1400-1500 teachers	Too Low
AIP physics teachers only, at Sadler's proportions scaled up for sections taught	2500-2700 classes	
Our survey class size, scaled up for 'missing classes'	4000 classes / 3200 teachers / 2500 schools	

The percentage of high schools in the United States with astronomy classes is therefore about 12-13%, based on 19,000 regular public schools or 21,000 public + private high schools. The number has gone up in real numbers and proportionately, since 1986.

Case Studies

States

Because this study has Department of Education data and/or large numbers of respondents from some states, it is possible to make small case studies out of several states. The DOE data was acquired for overall survey validity work but the individual states' data can be used here as well. To some extent, then, this section is a mixed of quantitative statistics and qualitative impressions.

In each table below, values are derived from various departments in the different states. "Est." means estimated, "Unkn." means Unknown.

Starting with Oklahoma, it is seen that the survey only has four teachers (one in a private school) from that state, which doesn't make for good statistics or qualitative studies. It is noted that half of the teachers were concerned for the future, that options for students were being reduced and there are hints that teachers will be removed from electives and put into remedial teaching.

However, the DOE provided data so it is possible to get a little understanding about the State (Table 46a).

Table 46a
DOE Data for the State of Oklahoma

Schools	Teachers	Teachers/ school	Sections/ teacher	Students/ section	Work alone	Single class teachers	Sections under 10 students
25	30	1.2	2.6	22.8	22 (73%)	15 (50%)	3 (4%)

The three surveyed teachers represent only 10% of the teachers the DOE knows about (all three are on the DOE list). These teachers mention two other teachers, so the survey has a teachers/school value of 1.7, much higher than DOE data. These teachers teach an average of 3.3 sections, a bit higher than the DOE data, the average class size is 24.3, not far off. One can not compare the other statistics at this point.

This survey received responses from 22 teachers (21 public) in Wisconsin, 22% to 27% of the DOE count, 17-22% counting the 17 active teachers only. There are 2.5 sections per teacher in this survey, 1.7 teachers per school and 23.2 students per class. Eleven of the 21 teachers taught just one section, a bit below the DOE numbers (Table 46b). Only one single digit class was recorded, so again the survey is deficient in reaching a portion of the population. Since only five names were found in common with the DOE data and 12 extras can be added, this survey has an 18% reach into the state's astronomy teacher pool.

Table 46b
DOE Data for the State of Wisconsin

Schools	Teachers	Teachers/ school	Sections/ teacher	Students/ section	Work alone	Single class teachers	Sections under 10 students
>79, possibly 99	>79, possibly 99	-----	-----	24.6	61 (61%)	42 (42%)	21 (27%)

Teachers seem to be relatively unhappy there. They were 33% optimistic, as opposed to 49% for the whole survey (this information will be detailed in Chapter 5). Thirty percent chose "appreciation" for the purpose of the course, only 5% lower than the survey statistic, and 14% each for multidisciplinary and for mental improvement, nearly right on the survey numbers. It has mostly Low Minority schools teaching capstone courses but there is a significant number of "all grades" and "Median" astronomy classes.

Our next survey data, from Georgia, indicated there were 11 public high school astronomy teachers responding. The data works out to be 1.3 sections per teacher and 23 students per teacher. The former is a bit lower than DOE estimates (Table 46c) but the latter is between the two possibilities. Our apparent completeness is 11 out of 43 at least, or 26%.

Seventy-three percent teach a single class, (comparable) and 91% work alone. This survey apparently didn't find enough of the multiple teacher schools.Table 46c.

DOE Data for the State of Georgia

Schools	Teachers	Teachers/ school	Sections/ teacher	Students/ section	Work alone	Single class teachers	Sections under 10 students
43 districts, 50 schools?	Unkn.	Est. 1.62	Unkn.	25.8 (20.8)	Est. 35 (70%)	29 (67%)	15 (19%)

Georgia is as optimistic as the rest of the survey and chooses its course purposes at exactly the same as the whole survey's values.

Table 46d
DOE Data for the State of Texas

Schools	Teachers	Teachers/ school	Sections/ teacher	Students/ section	Work alone	Single class teachers	Sections under 10 students
93	106	1.12	1.78	20.0	81 (78%)		25 of 159 (16%)

The state of Texas is represented by 15 teachers in this survey, all but one giving us all the data needed for this comparison; one failed to give class enrollment.

Class size in the survey is 21.1, compared to the DOE 20.0 (Table 46d). The survey finds 1.9 sections per teacher, just above the DOE's 1.78. The survey also has a low teacher per school ratio, 1.2, just 0.1 higher than the DOE number. Eighty percent of our teachers work alone, very close to the DOE number. Six of 15 teach just one section, lower than the state's 53%. None of the single digit classes were found.

The survey reached 14% of the state's teachers, based on raw numbers but when names are compared, there are only 8 in common. Adding 10 more extra names to the total combination of names and the reach is only 7%..

Texas' schools and teachers can be characterized as less than optimistic. There are six who stated attitudes that were optimistic or somewhat optimistic, and 5 who stated somewhat pessimistic, numbers uncharacteristic of the survey as a whole. It has more schools that are high minority than low or representative. Teachers complain that courses are being cancelled or enrollments are dropping because of high stakes testing and NCLB. There are few, if any, astronomy standards in the state's TEKS standards list, and teachers report issues regarding certification difficulties.

Table 46e
DOE Data for the State of North Carolina

Schools	Teachers	Teachers/ school	Sections/ teacher	Students/ section	Work alone	Single class teachers	Sections under 10 students
>28, probably ~39	>28, probably ~39	Unkn.	~2	25.2	Est. 24 (62%)	16 (41%)	>8(10%)?

The survey recorded only four public schools in North Carolina, a completeness of 10% to 14%. The statistics may be weak. The study found 1.2 teachers per school, 1.5 sections per teacher and class size averaging 27.3 students. There were two single class teachers (50%) and 3 out of four worked alone (75%), both above the DOE numbers (Table 46e).

The North Carolina teachers, therefore, don't make a good basis for statistics in the survey.

Table 46f
DOE Data for the State of New Mexico

Schools	Teachers	Teachers/ school	Sections/ teacher	Students/ section	Work alone	Single class teachers	Sections under 10 students
24	48	Est. 2	Est. 2	20.7	Unkn.	30 (63%)	22 (24%)

Again, a low survey count (4 teachers in New Mexico) which will affect the statistics. Surprisingly, the survey matches fairly well. There are 2 sections per teacher in this sample (and the DOE numbers in Table 46f), 1.75 teachers per schools (close enough) and 20.1 students per section (almost exactly on). One teacher works alone (25%). However, the survey has only one single class teacher in the survey subset; again the survey apparently reached mostly multiple teacher schools. It only reached 16% of the school pool and half that of the teachers.

New Mexico may be low for statistical use but the comments of teachers are strikingly uniform. For astronomy there is optimism (literally and in attitude scores). In this state, astronomy can count as a physics grade, and astronomy enrollment appears to the teachers to be climbing.

Table 46g
DOE Data for the State of Michigan

Schools	Teachers	Teachers / school	Sections/ teacher	Students/ section	Work alone	Single class teachers	Sections under 10 students
32	37	1.15			29 (78%)		

Michigan (Table 46g) has 13 teachers in our survey, netting statistics of 1.2 teachers per school, 1.88 sections per teacher, and 18.0 students per class. Eleven of our teachers work alone, or 85%. In theory, the survey has a 35% completeness factor, but since the number of teachers the state knows about is so much less than the NRT, this value is too high. In fact, when comparing to names in common, it is only 14%.

While the Optimistic percentage is 40% (compared to the survey 49%), and Optimistic + Somewhat Optimistic together 73% (68% in the survey), there is much going on that should cause that to be even lower. There are numerous complaints about planetarium usage dropping, that in many districts astronomy may be going away as a course, to be subsumed into Geoscience, funding is dropping, student choices for science electives are also becoming more limited. The situation here bears watching.

It would seem that this survey generally reached an average of 17% of the DOE base of teachers for each state. But given the fact that when actual names of teachers can compared with DOE data (for which we have three examples-Michigan, Texas and Wisconsin), an approximate 50% reduction in values is found. The survey's real penetration into the population may thus be, in fact, perhaps just 8-10%.

For averages on individual parameters, see the next section.

Several states for which data was requested failed to provide that. They include the large response states of Pennsylvania and Ohio, and a state the survey did not pull as many as one would like, California. Still, there is enough information for which one can paint a small picture of them, though, from the raw data the survey acquired.

Pennsylvania is an interesting case. In describing why a course should exist, 'mental improvement' is essentially tied with 'appreciation'. There are as many Lowerclassmen astronomy classes as Upperclassmen's. No other state has such a balance. It is 40% Optimistic and 57% when optimistic + somewhat optimistic are summed together for the teachers' own schools. Neutral is higher here than usual, 27%. There are several repeated statements about enrollments dropping and about having few if any standards in Pennsylvania classes. Astronomy is appearing in Earth Science courses, and astronomy courses are apparently in some danger as well.

Ohio teachers are a happy lot. Nine Optimists and only 3 non-optimists! Like the other states above, 'appreciation' is the purpose of choice for a class of astronomy about 40% of the time. The course is a capstone 13 out of 17 times. There were no persons who found negative effects of NCLB, indeed one of the rare extolments is issued here by a Ohio teacher.

On the other hand, one can see differences with California. In most states, both stellar and solar system astronomy are taught together and for the much greater majority, in the 80%'s. In California, star courses make up 30%.

Astronomy as a whole has lost a perceived prior elevated status. It has been relegated to an elective, only seniors can take it in some schools, interdisciplinary activities with other courses are reported as fewer than before and twice it is stated that students' science choices are increasing limited and that is causing some pre-enrollment and enrollment difficulties.

Unusual Cases and Non-U.S. Schools

During the course of the survey, some responses came from schools that technically did not meet the specifications of the survey. Nevertheless, sometimes by our request, these teachers filled in the forms so that they might provide some insights or other points of view. In particular, they survey had several strictly Earth Science/Geology classes where astronomy was a significant part of the class. There were three teachers who had tried, successfully or not, to get a course started. They would have no usable demographics but their arguments might have been instructive. There were four schools that were out of the fifty states—two in Japan, one in Canada, and one in American Samoa. Finally there were some simply unusual uses—night schools and alternative schools.

The survey has taken a limited look at these four situations. There isn't enough data for any of them to add to the statistical mix, and in most cases, they aren't all that different from the survey. But it is also worthwhile to see what can be seen.

The Earth Science/Geology classes are all in public schools. Three Passed AYP and one Failed; they were in Michigan, Colorado, Montana and Pennsylvania, respectively, in schools ranging from 560 to 1880 students, an average of 1035. Their 'purposes' were one each of the biggest usual three, 'appreciation, multidisciplinary and mental improvement' with the fourth being 'other' which was described again as "all of them." Two had more males than females though not by much, one more females than males and one evenly split. Two were median grade classes, two were upperclassmen classes. Racially, only two gave good numbers and both of those were majority White, one totally white. One had a portable planetarium, one had a fixed planetarium, the others had no planetarium at the school. One had an observatory, one had three portable telescopes, the others nothing. The average budget was $630 but was that low only because one had a $20 budget, else the group would be higher than the survey average, at $833. Attitudinally, they were mixed; two were optimistic, two were somewhat pessimistic. The teachers' undergraduate degrees were in science (2), math (1) and broadfield science (1). Three had masters, one had a doctorate, no degree of any level were in astronomy or physics though at least two graduate degrees were in some kind of education. For the future of the nation's courses, they were more optimistic. One optimistic, 2 somewhat optimistic and one somewhat pessimistic. Three of the teachers…were not teaching astronomy anymore. Two shifted, one retired, the other is still teaching. For prerequisites, one had none, one had 3 sciences, one 1 science, the other unknown.

The sample is too small for exact comparisons. The schools are on average smaller than the survey astronomy school average. AYP status' are about the same. Gender is also about the same. The racial aspects can't be determined. The teachers were less trained for astronomy or for that matter, earth sciences, though they have the same rough proportions of graduate degrees. Their views of the future of their courses in the school and nation are opposite to the astronomy teachers'. Budgets are higher.

The 'international schools' are an interesting group. One is in American Samoa, one in Ontario, Canada, and two were in Japan but were run by and for Americans—one a Department of Defense school and the other an 'International School'. Samoa is a U.S. territory, technically, but located so far away, it will be treated for now as international.

The Japanese schools were 325 and 1800 students in size, one with classes with more males, one with more females. The majority-male class was a median grade level while the majority-females were in an all-grades class. One had a planetarium and an observatory, the other a portable unit only. The DOD course lasted a year while the other school is still going, though the course stopped briefly for some construction. Consequently, the teachers attitudes were decidedly opposite, the DOD teacher pessimistic and the other optimistic. Both teachers at least had education degrees. The International school had a $3000 budget.

Comments were interesting. The DOD school teacher said "remedial teaching + AP kills enrollments in astronomy." The other school said that packets of information would be the greatest need for a teacher that far from home, though he had the advantage of the two domes and being near Japanese planetariums and observatories.

The Canadian school was 1300 students in size, with a $500 budget. It could be described as a capstone Upperclassmen class, low minority, no planetarium but with an observatory, requiring one Earth science class. He was optimistic for his school and somewhat optimistic for Canadian astronomy courses. Of course, they don't have No Child Left Behind in play.

The Samoan school gave the course purpose as empowerment. It was a 1500 student public school, with no planetarium, two science and one math prerequisites, more females in the class than males, a capstone, and High Minority because it is entirely Pacific Islander! Yet the course is now discontinued as the teacher retired. He at least had two science degrees and many astronomy courses and had taught there for 16 years. His budget was $800, all out of his wallet.

Again, all but one of these schools were larger than the American average high school size and altogether they do average about the size of schools with astronomy on this survey. Budgets, when known, are higher than the survey's schools.

There were three teachers who were trying or had tried to get a course going, one succeeded. The schools were all public schools, in Ohio, Pennsylvania and Wisconsin, smaller than average, 550, 1000 and 580, respectively. The Ohio school was an AYP Fail, the others Pass. All are pessimistic about their situations. The Wisconsin teacher said it would never happen, as it is she teaches 4-5 courses per day of different sciences. The Ohio teacher has never succeeded and the reason is always…funding. The Pennsylvania school *had* a course….which disappeared along with its rooftop observatory over a summer and has never come back since.

Finally, the survey had one online virtual school (class) and one Alternative High School night class. The former was 'single digit' size though it is attempting to consolidate all the other state online courses. The 'school' has, allegedly, 1200 students. It requires one math and two science classes as prerequisites and the teacher is somewhat optimistic for his school and somewhat pessimistic for the fate of the nation's.

The alternative school in New York should be compared with the Colorado Earth Science school. The latter was actually given to us for its night-time astronomy class. Both schools are comparable in size, 560 versus 650. The New York school was 'purposed' for 'mental improvement while the Colorado school was for 'appreciation', which makes sense considering the audiences were dramatically different. The alternative school had more females than males in the classes, high minority (essentially nearly 100% Hispanic), with no prerequisites. The Colorado school is also slightly more female but was a capstone course (racial demographics unknown). And, ironically, both do not exist anymore as the teachers retired and the courses discontinued.

Validities and Limitations

State DOE Statistics and What They Mean

It's a good practice to compare survey results to a complete, known sample. The closest way is to compare the spring survey's largest states' numbers to what was obtained from their state Departments of Education (DOE), where there is usually a statistics group. Completeness of sample, state class size and teacher statistics, such as teachers per school, or sections per teacher are all values that can be obtained or calculated. Using contacts in states who worked in DOE's (as determined by their email addresses) who helped get teachers for the survey plus a tip to the website of a national association for state science supervisors, as many states were queried out of the states represented in the table of 10 largest NRT states and the10 largest state counts in this survey. It might not have been surprising how often astronomy data can not be determined even though students clearly must be credited somewhere and somehow for taking a course in astronomy.

When a contact was successful, data was requested along the line of a list of X teachers teaching Y sections to N students in Z schools, where the data could be used to check class sizes, sections per teacher, teachers per school, and totals of schools and teachers in the whole state. Sometimes this data was obtained, sometimes only parts.

Data was obtained from seven states, Oklahoma, Georgia, New Mexico, Texas, Wisconsin, North Carolina and Michigan.

Oklahoma was one of two states to give all details. Their statistics bureau gave summary numbers as well as teacher listings. There were 25 sites, 30 teachers, 77 sections and 1759 students in the year of 2006-7. This yields 1.2 teachers per school, 2.6 sections per teacher and 22.8 students per section. In terms of teachers per school, 22 out of 25 schools had but one teacher. There was one school with two teachers and 2 schools with 3 teachers. Seventy-three percent work alone. Fifteen of those teachers teach but one class of astronomy (50%). The number of teachers teaching 2 through 6 sections are 6, 4, 2, 2 and 1, respectively. There are three sections with teachers teaching under 10 students.

Texas was the other state to send complete data. The names and data on 187 sections at 93 schools (there are two teachers who also teach at two different schools each) were received. There are 106 total teachers.

Eighty one schools were counted that reported just one teacher, 11 schools with 2 teachers and just one with 3, and no higher. This means a low average of just 1.12 teachers per school. Fifty-six teachers teach just one section, 28 teach two, 16 teach 3, and 5 teach 4 or more sections (7 being the highest). This makes an average of 1.78 sections per teacher.

28 sections reported no enrollment data. Using those that did report, the average class size is 20.0, *S.D.* = 11.5, median = 20.

Wisconsin was one of three states that had just district data. Obtained were the number of Male/Female students in each grade that took the course. However, there was no breakdown by school or teacher or section, just totals for 79 school districts. Some districts, LaCrosse for example, teach many kids, 267 in this district. There are, from the data, 3766 students in the state who took astronomy. It is presumed that there must be one teacher minimum per district, therefore there are at least 79 teachers and 79 schools minimum, in 2005. Using a basic 30 as a maximum, it can be estimated that the minimum number of sections for all the state as 153 (it will, of course be larger if the class sizes are smaller). If in the larger districts, a new teacher is added for every 3 sections, then there are about 19 more teachers, or a total estimate of 99. By this method, there are an estimated 42 single class districts, 19 with 2 sections, 6 for schools with 3 sections, and 1, 2, or 3 schools each with 4 to 10 sections. However, in larger districts, there are undoubtedly more than one school that teaches the class, so that may actually be 99 schools, rather than teachers. The real number must be somewhere in between. Other states rarely have schools with more than 3 teachers teaching, and they are rarely more than 3 sections. Twenty-one (50%) of those single school districts teach fewer than 10 students in a class.

Let us simply use the minimum 79 teachers/schools, and 153 total sections taught for 3766 students. This works out as an average of 24.6 students per class section. The districts with 1 or 2 sections number 62 schools out of 79, or 78%. The number of teachers per school can not be estimated but it must be close to 1.

Georgia sent only the number of students per district. There were a total of 1689 students in 43 districts. Fifteen of those districts gave credit to 9 or fewer students, leaving 28 districts with significant classes, changing the total just to 1668 students.

It is estimated that there are 81 sections being taught which works out to be 20.8 students per section. Using just the 28 districts with double digit class counts, the more realistic average is 25.2.

Cobb County, Georgia teaches more astronomy students than any other county, 369 students or 22% of the state total. Gwinnett County is second, with 187 students and Whitfield County has 104. These three districts account for 39% of all the students, and no other district has over a hundred students taking the course.

Personal knowledge indicates that 6 Cobb County high schools offer astronomy, which makes it generally 2 courses per school. Similarly, 3 schools teach astronomy in Gwinnett and thus 2 sections per school there as well One can therefore say that three districts offer 4 sections, probably at one school, 5 offer three sections, 6 schools offer two sections and 29 offer only one section, 67% of the schools.

A CD of data was received from Michigan following several attempts to get the data. The state listed the personnel of all the schools, like in a mailing list, indicating only what subjects they had taught and grades taught but no classroom statistics. There were 32 schools and 37 teachers of astronomy, 29 of whom had no other teachers of astronomy in their particular high schools. In theory, there is a 35% completeness factor, but since the number of teachers the state knows about is so much less than the NRT, this value is too high.

North Carolina, in 2005-6, had 2014 students take astronomy courses. Of those, 59% took it in two county districts alone, Mecklenberg and Wake. Twenty-eight county districts gave the course and at least 16 of them apparently had it with one teacher at one high school. Using 30 students as a maximum class size, it is estimated that 8 counties had two sections, 2 had 3 sections and 1 had five sections. The two big districts offered an estimated 16 and 25 sections, which realistically means 4 and 7 schools minimum offering it full time. The total estimate is 39 schools offering astronomy and at least this many teachers.

It is also known that the enrollment went down by about 400 the next year. The number of one, two and three sections went to 17, 5, 1 and 1 school with four section, no five section schools. Five small count districts didn't teach it the second year but 4 others were added. Mecklenberg County accounts for 75% of the student loss by itself, and Wake and Davidson went up. The percentages and averages don't change much between the years, just the raw counts.

New Mexico, finally, is in between as the data came as fall and spring numbers. This analysis only considers the former, which was a bit larger and therefore more likely to be statistically more accurate. The data has individual teachers by number and site, with student counts, but no section data. The state also has no common course name or code for an astronomy course; a district can name it any way it likes. The names can be "Geology/Astronomy," "Astronomy 1," "Astronomy" and other ways. Nevertheless they are all the same course, according to the DOE contact (Buser, personal communication).

1907 students got credit in 2006-7 in 24 schools. There were 48 individual teachers listed, 22 of whom taught classes of less than 10 students. This works out to average 2 teachers per school, higher than most states. Using our "30 max per section" rule, there are an estimated 92 sections being taught. One teacher (each) teaches 6, 7, and 8 sections, 3 teach 4 sections, 5 teach 3 sections, and 7 teach 2 sections, leaving 30 teaching a single course.

Five teachers taught between 100 and 199 students, 1 taught 249! The average is 38.9 students per teacher, so the number of sections per teacher must approach 2.

Tables 47a and 47b summarizes all our results of studying the DOE data.

Table 47a

Summary Table of DOE State Data for Course Characteristics

State	Schools	Teachers	Sections	Students	Teachers/ school	Sections/ teacher	Students/ section
OK	25	30	77	1759	1.2	2.6	22.8
WI	>79, possibly 99	>79, possibly 99	Est. 153	3766	-----	-----	24.6
NM	24	48	Est. 92	1907	Est. 2	Est. 2	20.7
TX	93	106	187	3182	1.12	1.78	20.0
GA	43 districts, 50 schools?	Unkn.	Est. 81	1689	Est. 1.62	Unkn.	25.8 (20.8)
NC	>28, probably ~39	>28, probably ~39	Est. 80	2014	Unkn.	~2	25.2
MI	32	37	---	---	1.15	----	_________
Averages					1.42	2.10	23.2

Table 47b

Summary Table of DOE State Data for Course Characteristics, continued

State	Work alone	Single class teachers	Sections under 10 students
OK	22 (73%)	15 (50%)	3 (4%)
WI	Est. 61 (61%)	42 (42%)	21 (27%)
NM	Unknown	30 (63%)	22 (24%)
TX	81 (78%)	56 (53%)	25 of 159 (16%)
GA	Est. 35 (70%)	29 (67%)	15 (19%)
NC	Est. 24 (62%)	16 (41%)	>8 (10%)?
MI	29 (78%)		
Averages	68%	53%	16.7%

Table 48 compares these realities to our survey as a whole and the numbers for the states out of this survey. Included are the results of t-tests or tests of proportions as appropriate.

Table 48

Comparison of DOE Values and This Survey's Values

Datum	Survey-wide	DOE Averages/*S.D./n*	*t* / *p* values
Teachers per school	1.31	1.42 / 0.383 / 5	0.910 / 0.11
Sections per teacher	1.77	2.10 /0.305 / 4	1.937 / 0.05*
Students per class	22.8	23.2 / 2.42 / 6	0.399 / 0.69
Datum	Survey-wide	DOE Averages (percents)	*z* / *p* values
Work alone	68%	68%	0 /1
Single class teachers	55%	53%	. 469 / .639
Class size under 10	~5%	16.7%	3.67 / < 0.001*

*p is significant

There are only 11 teachers who reported a class size in single digits in the survey.

In the states with a large enough survey response, this survey is usually moderately comparable in sections per teacher, students per section, and teachers per school. States with high or low averages tend to have high or low values in the survey even if not exactly the same.

Our average class size in the survey is quite close to the DOE statistics. So are the percentages of teachers working alone and those having just one class! But the last row clearly indicates that the survey missed a lot of teachers who are the only teacher in their school, teach just one section, and often teach just a handful of students. In fact, a test of proportions indicates that there is a statistical difference between our survey and the DOE data for the number of sections per teacher. There is also a statistical difference in class sizes, as determined by a t-test.

It is important to understand how this survey distinguished 'working alone." When there are individual teaching listings for a state, it is easy--no other instructors listed. When the survey has only sections taught, or an estimate of same, how far can one go in saying the teacher works alone? They may teach two, even 5 sections and have no other instructors. Or 5 sections can be taught between 2 or 3 teachers.

The survey has two states with complete teacher and school and section data, Texas and Oklahoma (Table 49).

Based on these two states, most of the courses with 2 or 3 sections are still taught by a single teacher. If one takes the number of times there is only one section taught, add that number to 2/3rds of the number of 2 and 3 section schools, you should have a good estimate of the number of schools with a single teacher. So statistically, when the survey has student counts in total and by teacher but not by section for each teacher, the estimate of schools with one or two sections by number, dividing the student number by 30, is a good approximation to the number of schools with a single teacher, who works alone.

Table 49
Comparison of Texas (TX) and Oklahoma (OK) Values on the Number of Sections Taught by Teachers

Number of Teachers	Number of Sections Taught 2	3	4	5
1	OK 6 TX 5 = 11	OK 4 TX 2 = 6	OK 2 TX 1 = 3	
2	OK 0 TX 5 = 5	OK 1 TX 1 = 2	OK 0 TX 3 = 3	OK 0 TX 3 = 3
3	----	----	OK 0 TX 2 = 2	----
Ratio 1 teacher: >1 teacher	11:5, or 2.2:1	6:2, or 3:1	3:5, or 0.6:1	1:3 or 0.3:1

But, when one looks at this survey's data, coming from about 40 states, the same way, one gets a slightly different picture (Table 50).

Table 50
Number of Sections Taught by Teachers in This Survey

	Number of Sections Taught			
Number of Teachers	2 sections	3 sections	4 sections	5 sections
1 teacher	39	15	3	3
2 teacher	15	5		4
3 teachers	4	1		
4/5 teachers	2	2	1	1
Ratio 1 teacher: >1 teacher	39:21, or 1.9:1	15:8, or 1.9:1	3:1	3:5, or 0.6:1

The ratios all get pushed over to the right by one column, and the column of 2 sections = the same value of 3 sections taught! A more accurate count then of "working alone" would be all the 1 section-no other instructors, plus 2/3rds the number of 2 and 3 sections taught values added together. But since the value of the '3 sections' is about equal to the 1/3rd remainder of the

2 sections, the conclusion above that adding all the 1 and 2 section values together to estimate the ‘working alone’ number when all you have are district counts still seems to work.

Survey Statistics

Non-Response

As high as our percentage responses are, why did some people not respond? Twenty people volunteered or responded to direct queries about their reasons for not responding. The responses fall into four groups. First and most was that they were not teaching astronomy, they were physics teachers only. Second-most was simply not enough time to do the survey—too busy, or the survey took too long to do. Third group was they were not appropriate people; they were a middle school teacher, a planetarium director with no classes of his own, not teaching at all. Only person stated that the survey was too difficult to do. The last group is just miscellaneous: ‘bureaucratic garbage’, health of a relative took time away from doing this, not teaching it yet, computer problems, conferences.

A small number of the non-responders took advantage of the anonymous web survey on non-response during the Last Chance weeks. There was no apparent differences in the responses from the previous volunteered responses. There were four ‘cold’ anonymous responses and two ‘hot’ ones which roughly holds the proportions of how many real responses in each group was received.

A problem with email surveys is now also apparent. Several people found survey invitations in their spam email filters. How many were lost that way can not said but the way the first invitation was stated versus the way the second one was stated indicated that a study needs to be done on how to get legitimate survey invitations through; the survey had more success, by far, getting attention with the reminder messages than the original invitations.

One further test that shows the representativeness of this population and that the responders and non-responders should be no different in their views will be seen in the next Chapter.

Geographic Distributions

Table 1 showed the ten biggest counts of schools *per state* in the uniqued NRT 2007 listing, and the top 10 states in terms of response counts in this survey. While this survey has six of its top 10 states appearing also in the top 10 NRT counts, it is necessary to also compare to other sources to see how geographically representative the survey is. Figure 7 indicates which states are this survey's top 10 response states (italicized numbers) and also the top 10 NRT states (outline numbers). It also shows the top 10 states in terms of population (dark shading and solid numbers). There is again a correspondence, seven of the survey's top 10 states are matched against the census numbers.

The survey did well in some big states in terms of 'reach', such as Wisconsin and Pennsylvania, but had more difficulty reaching teachers in California and New York, the two largest states for numbers of astronomy teachers. It did well in Pennsylvania and Indiana, states with many planetariums. They survey is probably safe on geographic representations—small states had small responses, most large states had large responses, just not all of them.

In addition, the schools in the survey match closely the proportions of public versus private schools, and rural/suburban/urban schools as found in NCES data. This further strengthened the validity of the survey results.

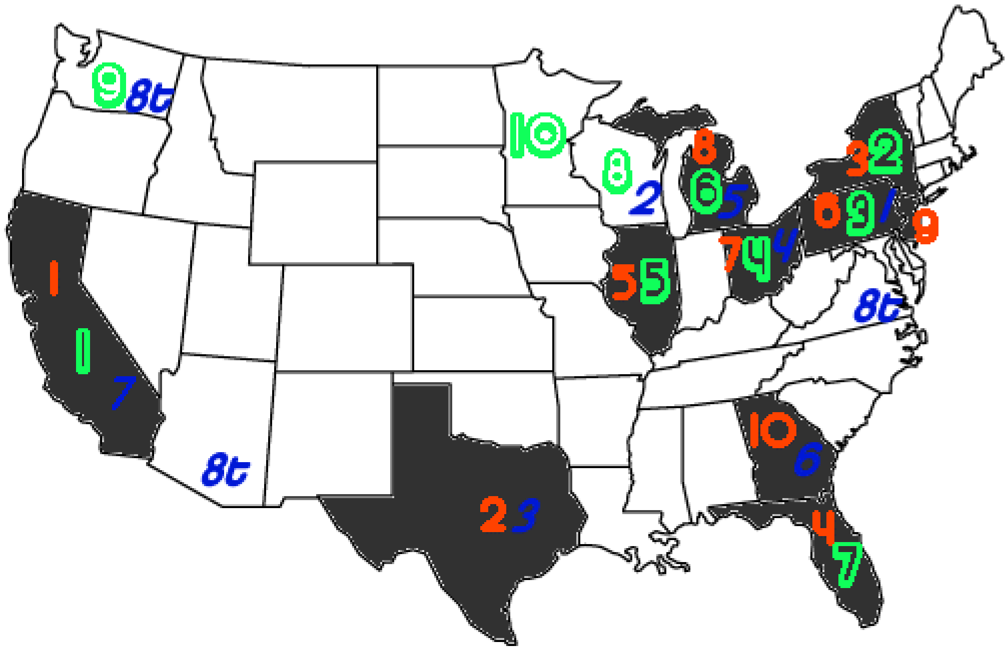

Figure 7. Top ten states in survey response (italic), population (solid), and NRT list (outline).

In regards to planetaria, the top four states in the 2005 IPS directory for planetariums are Pennsylvania (81), Indiana (25), Ohio (21), and New York (17). The first and third appear in our total top count lists. But when filtered for planetariums only, our top states as Pennsylvania (11), Ohio and Indiana (6), Texas and Wisconsin (5). In this regard the survey matches the IPS proportions rather well and only one portable counts in this list. In terms of the six highest states in terms of the number of planetariums known to exist, the survey reached 20% on average in each.

Numbers of Students and Schools

It is of interest now to see how our numbers correlate with others.

Out of 237 total schools in the survey response pool, 85% actually have active courses (i.e. Teacher status is C, C1, or CT at the time), giving 201 active schools with astronomy. These are both public and private. Using raw counts of schools per state and comparing to state DOE data, the survey would have an average of about 17% reach. That is, the number of schools the survey has per state are about 17% of what the DOEs claim. But this is an overestimate because teachers/schools the survey has show up on some DOE named lists (MI, WI, TX, OK) at an average of half that amount, so our real reach is about 8-10%, depending on whether or not those other teachers are added in to the DOE lists. Using the lower value gets 2512 schools. Multiplying by 1.3 to accommodate the number of other teachers in those schools gets 3266 teachers. The number of single-digit classes is 1.25 times as well that number, or 4083 classes.

Rounding off the numbers, and given the uncertainties, it can be claimed that there are 2500 schools teaching astronomy, 3200 teachers and regular classes, and 4000 classes total. This equals 12-13% of all high schools in the U.S..

Given the general rate of 23 students per class, and about 3200 regular classes, this equals 73,600 students. But there is also that hidden mass of small classes, adding 25% to the number of classes, or adding 800 classes. If it is assumed that there is an average of 5 students per single digit class, that adds 3200 more students. The total number of students predicted is now 77,600.

According the NCES (2007c), in the years 2002-3 and 2003-4, high schools graduated 2.7 and 2.5 million students, respectively. Assuming that the nation stabilized this approximately 75% graduation rate for the time period of our survey, and using the NCES value of 3.3% of students taking astronomy courses mentioned earlier, there should be 82,500 students taking astronomy. Given the uncertainties in the values (such as our class sizes' +/- 7 students), the 6% difference is likely not statistical different. This gives added assurance of the validity of this study.

In summary, approximately 80,000 students take astronomy (about 3% or more of all students) in about 2500 schools, about 12-13% of all regular public and private high schools. This is up from Sadler's 9% of schools.

CHAPTER 5

ANALYSIS OF MIXED AND QUALITATIVE DATA

Effects of No Child Left Behind

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?)

Along comes this Act. To say that it has caused dismay in the educational field would be an understatement. To say whether or not it has caused dismay in the astronomy class is the point of this question.

The answers to this question from the respondents were to the point, unlike that of the ‘advice’ question which is analyzed later but was used as a coding example back in Chapter 3. Most of the statements could be characterized not only easily but as a single qualitative coding phrase. Perhaps no more than 5% had two or more codings in them. This compensates somewhat for those respondents who gave no answer at all.

Out of the 237-teacher pool, 30 belong to private schools where NCLB has no effect or standing. Only one person in the private school sector had an answer other than “No effect” that was useful here. Forty more teachers did not discuss any effects on their classrooms at all but contributed various unrelated comments, opinions on the law in general without any astronomy course specific items. Twenty-eight did not respond. The remaining 139 responses were usable with 83 (46%) claiming there was no effect on them from the Act. Forty-six made statements that can construed as negative effects, an amount equal to 26% of the response pool. Only 10 teachers gave responses that could be construed as positive.

Considering those 139 comments which clearly indicated effects (or none) on courses in the high school astronomy course universe, the balance is clearly negative (33%, versus 7% positive). But the most common answer (60%) is there has been no effect on most of these teachers' courses (Figure 8).

The first question to ask then is why do so many astronomy teachers get to shrug off the Act that has caused much controversy elsewhere? The two most direct answers are that NCLB itself only concerns itself presently with Math and Language Arts areas, not science, and that the more direct effects are state-caused, the so-called "high stakes testing" that is NCLB-inspired but directly controlled by state departments of education. Another state-originating effect comes from some states simply having 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 aren't supported.

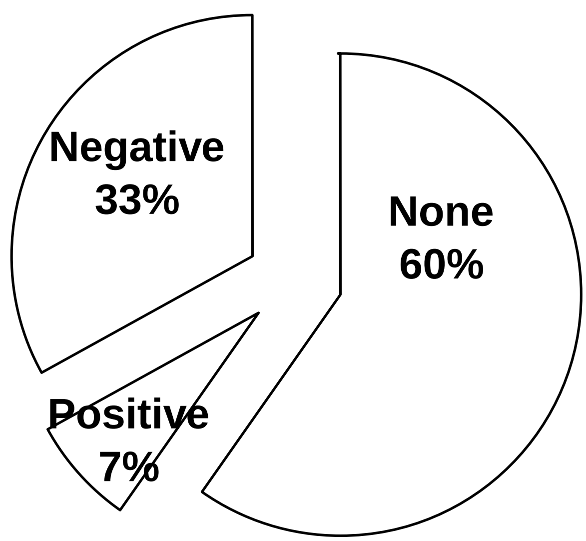

Figure 8. Teachers Reporting Effects of No Child Left Behind on Astronomy Courses

(NOTE: In all the quotations that follow a "Pass" or "Passing" comment means it is a school that had been rated as a Pass grade in AYP. Similarly "Fail" or "Failing" is that it did not meet AYP requirements for passing. Numbers alone, such as "1.5K" or "1500" refer to number of students in the school. There will be cases where the information is not listed because the status is unknown, or not considered relevant to the discussion. Also, the quotes are left intact as typed into the surveys by the respondents, including any misspellings and grammatical errors.)

> The state of Texas wrote their high school assessments to include only biology, chemistry, and physics. As a result, the astronomy course only makes when enough students sign up for it, and I am given no budget. --- Teacher at a 2.5K students Passing Texas high school.

Elsewhere, a Pennsylvania teacher noted that there was "little in the Pennsylvania state standards dealing with astronomy."

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, loss of funding.

Numbers

Teachers report a decline in enrollment due to emphasis on biology, chemistry and physics. As these courses become more state-tested, and therefore more state required, fewer students become available for electives, and students scheduling abilities become more limited.

> Before NCLB, I had 6 full classes of astronomy…now I have 2 classes of 10-12 students --- Self described somewhat pessimistic teacher in a 2K, high minority, Passing school in Texas.

Teachers report that electives receive more pressure. This pressure comes from standards testing. Courses with low numbers, as astronomy often has, find themselves more likely to be the first courses cut, and teachers have to spend more time justifying and/or recruiting. The logic appears to be that more effort needs to be spent on those courses that have state science tests than on electives.

There are other studies that indicate the same effects in other electives. See, for example, Hunt, 2006) and the October 2007 *NSTA Reports*, which has a report that "investment in these programs (environmental education) came to a screeching halt…" (NewsBits, 2007).

Maintaining the numbers is also harder.

> The only effect I have felt is the fact that students are now being mandated to take so many other courses that I have to try to attract students to my elective astronomy classes. . --- Teacher in a large 2.6K Florida high school with a planetarium.

Cancellations

There are not only dropping enrollments, sometimes courses themselves are dropped.

> It was cancelled to make way for core classes in math and science. Our department is the only one in the school where no new teaching position has been created in the 7 years I've been here. We are a PSSA school, preparing for the standardized testing. NCLB has killed the atronomy at our school. Our only hope is that STEE testing along with our NCLB testing allows science to become important again and that the content of that test includes astronomy. --- Self described pessimistic teacher in a 2.1K students Passing Pennsylvania high school with a planetarium.

Some teachers mentioned that they felt the cancellations are just down the road.

> 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 pessimistic, soon to retire Arizona teacher in a 0.6K students Passing high school whose class is open to all grade levels.
>
> I foresee pressure in the future to meet a need for a remedial Science class (or classes) for students who fail the Science protion of the FCAT (Florida Comprehensive Achievement Test), and those demands will take precedence over elective Science courses, such as Astronomy, that will fall by the wayside. --- First year in the course teacher in a small 500 student Passing Florida high school.
>
> So far my long time relationship with the district and region have insulated me from growing restrictions of NCLB. However I Have been informed that it is likely the course will not be continued when I retire since there are no specific PASS objectives at the state or national level. … The STATE has new laws channelling all students into specific courses and leaving litte romm for electives. --- Self described somewhat pessimistic teacher in a 2.1K, Passing Oklahoma school that uses a portable planetarium.
>
> 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

> We have noticed a rpessure form (sic) guidance counselors on a last resort basis. Now a distraction. --- Teacher at a large 5.5K-students New York high minority Passing high school.

Teachers have reported a large increase in students with lesser academic abilities put into their classes. In addition, because NCLB mandates that all groups of students must pass in order for the school to be labeled a passing school, more special education students are finding their way into astronomy classes, despite the fact that often there are prerequisites of prior passing grades in math, especially algebra, and other sciences. Eight of our 46 negative commentators brought up the effects of inclusion, more 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.

Counselors put 504 students in same class with those taking AP Statistics and AP Biology/Chemistry! No Child Left Behind is a great political statement, but it does no one any good to put the two extreme-needs types in the same classroom. --- Teacher in a large 3.8K students Passing Texas high school in first year of course.

A significant number of specifically learning-disabled students have been placed in a class they are ill-equipped to handle or succeed in. --- Former teacher from a 3K Georgia, Passing high school.

All three sections offered at the school are inclusion classes with the special education department. The students abilites range from limited literacy/limited math to gifted students. Even with differentiation it is difficult to meet the needs of all learners, especially when it comes to the math involved. --- First time teacher of a grades 10-12 astronomy course in a 2.1K New Mexico high school.

NCLB has impacted the course in a way that prevents high performing students from getting a complete experience in astronomy. Too much time is spent either preparing activities for the lower performing students or in assisting them with their understanding. --- Teacher from a small 300 student Passing Ohio high school.

At least one teacher thinks NCLB has directly affected even the best students' attitudes.

NCLB has negatively impacted the attitudes of students. Students are less motivated and seem to have less curiosity than in former years. --- Teacher in a 1.8K students, Passing . Ohio high school with a planetarium.

Teaching qualifications

More than a change of emphasis on various courses is evident; changes to teaching assignments occur as well.

> I think NCLB was behind the push to require chemistry for all juniors which then left no teacher available for astronomy. Administration wishes all students to have the same background, perhaps to make sure they are 'taught to the test'. --- Self described pessimistic former astronomy teacher at a Maine 2.2K high school.

> It limits the number of teachers that are eligible to teach the course. Astronomy is a course that I truly feel the instructor has a love for. By limiting the number of teachers eligible you may be potentially limited the best person for the job. --- Former teacher from Michigan high school.

Some teachers have had to make a choice in what they can, or will, teach:

> After teaching Astronomy here for four years, I was unable to teach this class due to this act. I have not taught it for 2 years. … I am not certified to teach Astronomy, even though I have 9 hours of college credit in Astronomy. I would have to take a test through the TEA which would have to be composite - Physics, Chemistry, Biology - with perhaps 5 question total from Astronomy. Not only does this cost money to be recertified and to pay for the test, but it would enable an administrator to be able to control what I teach each year. It would be my choice to not teach Physics or Chemistry. I am certified in Biology, but have a very strong interest and am very knowledgeable when it comes to Astronomy. So in order to remain in control of what I teach, I opted out of recertification. I have taught school for 27 years it is my personal opinion that if you can teach one subject, you can learn another and teach it well. Case in point, there are brilliant astronomers who would not be able to teach high school students. --- Former astronomy teacher in a 2.8K Texas high school that otherwise is Passing and has a portable planetarium to use.

Some teachers have found the choice forced upon them. In an email from a teacher following the formal end of the survey, this certification issue was further and vividly exemplified.

> 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 ave (sic) 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] Award … for teaching high school astronomy but can not get the state of … to acknowledge I am highly qualified.

The testing for highly qualified smacks of age discrimination for all us teachers who have been in the field more than 15 years. No such tests existed when we were doing all our certification requirements. I don't have an Astronomy degree and if I did I probably would be in college or research not teaching high school. I started teaching astronomy because I had a life-long passion for the subject. I have held several offices in my local astronomy club and twice served as a regional chairman for [an national amateurs group—name omitted for confidentiality] - Even conducted teacher training sessions in all three of (his state's) largest school districts. But on paper I am not highly qualified.

Anyway I am finished venting. But some sort of national test needs to be available to allow secondary teachers to demonstrate their expertise in a subject that is not widely recognized by individual states. Since school systems have to comply with all the regulations of NCLB they are going to be reluctant to introduce new programs that are difficult to certify. …

Another teacher's tale:

The only effect on 'my' astronomy program has been that a teacher was displaced from the middle school due to a lack of 'highly qualified' status and bumped our geography teacher. This made it necessary for me to be displaced from my freshmen feeder class, which is now taught by the geography teacher. Over time, as I assist him in developing more effective ways of teaching the class, I may recover (enrollment numbers) in my astronomy classes. Next year doesn't look good. --- Self-described somewhat optimistic teacher in an 800 student Michigan Needs Improvement school, and a portable planetarium possessor.

A third such event, occurring during this dissertation's revision process, was a highly active in astronomy education high school teacher in California being told that to meet a budget shortfall, she (a one-year from retirement teacher) would be layed off and the planetarium closed (along with many other non-core personnel, such as librarians. As of this writing, even a public outcry has not turned that decision around.

Loss of status

Teachers report that astronomy is being ‘left behind’ other sciences.

So much emphasis on reading, writing, and math that science has been peripheralized in my district. --- An Alaska teacher at a 2K students Passing high school.

No child left behind seems to only look at the traditional sequence courses of Biology, Chemistry, Physics. Local universities are the same. I am unable to convinve one local university that astronomy should count in place of their 'algebra based chemistry or physics' admission requirement. --- Washington state teacher in a 1.2K Passing high school.

Students are required to take Biology and two other Science electives. NCLB does not empasize (sic) 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.

This no longer counts as science credit for students. --- Teacher in a 1.3K students Pennsylvania high school with fixed planetarium and Pass status.

Elsewhere, teachers report their particular course “gets little respect” or feel “a sense that it is not important.” As an example…

It's not so much no child left behind as CORE 40. Astronomy is NOT a CORE 40 class so it's not considered 'important.' It can still be taught as a science elective but NOT as a science credit toward graduation. --- Self-described former teacher from a 1.5K student, high minority Indiana high school.

Loss of funds

With a loss of status seems to come a loss of financial resources as well.

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 students AYP passing high school.

Perhaps it has drained some money away from from all academic departments. School districts in Wisconsin are under a very strict state governance regarding the money they

> get from taxpayers' property tax. It severely limits any increases in spending. The money from NCLB has to come from somewhere....it may come from school budgets for materials and additional staff, etc. --- Self described somewhat pessimistic teacher in a 1.2K-students Wisconsin high school who teaches an all-grades astronomy class.
>
> 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.
>
> if a course's material wasn't in the standards or on the tests it didn't receive much budget. --- Another former teacher from a different small school in Wisconsin.

Secondary effects

There are secondary and indirect negative consequences as well. Some teachers apparently can no longer go to astronomy education-related workshops.

> 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 this comes from Pennypacker (2008) who coordinates a global version of the Hands-On Universe (HOU) program. Charting the number of teachers who have taken the HOU training program year by year, a rising trendline is abruptly plateau at the 2001 year mark, and begins to descend in 2004, when the War in Iraq began (Figure 9). Granted, other things in that year may also have had an effect and perhaps there was a logistical limit reached but this is just one example of claims mentioned by teachers that begin at this time period.

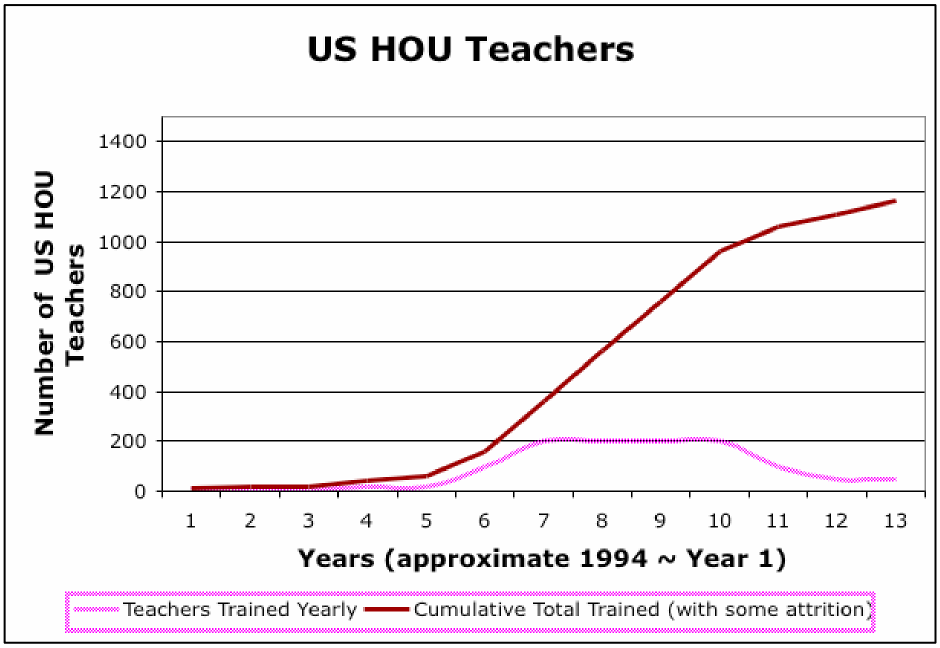

Figure 9. The number of teachers taking the HOU workshops, 1994 – 2007, from Pennypacker (2008), used with permission.

They also can't call in as many outside resources, either:

> we [astronomy club members] have seen a drop off in the number of request fopr the cliub (sic) to come out to schools and put on star parties. Teachers are commenting that they are so under presure(sic) 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.

Teachers also have fewer opportunities for collaborations and consequently there is a stifling of teacher creativity:

> NCLB has greatly inhibited other teachers in other disciplines from taking advantage of the interdisciplinary nature of astronomy. For example, when we were launching rockets, I offered to show the geometry teachers how to turn this into a good example of the use of right triangles. No one has ever taken me up on my offer. The primary reason is that there is no room in the curriculum for innovation or special projects. --- California teacher in a 3.4K Passing high school.

> Creativity is lost sometimes even if collaborations are not a factor.

> My main issue is the focus my state is placing on inquiry learning and the difficulties with creating adequate physical labs for a field like astronomy. I incorporate physics and chemistry labs and astronomy data collection, but its hard to find time for all that. --- Teacher in a small 600 student Arizona high school.

Another, second teacher reported that teaching to the standards so intensively creates no time to bring in current astronomy news topics. And a third teacher says it adds to the work load:

> negative effects have been more indirect, & usually involve extra outside work on my part. Examples would be producing documents showing how course objectives fit with state standards, more roadblocks in choosing or changing text materials. --- Teacher in a 1.8K-students Passing Missouri school with a planetarium.

For the students, the shift in emphasizing core sciences over astronomy has a chill on their abilities to apply to colleges.

> Too much emphasis on core courses, especially lab sciences such as Chemistry and Physics. Colleges do not recognize the lab work done in astronomy. As a result, most college bound students do not take an astronomy class at the high school level. --- Teacher in a 1.6K-students West Virginia high school with a planetarium and a grades 10-12 astronomy class.

There are logistical problems reported as well.

> NCLB and other state mandates have pushed students out of the classroom for more and more testing. The interuptions and attitudes created by NCLB reduce either the enrollment as students become limited in their choices, the number of meaningful days of class are reduced, or other science disciplines are deemed 'most important' compared to Astronomy. --- Teacher of 9-12 astronomy class in a 1.8K students Michigan high school with a planetarium.

Positive Effects

Fewer positive effects are reported than negatives. Two of them are at odds with some previously mentioned negative effects. One of these is enrollment. In some places courses are actually experiencing increases in the number of students.

> 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.

Similarly, in Illinois, in a larger 3.2K student, minority, Needs Improvement high school, a teacher reports that some students who do not wish to take Geoscience or physics take astronomy, thereby increasing his enrollment.

The other at-odds positive effect is the paradoxical increase in the amount of astronomy, but not in the number of astronomy courses. Here, the astronomy courses themselves are eliminated but more astronomy is put into certain geoscience courses so that the net effect is that more students, at a lower level, actually get more astronomy than they otherwise would have had.

> Negative=going away as a separate course. positive= incorpirate (sic) a meaningful amoutn (sic) of astronomy in new Earth Systems course. More firmly in curriculum for all students. --- Optimistic teacher at a 1K-students Passing Michigan school who claims his optimism because he stands to gain from more Earth/Space Science students.

Positive effects, besides upping some schools' enrollments, include more literacy work and math work.

> Positive: I incorporate more writing and math work in my course. --- An Alaska teacher of a grades 10-12 astronomy class at a 1.4K students, Needs Improvement high school.
>
> 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 students, high minority, Needs Improvement school in New Mexico.

Some teachers see positive effects in the future more than the present. For example,

> Starting next year, I believe, science scores could be included in schools' AYP for NCLB. With more testing being done in science, there should be an increased emphasis on science instruction. Already it is obvious that the present science testing includes Earth science and astronomy questions that require Earth science and astronomy instruction for all students. If there is increased science testing in the future (which seems to be the trend), then there will be greater possibilities for increases in Earth science and astronomy instruction if for no other reason than for schools to raise their overall science scores. --- Teacher in a 1.2K-student Passing Wisconsin high school with a fixed planetarium.

Why 'No Child' Has No Effect

It is worthwhile to examine some of the reasons given for the lack of effect on the course by NCLB. The most often credited salvation is that the course is offered only to seniors, who have gone past all the high-stakes testing that could affect a course. Seven of our NO EFFECT coded teachers mentioned that the course in no danger because it is only for seniors or upper division students who have essentially passed all the NCLB-created hurdles, such as graduation or mandated end-of-course tests.

> California has no Astronomy science standards, thus the ONLY way the school will not be penalized for students taking this science is to restrict enrollment to seniors (who do not take the state-mandated standardized tests*)*. --- Teacher in a 2K-student, Passing California school.

A paradoxical solution also exists out of NCLB effects. Standards can be helpful, if your course can be created using NCLB-“approved” standards. But more often, the salvation is that the astronomy course has no state requirements, standards or mandated testing; if so, it may be left alone by the administrations that are more concerned with students giving acceptable pass rates in math, language arts, and state-tested sciences like biology or physical science. This last rationale is at odds with some other schools, where courses are cancelled precisely because the astronomy course isn’t tested!

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

In summary, the existence of, or lack of, astronomy standards is not a determiner of successful warding off of NCLB effects.

More helpful to that success is having firm commitments from administrators, and perhaps student size. Large schools may be able to let an astronomy course fly by under the radar than smaller ones, but that is not a certainty either.

Future of the Course in the School

“I am [Optimistic, Somewhat Optimistic, Neutral, Somewhat Pessimistic, Pessimistic] about the future of my astronomy course in my school.” Now explain why here.

About their schools’ courses, teachers are on the optimistic/somewhat optimistic half of this attitude spectrum, 162 (117 + 45) to 55 (21 + 34)(see Table 51). Optimism is the far more numerous of the five specific choices, with a count of 117 and a percentage of 49%. The four other options are lower but comparable to each other in count, with “somewhat optimistic” having the second highest count (45), and the others range down to 21.

Table 51
Counts of Teachers with Points of View on the Future of Their Course in Their School

Pessimistic	Somewhat Pessimistic	Neutral	Somewhat Optimistic	Optimistic
21	34	20	45	117

The center of mass for the options with pessimistic = 1 and optimistic = 5, is 3.9, very nearly in the somewhat optimistic column.

Analyzing the explanatory responses for teacher local course attitudes, and its U.S. future counterpart that follows, are done slightly differently from the other qualitative questions. As before, each response is coded by its apparent theme (e.g. lowering enrollments) but it is also coded with its associate attitude [Pessimism, etc.] After the initial codings, the responses are stratified by the attitude and each is examined separately. Furthermore, while most of the responses generated just one theme, some have multiple themes and some of those multiplicities were both positive and negative.

When the initial coding and stratification was done, the number of response themes was totalled. A second count was done after grouping responses into larger, broader categories (e.g. student related, administration influences, and so on). Responses with more than one theme (whether identically positive, identically negative or mixed) were divided up and apportioned individually to all the categories found within. Thus, we counted not only the number of responses per theme but also per category and the number of responses may add up to more than the total number of respondents. Also, since sometimes there was a attitude selected but no explanation given, or an explanation with no attitude, the totals here do not necessarily equal the straight sums of attitudes listed in Table 51.

Viewpoints by Attitude

Optimists

There were 88 optimistic themes of which devolved into 28 positive categories, two more that were ‘mixed’ and 3 negative categories to “why” they feel optimistic. A positive category would be something that contributes to advancing the course, furthering or improving its condition. A negative category would be a worry or condition that causes distress or hindering the course or teacher in some way. A mixed category has statements that include both other categories.

By far, the greatest number of responses for optimism on the future of the course in the local high school belongs to ‘student interest,’ twenty five responses in this one category alone. Next highest were ‘increased enrollment’ (15) and ‘support of the administration’ (10). Other responses with at least 5 responses include “facilities would be wasted” (8), said by those with observatories or planetariums, ‘teacher’s own enthusiasm’ (7), ‘state requirements’ mandating the course and/or an ‘increase in students taking more science courses’ (7), and ‘community support’ (6). Typical responses in support of some of these points include:

> It’s growing at alarming rate. Becoming too big. Job security! --- Fulltime astronomy teacher at a 4K Passing Indiana school with a planetarium.

> The number of students wishing to enroll is increasing. Those that are taking it are excited about what we do, and they tell other students, thus generating interest. --- Teacher in a tiny Arkansas public school.

> The administration made the investment in the StarLab, and I have gone from one section two years ago to two sections last year, to 3 sections this year. --- Teacher at a 650 student Pennsylvania public school.

> Since Texas is increasing the number of science credits needed to graduate from 2 to 4, this class and others will continue to grow. --- Teacher at a Passing school of 1.8K students in Texas.

New Mexico has dictated that students need three science credits to graduate (one each in life science, chemistry and physics). Astronomy is classified as physics and thus meets this graduation requirement. The number of sections taught is dependent on the number of students selecting the course. In 2007 - 08, there will be at least two sections of astronomy. --- Teacher at a 1.8K student Needs Improvement school in New Mexico.

Planetatrium has been recently upgraded, enrollment has increased, good feedback from students, new textbooks ordered for next year. Also, increased state requirements in numbers of sceince courses to graduate. --- Teacher at a 1.8K Missouri public school.

As an alternative to physics the enrollment is increasing (2 sections last year, 3 this year, 5 next year). The students are quite interested in the Astronomy semester of Geo/Astro so they are more eager to learn the content, over all. --- Teacher at a 2K-students New Mexico public school.

Other responses include:

- “Will always have students.”

I have three classes in the fall. They accommodate 90 students, and the first year I had 93. Between the junior and senior class, 180 enroll for the class. Only 90 are placed. --- Teacher at a 700 student Michigan Pass school.

- “No change in enrollment expected.”
- “Students get college credit as well as high school credit.”

Kids love it, and get dual credit for college. It is largely non-mathematical, except for Keplar's laws, and I could probably fill 3 sections/year if I had time. --- Teacher at a 600-student public school in Iowa.

- “As long as the teacher is there, it will run.”

Students like taking it and I like teaching it. It will flourish as long as I am here. --- Teacher at a 1.1K students Needs Improvement Ohio school.

My administration really supports a variety of science offereings, so as long as I keep students motivated and they keep signing up, the future of course is fairly secure. --- Teacher at an Arizona Pass school.

- “School tradition and pride in the course.”
- “Good PR for the school to have the course.”

It meets the needs of our general level students. There is some administrative prestige and pride at being one of very few schools able to offer astronomy. --- Teacher at a Florida Needs Improvement school of 1600 students.

- “There are second courses/more sections/more teachers being added.”
- “Fills the need for upper level science courses.”
- “Fills the need for lower level science courses.”

> This is a required course for standard (non-honors) students. I feel that they gain an appreciation for the world around them in general from my course and I am supported by my administration. --- Teacher at a tiny private school in Pennsylvania.

- “Has produced science and astronomy majors.”

> 1. Enrollments have remained steady for the past 10 years.2. Students consistently rate the course highly in their evaluations.3. We normally have 1-2 of our graduating seniors decide to major in astronomy/astrophysics in college, and several of our graduates have obtained doctoral degrees in astronomy or space science. --- Teacher at a private New Mexico school with 1100 students.

The only damper on the optimism are three categories with concerns on student levels and attitudes. One teacher complains about the course becoming a dumping ground for low achieving students, another complains about “senioritis” being common in the students of the class. Two optimists commented on how astronomy will be taught more in Earth Sciences (or using Earth Science standards) but not as a separate course therefore they were happy to see more astronomy despite the loss of the course. An additional negative theme is that competition from other electives (whether other sciences or AP classes) may impinge on the course’s future.

> Student interest remains high--enough students choose to take the course to offer two sections each semester. However, new science elective courses are coming online that may compete for the same students. --- Teacher at an 1.8K students, Failing school in Washington.

Still, in this group, this teacher expresses the ideal situation for the continuation of an astronomy course in a high school:

> Administration wants it, science teachers want the course, guidance wants the course, students want the course (elective), the publicity Astronomy gets is great public relations for the school. ---Teacher at a 1.8K student Wisconsin Needs Improvement school.

Somewhat Optimistic

We see the beginnings of several trends with this group. First, unlike for the Optimists, mixed attitudes (a positive coding paired with a negative coding in the same response) increase here but it is also rare that more than one like-attitude appears (two positive themes or two negative themes). It is nearly always one theme per attitude per teacher. Secondly, not only does the number of responses and categories diminishes but there are no large count themes. Opinions are widely spread.

There are still more positive than negative responses. Forty-four responses generated 21 positive categories, 7 mixed and 8 negatives. The largest category, and the only one with more than 3 responses, remains 'student interest' with 11 responses. Categories with three responses are 'student attitudes and levels', the 'interests in the course by teachers' (or *other* teachers), and a negative reason, the 'effects of periods' and other influences reducing the number of courses that can be offered.

Supporting responses are generally identical to those of the optimists. Some newly appearing themes will gather prominence in the more pessimistic part of this spectrum. New themes include:

- "Going on trimesters has increased the number of courses that can be offered."

  > It is a long established course. Also, we are looking in 2 years at converting to trimesters and this would allow studnets more opportunity for electives --- Teacher in a 1.6K Pass Michigan school with a planetarium.

- "Other teachers want this teacher's job!"

We have a dome so there is a need to use it. A young teacher has a stronger Astronomy background than I (which is 1 course) and I am retiring soon. He is anxious to take it over. Several teachers in training have seen the course and facility and hope to apply as I retire as well. --- Teacher at a 3.2K student, Needs Improvement Illinois school.

- "Highest science scores in the school."

For the most part the administration leaves me alone because my students get the highest science scores in the school on the earth science test. --- Teacher at a California, high minority, AYP Pass school of 3.4K students.

- "Steady enrollment."
- "Course is current, unlike other courses."
- "Sky is always popular."
- "Administration will find a replacement for retiring teacher."
- "Internet access saves the course from the effects of remedial courses."
- "No pressures at all."

Negatives include:

- "Going on trimesters/periods has decreased the number of courses that can be offered."
- "Remedial courses are killing astronomy, reducing number of students and teachers available."

Since Astronomy is an elective, it is not on the immediate radar of adminstrators. They are more focused on required content courses (e.g., Earth Science and Biology). However, more electives are removed from the school curriculum to make way for test preparation courses (e.g., junior year math enrichment). Fortunately, the public interest in Astronomy is high and therefore I doubt our district would replace the course. If anything, I hope that Astronomy will be seen as an avenue for increasing students' science literacy and interst in science. --- Teacher at a 1.2K-student Passing Pennsylvania school.

- Teacher may be/has been shifted to other classes.

We currently have a 1 smester freshman course that is required for WASL testing (high stakes test for Washington State due to NCLB). We may change that to a 1 year course which could reduce my availablity to teach astronomy. --- Teacher at a Pass, 1.7K-students Washington school.

- "Not enough time in the schedule."

> We may switch to a 6 period day, which would eliminate the number of electives students could take, so less my sign up for astronomy. --- Teacher at a 500-student, Pass, minority school in Washington.

- "Extra teacher causes deep drop in enrollment."
- "New courses reduce enrollments."
- "Students rebel against higher standards."
- "Pressures on enrollments from AP and higher science courses."
- "Teacher is retiring/temporarily leaving and course will go."
- "Lack of administration support."

Neutral

Neutral responders gave only 21 responses. They fell into a slightly less than neutral distribution, 4 positive categories, 4 mixed and 6 negative. A typical response is similar to this one:

> As states are forced to deal with the recession especially in Michigan, cuts will be made. Since Astronomy is not considered an essential science like Biology or Chemistry is, it may be a course that is cut. Two, we teach our Astronomy class in the planetarium, a building off-site from our high school. Administrators look at the building as not a necessary part of a school system. Considering these facts, Astronomy in our school could be eliminated. However, we have had many years of successful Astronomy and that may be enough to carry Astronomy in the tough days ahead. Tough times but a popular program makes my answer neutral. --- Mixed opinion from a Michigan teacher at a 1.8K-student public school.

The largest positive response, once the mixed codes were distributed, was student interests, again. The largest negative count was still on student lower levels and poorer attitudes but it also a small increase in responses along the lines of lack of administrative support.

> The students support the work by their enrollment; however, as stated above, the administration considers this the least important. --- Mixed opinion from a teacher at a Passing 1.8K student Ohio school.

> low numbers in this class result due to scheduling not student interest. --- Teacher at a Wisconsin public high school.

Interesting new positive attitudes:

- "As long as students want it."

  This is an elective course and as long as there are many students wanting to take it, then this will be offered. --- Teacher at a 1.5K Washington public high school.

- "Will increase because of a non-core requirement status."

  All students are about to be required to take a non-core science, so enrolment should increase greatly. However, too many students will be looking for an easy science credit rather than having any interest in astronomy. --- Mixed opinion from a teacher at a 2.8K student Texas public school.

  New negative attitudes include:

- "Public disdain of science."

  (Will run) As long as I am here. We are heading towards a public disdain of science, scientists, education. --- Mixed opinion from a New York, 5.5K Passing, high minority high school in New York.

- "Budget cuts have lowered enrollments."

  BUdget cuts have cut a section, but won't go away --- Teacher at a 1.3K student Passing Washington school.

- "Too much work for one section."
- "Hard to justify without standards."

Somewhat Pessimistic

We start to see an interesting symmetry, the distribution of categories is almost a mirror image of the Somewhat Optimistic. There are 21 negative categories, 3 mixed, and a single positive. The four largest negative categories have all been previously but at lower rates, except for the biggest one: Retirement of the teacher and subsequent cancellation of the course (6). The other negatives are 'effects of changes due to NCLB and testing' such as more emphasis on bio, chemistry and physics and reduced scheduling to accommodate remedial work (6), 'students' lower levels and attitudes’’ (4) and a lack of administration support’ (3). Examples of negative responses include the following:

> We recently have adopted an 'excellence' attitude. This provides students with additional opportunities to take more honors or AP courses. With these additional course offerings, I have already seen my enrollment dropping. Along these same lines, we are 'dropping' physical science from a ninth grade requirement and letting the middle school teachers pick up the pieces. This is not good. I am afraid students will be coming to my class more unprepared than ever and I will need to 'dummy down' my curriculum. This will drive away the really bright kids who usually enroll in the class. --- Teacher to all grades at a 1.2K student Wisconsin public school.
>
> THE SUPERINTENDENT OF OUR DISTRICT WOULD LIKE TO ELIMINATE ALL EARTHSCIENCE CURRICULUM. Fulltime astronomy teacher at a high minority Arizona public school.
>
> Have been informed that it is likely the course will not be continued when I retire since there are no specific PASS obejectives at the state or national level. Also the STATE has new laws channelling all students into specific courses and leaving litte romm for electives. --- Fulltime astronomy teacher in an Oklahoma 2.1K-student public school.
>
> We have just had a change in the administration (head master) who has not fully accepted the rationale for continued astronomy at the school. He wants to return to a more basic, 3 year requirement of 1 full year of physics. Our requirements are: 3 years of science, 1 bio, 1 chem, and either 1 year physics or 1/2 year physics-1/2 year astro. --- Teacher at a 400-student private school in Illinois.
>
> The astronomy course has been dropped from the school curriculum in favor of teaching more toward standardized tests (state tests). --- Former teacher from a 2K-student, high minority public school with a planetarium in Texas.

Some negative responses have more, well, attitude.

- Teacher will quit if switched to a lower class.

> With low attendance figures and less of an emphasis on space sciences and astronomy, combined with a great shortage of science teachers being attracted to the school, I feel they may make me teach a core science class in the future. I would leave the county school system if I were forced to teach something other than astronomy. I came here because I was hired to teach astronomy and run the planetarium. --- Teacher at a West Virginia 1.6K students school..

- No standards, no course.

  The district is not happy about my course because there is no state standard for astronomy. Their conclusion is: if no standard, the course isn't worth offering. --- Teacher at a high minority 1.8K student California high school.

- Not enough earth science teachers so course cancelled.

  Astronomy is taught in Earth Science. In the state of PA, a lack of certified Earth Science instructors, plus pressure to add more and more Bio, Chem, and Physics levels, has meant that districts are under pressure to eliminate Earth Science (and Astronomy with it). Where Earth Science has not been eliminated, it is moved to middle school where the teachers do not need to be specifically trained in Astronomy. Currently, we are one of a few local districts that have managed to hang onto Earth Science as a high school level course. Upcoming state testing may help since state standards do include Astronomy at the high school level. However, even here I am somewhat pessimistic since past practice indicates that most schools will do poorly in Astronomy at the high school level which may prompt the state to eliminate Astronomy standards. If that happens, Earth Science will disappear as a high school class in PA taking Astronomy with it. --- Teacher at Passing 1.3K-student Pennsylvania high school.

- Astronomy cut as well as AP physics.
- Teacher was switched and course was cancelled.

Nearly drowned out in the flood of negative responses is the only positive response, that there is still a need for another science.

Pessimists

The Pessimists number barely more than the Neutrals, 18 responses in all. When devolved into categories, it is symmetrical in proportion to the Optimists, 11 negative categories, one mixed and no positives at all.

The greatest negative reason is that the course was cancelled upon the teacher’s leaving the school by retirement or for other reasons (5). Blips on the radar include requirements leaving no space for astronomy, and a lack of funds (3 each). There are smaller numbers for the continued appearances for no administrative support and lower student qualities.

> I am no longer teaching at this school, and astronomy is no longer being taught. The observatory is now unused, as are the other telescopes. The grant has ended and no more funds are coming in to help the astronomy program. THe district has been unable to find another teacher able and willing to teach the content. Essentially, the astronomy program is dead. This is the second time that this has happened in the school. The first time, the telescope was being used and astronomy was taught in the 1980's/early 1990s. It died off (not sure if the enthusiasm of the teacher died off, or what was the cause) and the course ended. When I started teaching there, I restored the scope and the course. Now that I have left, it has died off again. Very sad. --- Former teacher from a Connecticut 1.K high minority public school.

> Our school will be implementing cost savings measures in the next two years which include changing the schedule and graduation requirements. These combined changes will make fewer class periods available to the students, and as astronomy is an elective, I anticipate my enrollment dropping. --- Teacher from a Passing 2.3K student Wisconsin school.

> Enrollment is low, it is often dropped by the administratin due to 'lack of interest', yet students don't sign up or plan to take it down-the-road because it's availablility is questionable. We have increasing enrolloment in Conceptual Physics and Chemistry, which pulls staff away from lower enrollment courses, as the number of Physics and chemistry sections continue to grow. --- Teacher of a single digits class in a Wisconsin 400 student public school.

> when a freshman center was opened I had to go and my new principal would not allow me to contiue to teach Astronomy so the course died 2 years ago. --- Teacher at a 1.3K passing Pennsylvania school with a planetarium.

> The course did not make for next year. As stated above, the course is harder than average kids want for a science course. Above average kids would rather take an AP cours.e --- No longer teaching astronomy teacher at a 1.2K Maine public high school

Generalizations

It is revealing to look at the actual counts and percentages of response themes (Table 52). A negative value is used for both negative themes or pessimistic attributes. “Net” means there is a sum of positive and negative values in the same attitude.

We see good indicators of pessimism: the amount of reduced scheduling and what happens when a teacher leaves the teaching post. The former appears in our spectrum as among all but the most optimistic while the latter is found only among the two pessimistic attitudes.

Table 52
Themes Across the Attitude Spectrum in Teachers Perceptions of the Future in Their Schools

	Attitude				
	Optimistic	Somewhat Optimistic	Neutral	Somewhat Pessimistic	Pessimistic
Count	88	44	16	33	18
Themes					
Student Interest	28%	25%	19%		
Admin. Support	11%	5%	-13%	-9%	-11%
Increased/Decrease Sectioning of Course	8%	-7%	0% net	-18%	-17%
Negative Student Attitudes/Levels	-3%	-7%	-25%	-12%	-11%
Scheduling		-7%	-13%	-18%	-17%
Teacher Leaving				-18%	-28%

But the most indicative single theme has to do with administrative support, which has both positive and negative counts. If one considers optimism as positive (+), then administrative support has a +10 count (88 x 11%) value here, dropping to a +2 count among the somewhat optimistic. Lack of support, a negative (-), has a -2 count value at neutral, -3 at somewhat pessimistic and -2 at pessimistic. In percents, the trend looks more obvious (Figure 10).

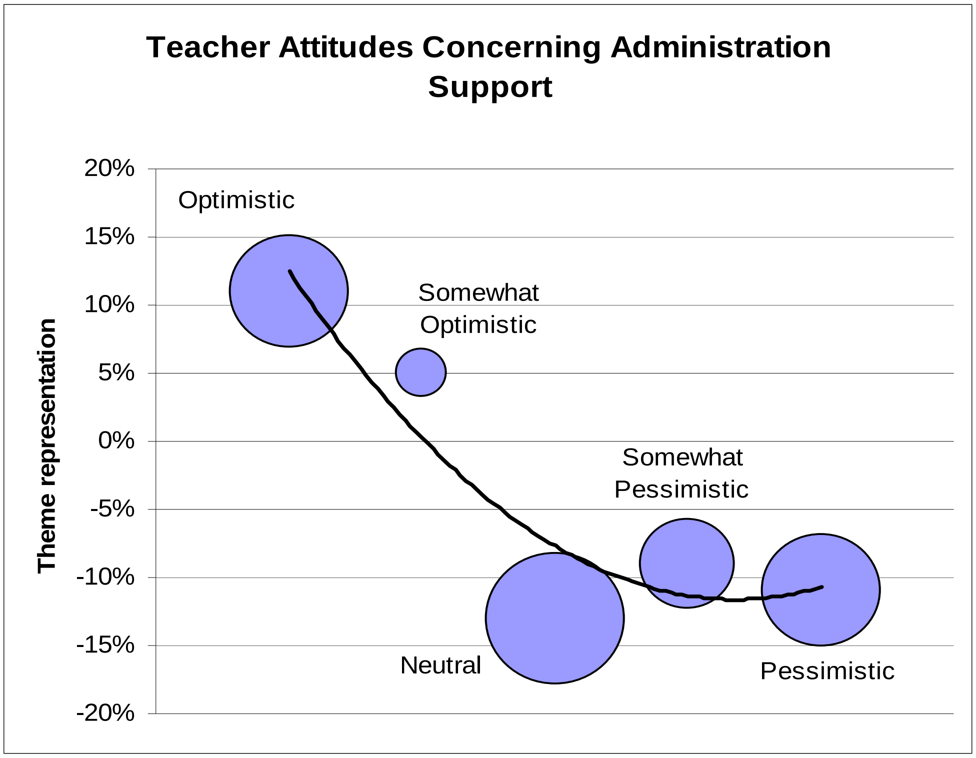

Figure 10. Teacher Attitudes Concerning Astronomy in Their Schools: Administrative Support.

Almost as good a marker of attitude is examining whether the number of sections is increasing or decreasing due to state requirements or types of scheduling changes, such as block versus period or trimesters starting or ending. This theme stars at a count value of +7 in the optimist attitude quickly dropping to low negatives or zero by neutral, and as low as -6 in the somewhat pessimistic attitude where other attributes take on more serious influences on the attitudes of the teachers. The trend in percentages is seen in the Figure 11.

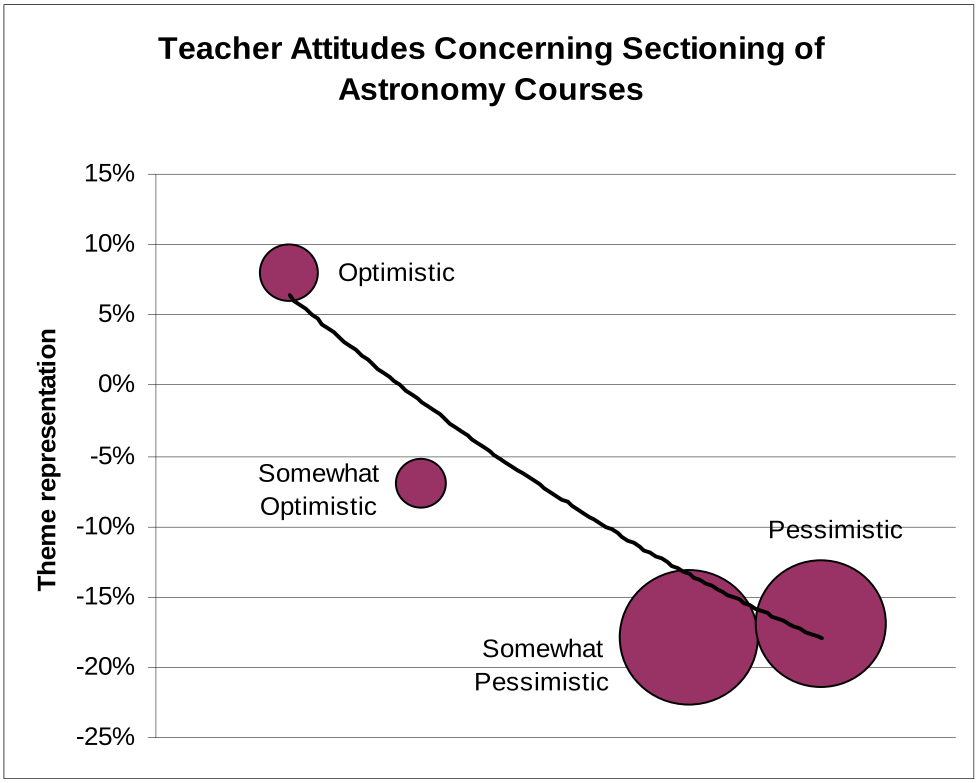

Figure 11. Teacher Attitudes Concerning Astronomy in Their Schools: Sections.

Despite there being many response themes, as a predictor of optimism/pessimism, one could almost get away with needing only a pair of checkboxes comparing the existence of "student interest" versus "teacher leaving concerns" (Figure 12).

This band of themes most clearly indicates what an auditor might suggest to improve the station of the teacher/course: Do whatever it takes to increase student interest, find whatever it takes to get administration support.

Because at least half of all astronomy courses are teacher created, the course is in danger of being retired at the same time as its creator.

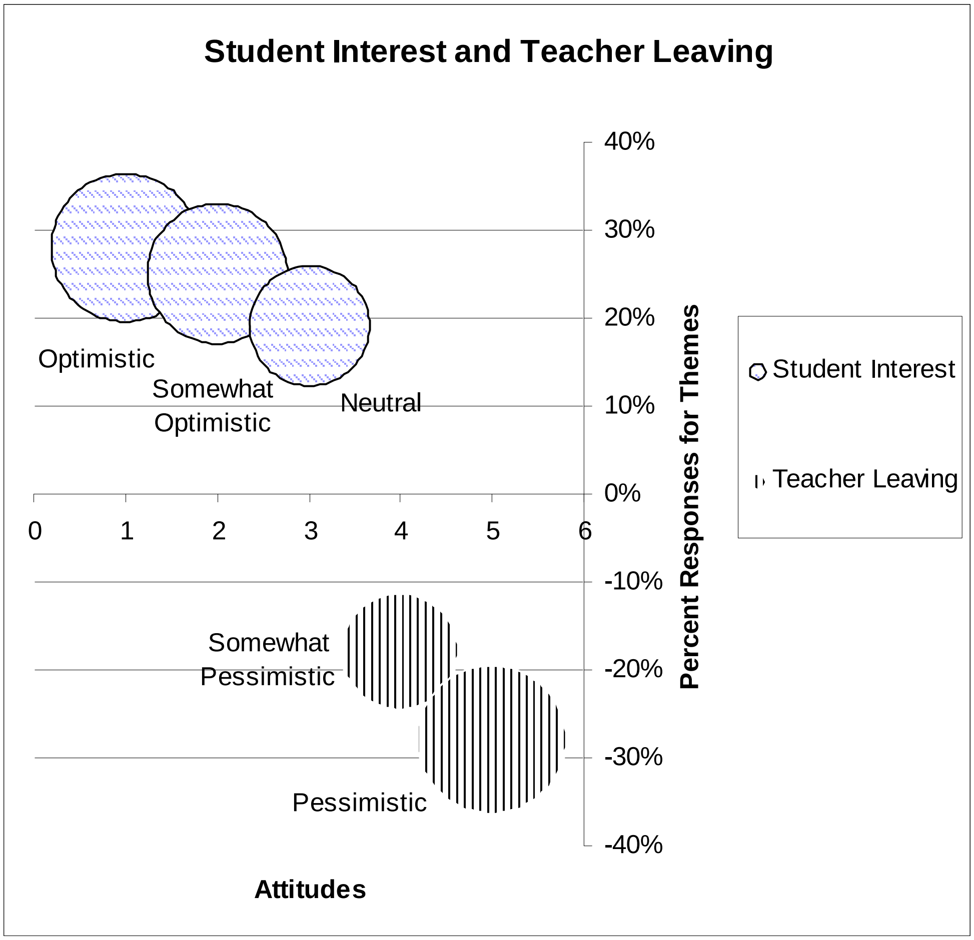

Figure 12. Teacher Attitudes Concerning Astronomy in Their Schools: Student Interest and Teacher Presence.

<u>Future of Courses in the Nation</u>

How do you feel about the future of high school astronomy course offerings nationally? "I am [Optimistic, Somewhat optimistic, Neutral, Somewhat pessimistic, Pessimistic]." Now, explain why here:

The 'grass is greener at home' would describe the answer to this questions. There are more negative themes expressed though optimistic/somewhat optimistic still leads the downside, 118 to 58, about 2 to 1 instead of the 3:1 seen before (see Table 53). The center of mass for the options with pessimistic = 1 and optimistic = 5, is 3.4, or about halfway between neutral and somewhat optimistic. The neutral responses tally higher than for the local scene. Teachers expressed more reservations in prognosticating the national scene than for their own familiar surroundings.

Table 53
Counts of Teachers with Points of View on the Future of Their Course in Their School

Pessimistic	Somewhat Pessimistic	Neutral	Somewhat Optimistic	Optimistic
14	44	53	60	58

Unlike the similar, previous question on teachers attitudes for the future of courses at their schools, these responses are considerably more dichotomous, that is, most of the themes found exist for the two optimistic attitudes, or the two pessimistic attitudes, but rarely for both. For the two optimistic attitudes, the ratio of positive to negative themes is very close, and the same though reversed for the two pessimistic attitudes. Three themes in all were present that could be a Likert-like scale varying from small to large, and only three others varied in a positive/negative manner.

Neutral responses themes (as opposed to neutral attitudes) were generally along the line of an observation, like the course depended on the size of the school, with no particular leaning towards one attitude or the other. Neutral themes show up mainly in…the neutral group, which has few positive or negative themes at all.

There were also an unusual number of ‘blanks’ where no theme whatsoever was expressed for a particular attitude. These are not counted in this analysis.

Thus, unlike the previous question, views of the teachers in their categories are much more firmly entrenched in the attitude of choice, and they form three distinct groups, optimists and pessimists, with no real gradation between them, and neutrals, with no attitude at all.

Viewpoints by Attitude

Optimistics

There were 25 positive themes versus 3 negative ones. Optimists feel the way they do because they see value in or support of or by NASA in general and other space missions in particular, whether specific probes or the fact that there are Chinese space missions or efforts to send humans to the Moon or Mars. Also, the various space telescopes and missions are producing a constant stream of news that piques interest in students and the general public. These alone count for 16 of the 48 responses, a full one-third.

> Greater press coverage of astronomy discoveries, space missions, and manned space flight will fuel the desire for the general public to know more. --- Teacher at a small Kansas 350-student Passing school.
>
> It is an area that interests students of all ages. The recent Pluto debate has really shown that people are still enthusiastic. --- Teacher at a Passing 1.3K-student Pennsylvania school.
>
> I think Hubble and other telescopes provide wonderful views that pique the interest of young people and they really want classes later on. Parents will demand these courses be taught. --- Former teacher from a Failing, 1.7K student West Virginia school.

Thirteen percent voiced a positive theme on increased interest in the course. In person or in hearsay, they see an increase in enrollments, and the number of schools offering the course. An increase in interest in science education is claimed as well.

> I see a trend to increase the science and math content of curricula in high school in order to maintain global competetiveness. --- First year astronomy teacher in a Passing 500-student Florida school.
>
> I hear more and more schools are now offering astronomy than in the past. We have had several schools come and visit our school to learn how to get it started. --- Teacher at a 2K-students Passing California school.

> States such as Texas and California are increasing their required high school science graduation credits and math and science are receiving more emphasis and funding from the Federal government. --- Teacher at a 1.2K student, Passing high school with a planetarium.

> I have seen my course grow from one or two a semester to three classes each semester. If teachers are enthusiastic about whatever they are teaching AND provide the students with a range of hands-on activities it will grow. In these days of EOI testing it is a privilege tot each a course where I can exercise my creative juices and curriculum development skills. I worry about the teachers who get asked to teach the course as many have little to no background, little to no support, and are teaching single sections with little equipment or chance of funding. --- Teacher at a 2.2K-students, Pass Oklahoman high school.

Others are optimistic because of attributes of the course itself, namely how its interdisciplinary nature can integrate other sciences well, and be versatile in usage, that resources are rich and increasing, that classroom technology for astronomy is on the rise, which includes computer softwares (Starry Night, notably), telescopes local and remote, and planetariums (9 responses, 19%).

> As technology becomes more a focus in high school education, astronomy becomes a really useful science to show students the uses for and benefits of that technology. Also, as the field of astronomy continues to dominate the scientific (and regular) news, it gets easier to interst students in the field. --- Teacher at a 600 student, Passing Arizona school.

The only negatives are that funding is killing science courses that are not biology, chemistry and physics (hereafter referred to as BCP), there are not enough teachers of astronomy and that online versions of astronomy are not helpful to high school students.

> I think students in general love the material. There's a lack of people who can really teach it. --- Teacher at a 700 student Passing Ohio school.

Somewhat Optimistic

This largest group of responses numbers 57 falling into 31 positive themes, four negatives, and 6 mixed. The responses are somewhat similar to the optimists.

NASA, space programs, even the nascent private space industry all support the feelings of teachers towards the future of astronomy courses nationwide. So does the integration aspects of the course, press coverage, other attributes of astronomy such as its wonder factor, technology of the classroom, more courses are seen, student and public interest.

> The recent trend of having private space ventures will drive interest in astronomy. NASA and NOAO do a good job keeping public interest in astronomy in the news. --- Teacher at a 3.4K student, high minority Passing California school.
>
> At least in our state, with the UW behind us, it is spreading. It was just me and now there are 6 area high schools --- Teacher at a 1.2K Washington public school

Some new positive themes include a sense that new emphasis on STEM in schools will support the growth and value of astronomy in the high school, that astronomy is a popular freshman college course and that that might trickle down to the high schools, that astronomy can meet at least Earth Science state and national standards.

> Think with the increased emphasis on Science, Technology, Engineering & Math at the state and national levels, we will begin seeing more science electives offered in our high schools. Funding is increasingly available to improve programs (and classes) in these areas. --- Teacher at a 700 student, Needs Improvement, Kentucky school.

Good attributes of teachers, their strong-will and enthusiasm and that they are ‘visionary’ also is noted—in fact, two teachers mention they are doing things to make themselves better teachers or create projects to increase interest in students. The fact that the course can be good for any level of student is also mentioned.

Though there were only four negative responses, they were multiple in their content: NCLB/testing/BCP emphases are causing cuts in budgets and electives, there are few enough teachers to go around as it is, and there is less and less room in the schedules for a course.

> It is a good, fun course. It does however have to compete for the student's time with other good courses... sometimes of greater prestige. --- Teacher at a 700 student Virginia public school.
>
> Generally, I think Astronomy will continue to be a viable course due to human interest in the subject. However, NCLB and AYP does not focus on Astronomy. It will be VERY easy to imagine a future in which all emphasis is placed on Bio/Physics/Chem...period. --- Teacher at a 2.8K student, minority Georgia Passing high school.
>
> Again, my state is probably going to require more science for graduation so I believe more students will open themselves to the possibilities. However, having said that, I'm under no illusion that most students who have any inkling to go into a scientific field will be pushed to take the classics (chemistry, physics, AP sciences)in lieu of astronomy or Environmental ed. --- Teacher at a 1.5K, Passing Wisconsin school.
>
> Most students want to learn about astronomy, so getting students is not a problem. The problem is finding instructors and time to offer astronomy. The other problem is equipment such as telescopes. Students want to use a telescope so they can see the wonders of the universe. Another problem is large schools in the city that can offer astronomy have problems using telescopes because of light pollution and rural schools are not normally larger enought to offer astronomy. Another problem is teachers who have had some astronomy in college have never used a telescope. --- Teacher at a 650 student, Passing Arizona school.

In general, the attitudes of optimistic/somewhat optimistic differ little.

Neutral

They may be called neutral but unlike the true neutrality of opinions in the future at the local school question, there is no balance between positive and negative themes. Here we find one positive category, 9 neutral, 9 negative, and most revealing, 19 Unable to Answer.

The last mentioned category appears only in this attitude (with the single exception of one in the somewhat optimistic tally). This 44% subgroup indicates how isolated many teachers are from one another. The nearly universally-repeated expression was that they had no idea how things are in other schools or states, they know no other teachers of astronomy.

There are 13 themes in the categories that are negative, which actually out-tally the purely neutral, but not by much. Most have to do with effects perceived from NCLB and testing: NCLB inhibits teachers, there is a lack of funds, students or support, administration attitudes that if there are no standards, there is no astronomy course, and that there are few enough texts or teachers to teach those that are.

> I think most schools could offer astronomy, but do not have teachers who are qualified to teach it. --- Teacher at a North Carolina, 1.5K students Pass school.

Neutral themes (numbering eight responses) include such diversity as the existence of astronomy depends on the size of the school or its location (and the location's economics), that no changes are seen over the last ten years, or that no changes are even expected.

> Depends on standardized testing and if astronomy is incorporated and if schools have the money and time to support additional science classes. I can only speak for California, since there is no state test, Astronomy is an elective science which I think makes teaching astronomy more fun, but makes it less attractive to schools who need test scores and don't have money for electives. --- First time astronomy teacher at a 1.4K students, Needs Improvement California school.
>
> I do not think there will be much affect on the offerings nationally on average. There will probably be some attrition in smaller schools and growth in larger schools. --- Teacher at a Passing 1.7K student Washington high school.
>
> Future seems to depends on region, , community, local economies: I know educators losing jobs as planeatriums close, other areas are growing. --- Teacher at a 1.8K students, AYP Pass Missouri school.
>
> In many states besides Ohio, school funding is an issue that must be solved. Boards with no money will cut programs and teachers that do not factor into state/federally mandated school evaluations.In many cases, specialty science courses such as astronomy could be cut. --- Teacher at a 2.4K students, AYP Pass Ohio school.

Somewhat Pessimistic

All the themes in this 44-count response group are negative save one which is neutral. The problems are many. Two examples:

Growing problems with light pollution.- Trend of declining interest and understanding by USA citizens about science.- Lower grade trends in science force the goverment to increase standards, of which astronomy is rarely listed.- Cash is hard to come by for starting an observatory based astronomy class.- Teachers are overworked and find that learning something new takes too much effort. --- Full-time astronomy, New Hampshire private school teacher.

I see more of a trend to 'core' science classes of biology, chemistry and physics with less emphasis on earth science and astronomy and space science. There is also a trend to water down science classes and make them 'general science' classes without including any astronomy in them. Less teachers are getting certified in science to teach at the high school level and of those that are there are more biology teachers who know little or no astronomy. Elementary teachers are not up to date on astronomy and often teach the space science section of their astronomy section with out of date or just wrong information. Many students come to class with preconceived notions about astronomy that is just plain incorrect, such as astrology and astronomy are the same, aliens have visited the Earth, UFO's are really alien space crafts, Americans never landed on the moon, the government is trying to cover up reports of aliens visiting earth, there were advanced civilizations on Mars, the 'face on Mars' is real, the milky way is part of our solar system, the north star is the brightest in the sky, Pluto is a planet, astronomers still look though telescopes, the big bang never happened etc. --- Teacher at a West Virginia public school.

Five theme subgroups appear in this attitudes' responses:

1) *Effects of NCLB (25 responses)*

The 25 responses here are along the lines of “No standards? No value,” or “no tests? No money or value” or “Not required? Course is dropped.” Also, complaints that administrators are only teaching to the test. The largest count in this subgroup is that courses are killed off because of NCLB or the emphasis on only the classic BCP sequence (n = 6, 24% of subgroup and 14% overall).

> If it isn't a required class, I think classes like astronomy are going to be dropped from high school programs. --- Teacher at a 150-student Arizona public school.

> Our school sytem has already eliminated the Gifted student programs and elementary and middle schools and now is progressing into the secondary levels restricting or dictating what courses must be emphasized. --- Full-time astronomy teacher in a Passing, 2.1K-student Oklahoma school.

> Again, there are not enough teachers, not enough scheduling time, a lack of money.

> Across the nation, I am not sure about the future of astronomy education because of the lack of qualified teachers. Astronomy requires a background in chemistry and physics. It is difficult to find qualified people in one of these areas, let alone both. --- Teacher, course terminated, at a Passing Texas school with 2500 students.

> there are more and more mandated courses in all subjects and students do not have room in their schedule for many electives --- Former teacher from a 1.8K Texas public high school.

2) *Status perception (5 responses*)

There is perception of a low value or status of the course and the science. Teachers see it particularly among administrators. This perception manifests itself by administrators not spending money on the course, perceiving it expensive to start and maintain and logistically difficult to manage, especially its observing sessions.

> Because Astronomy is often viewed in the same light as Music and Art, they are not essential to 'everyday life' as described by administrators. Thus, the time is viewed as 'better spent' working with students to increase standardized test scores. --- Former teacher at an 800 student Texas private school.

3) Other effects (3 responses)

> In high school now there are 2 curricular pressures: remediate basic science and take as much AP as possible. Astronomy does not have an AP course, and is certainly not perceived as a core course. --- Teacher at a 1.6K student Michigan Passing school.

> At my school we have the students and faculty, smaller schools may not have that option to keep a course like astronomy. --- Teacher at a 1.4K students, Passing Wisconsin school.

4) *Effects on or of students (4 responses)*

The great ‘student interest’ factor of optimists turns negative here. Teachers note that some students avoid astronomy out of fear of its physics-like content or math. Others note fewer of the brightest show interest as well, and half of the respondents note that students have lost interest because it is not the ‘easy’ course they expect.

> Astronomy is physics - related. There is student fear and apprehension about such a course. Astro is an observation based science and students want more stimulation --- Teacher at Florida 1.6K student, Needs Improvement school.

> I'm not sure how many students are willing to take a semi-challenging math/science course when cupcake classes are out there, only the brightest who see its importance to connecting several science discipline at what that will mean to their success in science fields in college. There are not enough of that type of student in our school to fill a section every year. --- Former teacher from a 2.1K student Passing Pennsylvania school.

> More and more, students seem to think that the only job in astronomy is to be an astronaut. Others think that it is just boring research. Many also say that it has no purpose--what does a white dwarf matter. I also see that the imagination is lost sooner (video games) and it is harder to awestrike the students with the fascination of vastness of astronomy. Understanding the world around is nolonger as interesteing to our younger generation. --- Teacher at a 2K students, Needs Improvement Minnesota school.

5) *General effects in public education (4 responses)*

This new set of themes concerns a perceived deterioration of the public school systems: there is a general decline, it is becoming a ‘rote’ system of memorization, and it is not a striving for excellence.

> The obsession with back-to-basics instruction that can create myopic views of the purpose of education in general (and science education in particular). --- Teacher at a 3.4K student Virginia Passing high school.

> NCLB's focus on testing and math and reading pulls resources away from other content areas and elective courses. Leaving no child behind is a nobel cause, but focusing exclusively on this task removes resources and opportunities from higher-achieving students. Basic skills in math and reading are not enough to produce literate, resposible citizens. Students also need to learn the higher-level thinking, ethical, and societal issues that arise in elective science courses. --- First year astronomy teacher at a small 350 student Passing Wisconsin school.

> We seem to be too interested in creating consumers and not very inteerested in creating good citizens --- Former teacher from a North Carolina, 1.5K Passing school.

> Too much emphasis has been placed on merely teaching basic skills in order to 'pass' minimum expectations. The whole mindset of secondary education seems to have evolved into just getting by. Where are the advocates for excellence? What about being scientifically literate in order to be a good citizen, with no special need for job skills? --- A Michigan private school teacher.

The one neutral theme concerns simply the funding situation is dire but not that it directly affects the astronomy course.

Pessimists

Pessimists are similar to their Somewhat Pessimistic siblings. Three of the above theme subgroups show up here from them: the effects of NCLB, other effects and public school deterioration.

> Astronomy is about getting students to think about things bigger than themselves. It is an interdisciplinary course that ties together math-history-science-art-philosophy. Education today is going the other direction, towards easily identified learning targets and correct answers on multiple choice tests. --- Teacher at a 2.5K, Needs Improvement, New Hampshire school.

> People have lost their connection to sky and Earth. Most people can't see a majority of the night sky anyway due to light pollution. --- Teacher at a Pennsylvania, 300-student public school teaching underclassmen.

The largest single response (n = 5, 33%) is how courses are cut because of NCLB’s effects and emphases elsewhere but astronomy.

> NCLB restricts course offerings to a 'one set fits all' mentality. We have seen all our non-college-bound useful courses evaporate under this idiotic law. --- Teacher at a 2K-students, Passing California school.
>
> Not good. NCLB takes out courses, even popular ones. Not perceived as a true science, it is a luxury. A struggle (is the future). --- Former teacher from a Maine 500 student public school.
>
> There is a perception that the true sciences are Bio, Chem, and Physics. Pressure is on for high schools to provide those at the AP level. In order to do that, room must be made in schedules so the pressure is on the elimate Earth Science and with it Astronomy. --- Full-time, lower division astronomy teacher at a Pennsylvania 1.3K school.

Lack of money to create courses is a distant second with two responses. NCLB effects and other effects are nearly equal overall (7 responses to 6).

The only positive is a hope that as science becomes more incorporated into AYP determinations, astronomy courses could increase in number.

> Astronomy may be more now that science will be a component of AYP & NCLB. Not optimistic, it will be peripheral, not taught in period schools --- Teacher at a Passing Georgia 1.7K-student high school.

Generalizations

It doesn't matter much if the teacher is optimistic or not, there are three themes that are always present in their attitudes, all negative: courses are being cut because of NCLB, the Act has brought an increasing lack of funds to run astronomy courses, and there is a lack of teachers. For all three themes, counts show up in 4 of the 5 attitudes (Table 54). We shall for the moment ignore the neutral response counts, as they are always low if present at all.

Table 54
Negative Themes in Teachers' Attitudes Regarding the Future of Courses in the Nation

	Attitudes			
Theme	Optimistic	Somewhat Optimistic	Somewhat Pessimistic	Pessimistic
Courses cut	0%	9%	14%	33%
Lack of funding	2%	7%	7%	14%
Lack of teachers	2%	2%	5%	7%

Clearly, the effect of these problems on teachers' attitudes increase with increasing pessimism, though at different rates.

Another three themes seem to have dichotomous positive/negative aspects: the amount of interest in astronomy among the general public, and with students, and the perceived effects of astronomy standards in state and national levels (Table 55).

Table 55
Dichotomous Themes Across the Attitude Spectrum Regarding the Future of Courses in the Nation

	Attitudes			
Themes	Optimistic	Somewhat Optimistic	Somewhat Pessimistic	Pessimistic
Public Interest	8%	5%	-2%	-7%
Student interest in astronomy	6%	5%	-9%	---
Astronomy and standards	6%	1%	-5%	---

Asking of the teachers whether there is interest or not from the general public could be a useful dichotomous variable. Student interest values are nearly as dichotomous, though it does fall off the radar for Pessimists with other things taking more prominence for them. Likewise, an astronomy course's help in meeting state or national standards, or lack of standards being a detriment, follows a similar dichotomy.

As seen in the local school question, several themes would make good future survey checkboxes. They only exist on the Optimistic or Pessimistic halves of the spectrum, but not both.

If a teacher responds with "the value of astronomy, its integrated nature," they are leaning optimistically. There are no pessimists here. Similarly if they point out that because space is always in the news, NASA supports astronomy, and similar programs are on their radar and useful, they are optimistic. Pessimistic and Somewhat Pessimistic teachers are the only ones that note the loss of value or status of astronomy courses, a steady 7% of both groups. Similarly, they are the only ones who pine about a general decline of American schools.

Neutrals fit in nowhere in this analysis. 44% of them claim no ability to answer the question, 12% note the various ill effects of NCLB seen by the optimists and pessimists, and 16% show various others of the larger themes noted in this section. (Other smaller influences make up the rest, clearly insignificant here). The only large count neutral *theme* to show up is the inability to answer the question and only the fact that the appearance of astronomy may be a function of school size appears in neutral and one other attitude.

In effect, there are no neutrals in this spectrum; there are three separate groups, optimistic, pessimistic and not really in the know.

Attitudes Overall, and "Late" Responders Equals "Non-" Responders

Attitudes Overall

It is an interesting exercise to combine the teacher's two attitude perception choices together. Are they generally consistent, or optimistic in one but pessimistic in the other? If pessimism is negative, the single attitude Likert scales could range from values of -2 to +2. Adding the two scales, local and national, together changes the overall scale to -4 to +4. Table 56 contains the summed values and the distribution is plotted in Figure 13.

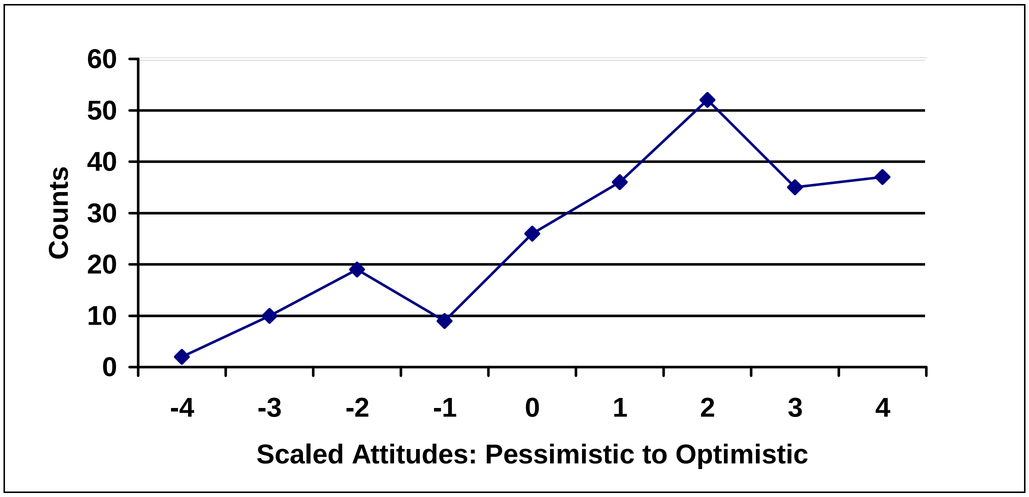

Figure 13. Overall Distribution of Summed Attitudes Towards Future of Astronomy Courses in General

Table 56
Counts of Teachers with Summed Points of View (Labeled and Scaled) on the Future of Astronomy Courses in General

Pessimistic -4	-3	Somewhat Pess. -2	-1	Neutral 0	+1	Somewhat Opt. +2	+3	Optimistic +4
2	10	19	9	26	36	52	35	37

While there is a pessimistic group evident, overall there is a distinct peak at Somewhat Optimistic. Numerically the overall mean is at +1.36, closer to somewhat optimistic than to neutral. Grouped by attitude, there are 40 pessimists, 26 neutrals, and 160 optimists.

Late and Non-Responders

A key validation in survey work is to try to get some kind of answer out of the those invited to participate but declined. As stated in Kratwold (1997), late responders tend to mimic the non-responders. In chapter 4 the reasons known for *why* people chose not to respond were mentioned. What is needed is to find out if there is any correlation with *when* they responded, or *how long they waited to respond*, i.e. response time lag. Furthermore, knowing that a voluntary response group alone does not make an acceptable research design, it would also be good to know whether the so-called Hot group has similar or different responses to the so-called Cold group.

To accomplish this, four multiple linear regressions were performed on the entire data set (Table 57). The dependent variables were (separately done) attitudes (Optimism to Pessimism) for the local school situation, and for the national outlook, i.e. the current question being analyzed in this Chapter and the previous question. The independent variables were: Hot-Cold group membership, done as a dichotomous variable with 0 = Hot; lag time in days (determined by the difference in days between the date of invitation and the date of response being received), and either the date of invitation or the date of reception.

In all cases, there were no overall correlations found. Probabilities range from about .30 up to .70 with significance needing to have a probability of no more than 0.05. Therefore one can conclude here that there were no statistical differences in the responses due to group membership, to date of response, to date of invitation or in regards to the time lag between response and invitation. The pool of responses are remarkably uniform and one could expect non-responders to have similar responses to the responders.

There were two individual parameters that had barely or almost significant *p*-values in one test. In the national outlook testing against date of response (the surveyed date), the response time lag main effect had a *p*-value of .058 and the interaction effect surveyed-dateXresponse time lag had a *p*-value of .045. The linear regression coefficients were .037 and -.001, respectively. If one assumes that the response time lag effect is actually in play (i.e. truncate the *p*-value at the second decimal), one would expect the responders here to grow more optimistic with increased response lag. As the average response lag was 10 days and the majority less than a month, the responses should increase no more than about one-third and one 'attitude', small changes regardless. The interaction effect would slightly diminish the values back to more pessimistic values but with such a small coefficient, it would take a long response lag combined with a lateness in the survey period to have any noticeable effect. With the other independent variables causing so much overwhelming random variation, these two effects are not likely to be noticeable.

Table 57
Multiple linear regressions and their p- and R-values

Dependent Variable	Date:surveyed or invited	*p*	*R*	*F*
Local	invited	.705	.132	.651
National	invited	.754	.127	.570
National	surveyed	.300	.183	1.214
Local	surveyed	.426	.165	1.000

Note: All regressions included response lag in days and research design group Hot/Cold. All df = 6.

Thus, for each of two dependent variables, four multiple regressions with interaction factors included, treating all numeric variables as continuous, and not worrying about the highly skewed distributions of two of the three independent variables, the result is that there are no significant (or of practical significance!) main or interaction effects at all. A power analysis was not done but the complete-data n=223 should be sufficient. In other words, the survey responses were uniform across: date invited to participate; lag time between distribution and return of the surveys; the nature of how the respondents were identified and contacted; and any interactions between those factors. This supports the validity of the survey methodology and to the validity of the survey results that are discussed in Chapter 4.

Starting a New Class

What advice would you give to those who would wish to start an astronomy course at their high school?

About 90% of the teachers provided an answer, some quite extensive. Most focused in on one particular key theme. Unlike the previous questions, the responses often had multiple codings instead of a single or occasionally second theme within the response. Out of them, six major themes were seen. The six themes are:

1. General Statements and (Pre-)preparation Advice
2. Making Your Case
3. Designing the Course
4. Keeping the Course Going, Recruitment and Support
5. For and About Teachers
6. Cheerleading, and Other

By far, the largest theme is Designing the Course, with 3 -4 times as much material as any other theme.

This question was meant to form the basis of a prescription or program for teachers to use. Therefore this analysis shall proceed in the order of the themes listed above.

General Statements and (Pre-)preparation Advice

According to the survey respondents' collective wisdom, there are things you must do even before you actually begin to do the course, things to know, things to look for before you get into the details. "Be prepared" is more than a Boy Scout motto, it is a necessity for starting an astronomy course. Unlike an established physics or biology course, one can not expect to jump into a new course of astronomy without significant planning, even if the course was approved without your efforts. One response was simply "Preparation is crucial" and another was "plan well." A third was more detailed: "Preparation should start well in advance of beginning course."

The next logical question would be, "What do I need to do to be prepared?" A general answer would be to "know what you are going to do before you start, seek any/all resources and arrange them in a logical order."

> Do research, make a package of images and content, clear objectives, how it benefits school and students. –Teacher at a 3K-student public school in New York.

A common generality is to research text materials, software, equipment, lab materials and technology and have them all available in advance. But there are other things to do besides determining classroom materials.

1) You will need to decide what student population to aim for. Do you want a capstone course, or a general-for-everyone course? Quantitative, math oriented or conceptual? Many students or just a few? You may need to set prerequisites. These filters help the course to succeed by either causing a VERY limited number of science electives or allow it to count as a science course required for graduation. Decide if you want a physics based course or not. You might just teach the basic Astronomy concepts so that students going on to college will be familiar with the vocabulary and ideas. In any case, you need to take the time to think about the niche that the class will fill among the science courses.

2) The erstwhile instructor needs to garner support. You need to make sure there is a demand for it and have a willing administration. Demand will come from students, and you will also need to get interest from your colleagues, especially your science department head, and from the guidance counselors.

3) You need to actually find those curricular materials. Suggestions fall into two kinds, networking with people and using the internet. The internet includes the use of astronomy/astronomy education listserves (see a list in the quantitative section). The astronomy community is very active and vociferous and have experience-based insights they are willing to share. Person to person contact includes getting in touch with astronomy teachers in the area, and local astronomical societies and college teachers can help you. Some consider it worthwhile to try to find, or make, a support group and then try to meet several times a year with other astronomy teachers to get ideas and trouble shoot problems. A suggestion that would be helpful is that you should find a mentor or someone you could communicate with that can get you started and help with the curriculum. Definitely visit other schools Astronomy programs.

4) Once you have your support and your curricula, prepare your proposal well.

> You must have willing students, present the value of the class, how it will help with AYP goals and enrich students lives. –A teacher at a Georgia 1700-student public high school.

Write the guidelines and the course description carefully. Review and develop a good high school appropriate curriculum; review and choose an appropriate level textbook (or none, as is also common). Then, as several dozen teachers exhorted, “Do it!” Ask your principal and then go to the school board. Follow the protocol for clearing the district curriculum review committee.

Several teachers gave warnings:

- "Be prepared for rejection by your administrators."
- "Be persistent."
- "It will take time."

> Keep trying-- it took me two or three years after first approaching the administration before the course was actually offered. No one was against offering it, it simply took that long before everyone who add a say in it (local school board, state school board, etc.) actually approved it. ---A Tennessee 1.1K students, public high school teacher.

Apparently, the rewards are worth it since more than half of the survey respondents created the existing course.

Making Your Case

In making your case for a new course, there are several broad areas that you will need to address. Out of 69 tendered comments for this subgroup, the two largest collections are in justification arguments and in showing there is need and support for it. Another thing you must do is show what astronomy is in a way that will excite the administrations, how you can define it as not just a course but a course that will help the students.

What is astronomy and why do we need it?

> Astronomy is a science that amateurs can contribute to. Understanding the universe, you can understand how fragile earth is. Astronomy is a fun science that anyone can do. ---A public teacher at a Failing Oregon high school.

Some teachers are as zealous and devoted as science fiction aficionados. It's the final frontier. It's the future, the mother (even the grandmother!) of all sciences, the oldest science. While true, this won't get you past the principal unless he or she is also a devotee to Urania. Better arguments to use include:

- "Encompasses social issues/history/science into one."
- "It is multi-dimensional since it covers not only all sciences, but math, history and geography as well, an exciting cutting edge science and current missions and findings are in the news."
- "It causes students to look at science concepts and practices from new angles and re-introduces them to the wonders of the universe, by forcing them to become more observant of natural phenomena."

Justifications

You can attack the issue of justifying the course from several angles, the multidimensional aspect introduced above, standards, high stakes testing, and interest among the students. Let us take this one aspect at a time.

> As far as convincing administrators, Astronomy is probably the oldest science, but it is just coming into its own as we speak. Astronomy is the cutting edge science of our day, which is quite exciting. Also, it is amazingly interdisciplinary. Almost every other science can be linked to an Astronomy course. --- A teacher at a private high school in Connecticut.

Get administrative support by showing them that an astronomy course can cover a wide number of science electives (i.e. chemistry, physics, biology via astrobiology). Astronomy is most often a capstone course. Once you have had biology, chemistry, physics (or at least some of these), you can use all that prior knowledge; you can possibly make this a prerequisite to ensure it. Emphasize the tie-ins to physics, math, chemistry, biology, earth sciences, even history. You don't even have to teach it all either, it is a wonderful opportunity for team teaching (see the section on colleague support below). Astronomy can be used to generate support by introducing the astronomy concepts in the other courses so that it will both excite and be familiar to students who wish to take the astronomy course later. Thus, it is a great method for exposing students to science and bring relevance to their other math and science courses.

In this era of NCLB, any course that doesn't fit into standards or high stakes testing has a difficult chance of getting on the schedule. Your state may not have astronomy standards at the high school level, either in a course, a subject domain, or in other classes, but that can be overcome. For example, in New Mexico, standards from physics and chemistry are used as a guideline and national science standards are used for what is lacking in adequate state standards. Some teachers in other states have used astronomy to fulfill state requirements in History, Chemistry, Physics, Mathematics and Earth Science. Elsewhere, Earth and Space Science and physical science standards can be used as sources of standards for the proposed astronomy class.

> If all you focus on is the space standards, your class focus looks really small. But astronomy covers so many other scientific disciplines (including some life science) that once you incorporate those, the class looks really comprehensive. --- A teacher at a small public Arizona high school.

If possible, tie astronomy to high-stakes testing to have an improved chance of getting it approved.

Finally, astronomy excites students and this could be one way to reverse flagging student interest.

> Students are interested in the subject. Everyone has an interest in astronomy, but not in other sciences. CHemistry and Physics get students who 'need' it for college, while astronoy gets students who are taking the class because they want to. --- A Washington state teacher in a large public Needs Improvement high school.

Use the argument that astronomy is a high-interest subject and provides an excellent opportunity for a science elective to 'make' at the high school level.

Support

Use student support to help get you your class. Student support alone does not mean a course will be created but it will buttress your claim that the course will have takers.

To get student support and numbers, talk it up with students and generate excitement for the course so that students will register for it. Students can talk to their parents and get them to push for it in conferences. Students will be more interested and less bored with a course that is very hands-on, such as with night viewings, satellite watching, remote access to equipment. Survey your intended population, before and/or after you seek interest, to show the level that existed and the level that it was raised to.

If you are starting from nothing, talk it up informally, and perhaps start an Astronomy Club. Do it at (or at least make welcome) the lower grade levels because, since it will take some time to get approval, the juniors and seniors are the less likely to take the course but excited freshmen and sophomores will reap the reward of their support.

Another way to reach both teachers and parents is to do public outreach and involve the community.

> get telescopes out in the evening after football games, et.c, and they can 'lobby' for it. --- A Georgia private school teacher.

A teacher advised, perhaps tongue-in-cheek, that if you can get the community involved, you will also be able to cause an outcry if the course gets threatened.

It is important to establish both student interest and the level of support that the school is willing to offer in order to sustain the course once developed. Get the support of both your students and your colleagues. Make sure to have support from administration and counselors. Excite teachers and counselors about the things going on in astronomy. Get the support of your department chair and/or your science administrator. For your colleagues, also come up with a good presentation you can use in general science courses to garner interest. Cultivate students in your early Mathematics classes.

The proposal

All the good words in support of your effort will do nothing is the administration is into numbers. There are two good sources to help you on this. One is to survey the guidance department to see what need there is for additional courses in science at the level for which you intend for your course to be taught. Your own department may also have that information.

> a science department audit report suggested that a astronomy course should happen, --- A Pennsylvania private high school teacher who just completed her first year of the course.

Having gathered support, numbers, and proven the needs, you need to do a few other things before you head to the administration.

Even though you have tied the course to standards, you should bill the course as 'extension' of material in more basic courses - don't duplicate material. Your proposed class should be flexible, it can be a semester or a year-long course.

> Additionally, emphasize how the course can provide a real capstone experience to the science curriculum, since astronomy involves all other sciences (even life sciences: we discuss natural evolution, dangers of radiation, etc) and mathematics. --- A private high school teacher from Ohio.

Other points include:

- “Astronomy is an excellent way to further the scientific thinking of our students.”
- “Most students are not going to become astronomers, but all students are going to see the stars, sun, and moon the rest of their lives.”

Since course creation by the teacher is one of the two main ways a course is created, the teacher is an important aspect as well. The aforementioned Ohio teacher also said,

> Make your passion about astronomy and sharing astronomy evident in the proposal, and administrators will see how students would benefit from having such a course and teacher. Keep pushing it to your administration and don't give up, continue to express the importance of the class.

Designing the Class

Now that you have approval in general, let's get some specifics towards your course and your curriculum. (You *can* do this while creating your proposal—it wouldn't hurt but it will add to the time it takes to get the course approved).

The largest number of suggestions and advice were on the curriculum of the course. Resources you can use for your materials, including your textbook and equipment, was the largest collection of comments, 59. Offerings on how to do the class, its classroom style, numbered 36. Deciding the overall design of the curriculum—what do you want to accomplish--and finding curricular materials had 26 suggestions. What activities to do, inside or outside the classroom, finding materials, had 22. 'Who should take the class' had 19 comments and related topics on prerequisites and student types had 16 and 6, respectively. There were 14 comments on generalities and money.

What course do you want? And for whom?

There are a number of variations on the level and nature of an astronomy high school course. The course's position in the overall scheme of science in the school needs to be examined.

> Find out where the Curriculum Coordinator/Administrator and/or Dept. Head wants to 'place' the course in level of difficulty. I had problems with my Dept. Head with the course being 'too hard' in dealing with background knowledge necessary to appreciate/understand later concepts. An example would be inverse square law of light

> … or the Absolute vs. Apparent Visual magnitude of stars. I was asked to 'dumb down' the content. --- Teacher at a very large private school in Pennsylvania.

Astronomy quite literally covers a lot. It's a big universe. Where should you begin? Astronomy can be taught at a range of levels. You need to make sure of the audience that the course is intended for. It could be introductory science, up to college level. Know your intentions first, what you most want the students to take from the course.

> 1. Determine if it will be for high level enrichment or a more general offering for all students. 2.Determine the level of Math you will require. (I try to keep it to simple Alg and graph reading.) --- Teacher at a very large public high school in Illinois, with a planetarium.

One suggestion made was to try a lower level "physical science approach" just to get started, to help with enrollment, i.e. try to make it for everyone. Teachers frequently noted that there are plenty of physics and chemistry courses that drive kids away with the math. A frequent admonition was not to make it too difficult.

- "Aim for challenging, but doable for average student."
- "This course needs to be kept on a very low level, no or little math."
- "You should not load it up with lots of math or make it another physics course. (If you do, be prepared to change it with the students you get!)."

> I think that there is a tendency by some to make an Astronomy course too math intensive. I think that the night sky is a cool place and if you help people learn to see, ask questions, ponder, and find real world connections, a teacher can then lead the students to the math and science connections. You don't have to know how to play an instrument or read music to appreciate a music score that invokes meaning or emotion . --- Teacher at a 1.8K student sized public high school in Michigan with a planetarium.

An issue frequently brought up, though, with this level of course is that you are more likely to get students who are there 'for the grade' instead of 'for the interest'. Are you getting students who want the course as an elective or who need to take it as a way to get 'easy' graduation credits, and who will be disappointed, bored, or troublesome if it isn't easy, or a mixture?

Others go another route, recommending teaching the course at a high level and using differential grading/instruction. There are issues here as well. For one thing, astronomy has to compete with AP and other electives.

> Most advanced science students do not have room in their schedule for this kind of class, so it is necessarily a general class for non science majors. Plan accordingly. --- Teacher at a very small private school in Maryland, with an observatory.

Can you do both? There are only rare opportunities to offer two courses; only 15% of the respondents taught a second astronomy course. They do not have to be two courses of different content (stars versus solar system). They can also be two levels. You can approach astronomy from a conceptual standpoint, and not a mathematical one, saving the math for a higher level course. Or perhaps take the suggestion to offer both quantitative and non-quantitative/descriptive versions of the course in order to meet the needs of a broad range of student backgrounds and interests.

Regardless, especially if you have argued for approval using the multidisciplinary aspects of the science, your astronomy course needs to be an integrative course. Include processes of science, theory of knowledge, history of science, as well as the content of astronomy. The point being made is that students need more understanding of the nature of science and not just lots of facts.

Who will you get in the class seems to boil down to two kinds: 1) Those students who share your interest and 2) those students who have failed science repeatedly and are on the hunt for ANYTHING to graduate.

A teacher wrote that you should, in designing your course, "assume the students know nothing substantial about astronomy." There may also will be resistance to your intellectual challenges.

> anticipate student resistance to any challenging science. My course is a graduation requirement completion course, and many unmotivated students enroll in it, anticipating and easy course. I have reluctantly adapted the course to the students abilities, and willingness to(not) work! --- Teacher at a 1.6K students public high school in Florida.

One way to determine who does get in is by setting prerequisites. This study has shown that a full quarter of the schools surveyed do not have any prerequisites, whereas the majority have just a single math or science course to be required. There is clearly balance between having enough students to have the course run, and having enough filters to get students who can or will handle it.

Fully one-half the teachers who mentioned student levels decried their classes being "dumping grounds" or full of "uninterested students" or "thought it would be easy for graduation credit." Many of the other teachers stressed that lack of preparation in algebra, math or science hurts the students they get, and lowers the teacher's expectation or teaching level.

If you ask for certain prerequisites, your enrollments may drop - but you probably will get a more prepared and serious type of student. On the other hand, lowered prerequisites likely will cause the enrollment to increase with the caveat that the range of abilities of the students will also increase. One of those fallout challenges of this approach includes the inclusion of ESOL students. Textbooks available are aimed at college levels and will be difficult for them.

What should your course look like?

Our 36 comments were almost exclusively "make it hands-on," "do inquiry," "mix hands on activities with visuals, text, (some) math" and it is very clear that this class should be an active one for the students. One other consistent request—include observing.

> Teaching astronomy once was all hand waving lecture, pretty pictures, and pencil-and-paper exercises, now you can teach it as a hands-on inquiry science course. --- Teacher in a very small private school in Oregon.
>
> Make this course lab-based. Overall, I feel that the students learned the concepts best when they had hands-on experiences. I have students coming back after they had a college Astronomy class saying that they were amazed at how much they had learned in the high school class. --- Teacher in a very large 2.8K Texas public high school with a portable planetarium.

Some other suggestions.

- "Teach concepts before terms and labels."
- "Make 'hands-on' with activities and planetarium time," (presuming you have one).
- "Use a lot of labs, especially the ones that reinforce the math components."
- "THERE MUST BE SOME FORM OF 'HANDS-ON' ACTIVITY, IE, COMPUTER LAB, SOLAR OBSERVING, ETC."
- "Practical astronomy is a real hook. The students love extra observing sessions and using the telescopes."
- "Do lots of activites, including opportunities for telescope observing and field trips."
- "Nothing like direct observation."
- "Make the course as 'hands-on' as possible....severely limit lecturing"
- "include repeated observations of daytime and night time sky."
- "Learn how to teach it … using image analysis and internet controlled telescopes."
- "Develop observing activities for students to relate their learning to the real sky."
- "Schedule a lot of computer time because that is where the great pictures/activities/ news are."
- "Teacher prepared power points help as well."
- "Use plenty of visuals including videos. The more image-based and dynamic you can teach and demonstrate the concepts the better. Use RECENT materials, and if at all possible get the use of a digital projector on a big screen."
- "Make it challenging as well as fun."
- "Keep it simple."
- "Keep it fun."

- "At all costs you should avoid making it a study in memorization instead of a great exploration for the human spirit."
- "No "drill and kill.""

The curriculum

> Unlike 20-30 years ago, when it was very difficult to find suitable materials for high school astronomy courses,there is a surfeit of useful materials. The task is now choosing among good options and not trying to do too much, rather than having to write much of it yourself or photocopying from Astronomy, and Sky and Telescope. ---Teacher in a very tiny private school in Oregon.

One major theme in this area….use the Internet. There aren't many high school astronomy curricular packages in the material world, and those things you can find on the Internet are often free. Once you find a good basic curriculum with which to start, you can add outside material as you see fit.

> (I) have TO (sic) much in resource materials and 99-percent is free. --- Teacher at a very small public high school in Kansas, with a portable planetarium and observatory.

Recommendations (often made repeatedly) for finding curricula you can copy or use outright include:

- "Lab activities and other forms of activities are available on the internet."
- "Teachers can get lesson plan ideas and activities at various NASA sponsored websites"
- "Look at other astronomy classes offered in other schools for ideas and curriculum advice."
- "Probably a good starting point is to visit with teachers who have already developed a course."
- "Contact AAS, or regional Planetarium Society, for educational packets, books, hand-outs, etc."

Major point: Don't start from scratch.

What should your curriculum have, look like?

Recall that astronomy is recommended to be taught in a multidisciplinary way, to match standards, and to be hands-on and experiential.

> Try to integrate the curriculum with existing courses. For instance, I begin with the history of Astronomy and realte (sic) it to the history courses that the students have taken or are currently taking. I also relate to Chemistry (spectroscopy) and Biology (we dissect cows' eyes.) ---Female teacher from an extremely small, private religious school, in Pennsylvania.

First, you should research your topic choices and the focus you wish to have – say, physics related astronomy or planetary geology. Then, within that, choose what your goals will be, what you wish them to know by the end of the course, and design your course around it.

In regards to standards, make sure you cover as many as appropriate and available, whether using state or national standards. In some states you need to be careful how you position the course. In California, you should put this in the physics content domain for the state (and its universities) don't consider astronomy and earth and space content as being capable of supporting substantial lab activity. In Georgia, you need to include lots of chemistry and physics to prepare for the state graduation test.

Some curricular topics may not be covered by your book but can be strong motivators to bring in students. A Michigan teacher's experience in college astronomy was that that course only paid lip service to identifying constellations; at the high school, he spends time on constellations, teaching students to recognize them, and requiring attendance at star parties. It was one of his biggest 'hooks' that encouraged students to take this class, and considers that the topic probably will be remembered "long after they have forgotten the HR [Hertzsprung-Russell] diagram."

You must consider your students, not only for their levels but for relevancy.

- “Make whatever you teach relevant or frame it within essential questions”
- “Students love two topics...aliens and black holes.”
- “…ask questions such as: how can spectroscopy provide us with evidence of life elsewhere?”

If students have specific needs, they need to be addressed. One teacher thought that students should have a say in shaping the syllabus, that one might as well teach something that is interesting to them.

Other advice includes:

- “Do research on activities that you can incorporate to each unit.”
- “Focus on the basics and keep revisiting the basics (physical science concepts).”
- “Too much of the current science curricula focuses on what is already known (i.e. facts to memorize). Avoid this.”
- “There’s a debate between semester-long and year-long courses. Do what works for you.”

A large number of actual curricular tips and topics were suggested. Some particular activities mentioned for inside the classroom:

- “Do not fear having some astrology in the course as well. It captures the interest of some who ordinarily would not have an interest and leads them to learning more about the basic astronomical concepts.”
- “Don't just do the planets -- do all the new and exciting stuff. Make stargazing part of the course.”
- “Stress the HR diagram.”

> Be flexible in opportunities you provide for your students. In addition to what you do in class (content...labs...investigations... discussions.. .projects. ..tests. ..how to be a good observer...how to correctly use the equipment, etc, provide a myriad of ways the kids can earn points (from night observations, poetry, raps, art projects, involvement in research projects like GAVRT and the Variable Star group, Spectroscopy, tracking binary asteroids, astrophotography, camping at Star Parties, outreach activities through Community, educational, and Scout Groups).) .--- 2.2K, Oklahoma public high school teacher.

Far more teachers addressed this one true problem: Astronomy meets during the school day but needs extra hours to observe the real sky at night. Consequently, a large number of suggestions had to do with night time observing.

A detailed prescription for this is from the above Oklahoma teacher:

> Work on how to be a good observer and slowly introduce the equipment you want them to use. (Keep a tarp or drop cloth under the scopes to catch the screws that fall off in the dark). Offer evening observation sessions or early morning sessions to watch the parade of seasons. I try to offer one observation session a week (weather-permitting) and I usually have 20-25 students attend each week. I allow them to bring their family, friends, etc. as long as they stay on task and stay off the cell hones. I require 3 sessions but offer alternative assignments in case students have an unbending work schedule or activity schedule. I work with them to provide alternative sessions or they check out one of our 'Penguins' (Explorascopes).
>
> Be willing to take them to dark sky sites (with the permission of your adminstration) and meet professional and amateur astronomers and be part of their observation teams. In the Fall I take my students camping for a 4 day period to the **** Star Party in the ****...the darkest skies in the SW! We average about 25 per trip. They return to school so fired up that they become the extra 'experts'. I encourage students who did not come to buddy up with these now 'intermediate level' students and pick their brains. In the Spring semester, they attend a Messier Marathon at a dark sky site. Before going, be sure they understand and follow Dark Sky etiquette. [Information that could identify the school and teacher replaced with asterisks.]

Other outside observing suggestions:

- “Do observing nights with the students. Even if you don't have a good telescope identify constellations, get a pair of binoculars, look at the moon, do anything to get them interested.”
- “Since most of these sessions are on weekday evenings, I begin at 9 p.m. and end promptly at 10 p.m. unless we are off from school the next day. We juggle the times in case the HST or ISS or an Iridium flare is passing overhead (a great way to have them practice using azimuth and altitude using their hand positions for degrees).”
- “Schedule at lease 1 'Star Party' star-viewing evening with local astronomy club/organization.”
- “Have star parties, talk with students and parents”
- “After they know their constellations, use scavenger hunts to locate as many celestial objects as [possible but start slow and work a small patch of sky.”
- “Conduct night viewings with/without telescopes.”

And…

- “Many community groups such as astronomy clubs and college observatories will have their own equipment (in case you don't have much with which to start) and can invite your students to Star Parties.”
- “Take field trips to use telescopes at least once a month. Though rare, some places also have heliostats you can use as a day-time field trip to look at the Sun.”
- “Utilize local professors and graduate students, not only for star watches but also for speakers and resources.”

(An Oklahoma teacher’s tip if you do a lot of field trips and nights out: “Prepare detailed permission slips for the course and observations. Provide additional ones for Overnight trips. Students should leave a telephone number where they can be reached in case of cancellations or no shows. Most importantly, follow the procedures in place in your school district.”)

Another suggestion: a course syllabus, listing all assignments for the students so that they may work ahead.

Not all ‘outside activities’ have to do with observing:

> My claim to fame has been GNATS (Go Now And Teach Someone) where students get class credit for reteaching cool Astronomy lessons to friends and family. --- A Wisconsin teacher in a very large 3.8K-student Needs Improvement high school.

Alternative ways to reach other people that will benefit your students:

- “I use the elementary schools around the area to have the high school students share what they learn.”
- (for clubs and observatories) “Offer to provide the Outreach arm of their organization as you get your course together.”
- “Use students to help with local planetarium programs and amateur astronomers star parties as much as possible. Let them become docents to explain what they have learned to others.”
- “Have them write letters to future students and they all tell them to come to any observation sessions as often as they can.”

You can do star charts and constellation watching and a few other things with eyes alone. One needs telescopes or binoculars to see planets.

- “if you can get ahold of a decent telescope and binoculars that would be great (applying for grants is a great way to do this).”
- “Have telescopes available for hands-on work”
- “Just a couple of telescopes and binoculars is all you need.”
- “You need a good telescope to show things to the kids.”

You can buy your own,…

> Perhaps buy Celestron Explorascopes and tripods and check these out to students on a rotating basis, so they can actually use a scope at night. I am getting ready to do this next term. I have three scopes for check-out. They are only about $60.00 each and are nice for looking at the moon. STudents were excited about this option. --- Teacher in a 1.2K students public high school in Wisconsin.

… use someone else’s, or sign up for time on some remote telescopes (both optical with cameras and run by Internet connection, or radio!) More and more telescopes are on-line in real time (e.g., Tzec Maun project) so students can be engaged in real inquiry into real problems without having to invest in telescopes and observatory shells.

Unusual and rare, but several schools do mention them, are solar telescopes.

Curriculum in the material world

In this section, we shall look at things you ought to have in your new classroom, and we start with textbooks.

There are many astronomy textbooks used in high schools. Almost all of them are college-level. Many of the respondents, though, chose not to use one.

I started out the first two years not using a textbook because I had enough resources to do the class Parents complained because they paid a textbook rental fee. So we got textbooks. --- A small Kansas public high school's teacher, with a portable planetarium and observatory.

- "Do not get trapped by the book."
- "Do NOT rely on the textbook."

Advice given includes:

- "Do a THOUROUGH search for a good textbook."
- "A good textbook is recommended...especially if internet access is limited."
- "Use a textbook the students who will take the class are capable of using."
- "Use an authorative and well-written textbook that is appropriate to the ability of students."
- "Select a good text with electronic media support."

But…

- "We had a difficult time finding a high school book. The book we use is only used as a guide."
- "Find a textbook (most are college level) that has a lower reading level and suplement with lots of other material. I couldn't find a good textbook at all."
- "I taught astronomy without a textbook for many years and don't use a textbook very often even though we have them now."
- "I choose to have no book."
- "Develop a useful text because there aren't too many publishers who have good high school astronomy textbooks."

Some things to go with the textbook:

- "Depending on the capabilities of the students, a good lab manual might be useful...especially at the middle school level."
- "The book we use is geared for high school. Do not pick a college text for the average students."
- "The textbook that I use needs some augmentation to meet all of the physics standards."

What is available for augmenting your textbook, or lack of one? Not only is the Internet recommended for finding curriculum materials, it can BE a component of your curriculum. Teachers frequently exclaim how there are so many excellent websites for both students and teachers. Available both as online and downloaded software is the CLEA (Cooperative Learning Exercises in Astronomy) virtual lab exercises from Gettysburg College. Professional astronomy databases such as the Sloan Digital Sky Survey are now available to teachers and are becoming increasingly easier to use. You can supplement your lessons with Internet podcasts such as that available from http://chandra.harvard.edu.

Alas, not everything is free. Some things cost money. If you want to use the above effectively, you need a lot of computers, or have a good projector mounted on the ceiling and a good large screen at the front of the room.

Also not free but recommended are planetariums. It's been many years since the U.S. educational community was primed to put a planetarium in every new school. Indeed the number of planetariums has gone down over the decades. But if money is available, there are two ways to go concerning planetariums. You either need a StarLab (portable) or a fixed dome planetarium.

If you can't buy one, try to find a way to have easy access to someone else's. If your school has one, then use it. But if a fixed dome just isn't possible, then buy a portable. There are the basic StarLabs, opto-mechanical star cylinders, and a new set of portable digital projector systems.

> a portable planetarium is a great piece of equipment to have to have practical observation experiences during the normal school day ---An Oklahoma 1.8K students public high school, with a portable planetarium.

But electronic “planetarium software” are recommended as well. These computer programs recreate the night sky and can show phenomena inside that might take a regular planetarium to show for a class or months of observations.

> Several fantastic software programs exist allowing Astromony to be taught without a planetarium or observatory. Another benefit of software programs (e.g., Starry Night) is they allow students to gather data quickly and efficently which greatly facilitates teaching from a science inquiry perspective. --- Teacher from a 1.2K student public high school in Pennsylvania, that also has a fixed planetarium.

Other planetarium softwares recommended include Voyager and Stellarium.

And where do the teachers recommend you get money, when the average budget is under $500 per year for normal supplies?

- “Startup costs can be relatively low. Be sure to find continual funding for all you plan to do. Start-up funds are often found from other accounts and give false picture of future support.”
- “Grants are essential in obtaining necessary equipment”

Keeping the Course Going: Recruitment and Support

Now that the perfect course has been created, students are needed. It often takes a few years for the course to become established and for student interest to grow so the school should allow time before making decisions on the success of the course. Just make sure, a teacher stated, that your administrators aren’t too quick on the trigger to cut the class after you start it.

Getting the students the first time

> The nature of the teenage beast is to be, contrary to Copernican theory, self-centered. Astronomy is a branch of science that teenagers are actually interested in and can actually practice for the rest of their lives regardless of what they choose for a career. It gives self-centered teenagers something larger than themselves to contemplate. The best way to get students interested in science is to find what they are actually interested in and then teach

> them scientific principles along the way. ---Teacher at a 1.1K private high school in Hawaii.

You need to get the word out. Specific students you want can be personally invited through a letter. Students may be more likely to join a class if they know that they are wanted. Next best method is word of mouth, through the students, to get the numbers needed to start a class.

Design a brochure with visuals describing the course and pass it out through other science courses. Market the course to students based on that niche.

> To start an astronomy course, interest must be generated at lower levels. For example, in a biology class discuss the requirements of life on Earth, then what life could be like under the icy oceans of Europa. In chemistry, use spectroscopy to talk about composition of stars. In physical science, use speed and motion to talk about the speed of light and what happens if you travel faster than the speed of light to escape a black hole. Once the interest is created at lower levels, then remind students periodically that they have the opportunity to take a full year astronomy class later in high school. This word of mouth is the best ally in building an astronomy program. --- Teacher in a large 2.5K public high school in Texas.

Also advertise to students by going into freshman (and other) science classes and showing some podcasts or short video clips. Go into math and history classes during your prep period (or switch around or team teach) and insert some astronomy into their classes to arouse the interest.

An incentive that will help if you can offer it is to coordinate with colleges nearby for credit (and as a curriculum guide as to what to teach!). This has been found a help for schools with at-risk students as well as the college bound.

Do some 'try this out' activities. For example, it is recommended that you start an astronomy club to gain interest amongst the students. The teacher who tried that said, "Once students get a peek at Jupiter or Saturn or the Great Nebula of Orion through a telescope, they are hooked."

Ongoing support after you start

If your course succeeds, several things can happen. The students may become passionate about it. If they are excited about it, their friends may get excited and want to take the course. (If they don't, guidance counselors may have to beg students to take it in order to have the minimum number to have a class each semester and that isn't going to help your employment.)

Some outside support would be good, and a defense if the course gets threatened.

- "Collaborate with other high schools or your local community college/college/university"
- "visit frequently with college instructors who taught astronomy courses."
- "Contact the local astronomical society for help with observations…makes what you teach much more relevant to the students"
- "Seek active participation from a local parent or parent organization which can help acquire equipment or organize field trips."
- "check professional associations."

Teachers: The Final Piece of the Puzzle

Are you the one? Can you teach this course?

Sixteen survey respondents mentioned what kind of teacher they thought SHOULD be in the front of the room….and almost unanimously they said that teacher needs to be enthusiastic and knowledgeable about the subject. Some sample comments:

- "Make sure the instructor DOES possess a deep interest in the topic - do not just allow a 'science major' to teach it."
- "know the real sky and the material very well and make it serious"
- "Enjoy astronomy first. If there'ss (sic) no passion on the part of the teeacher, the class will probably not succceed."
- "Be enthusiastic! Tell the students when you don't know an answer but work with them to show how to obtain the answers. Model scientific inquiry."

- “Make sure you have a well-qualified instructor if the course is to be advanced/college level”
- “Give the course to a person who is versed in inquiry and has a passion for science as a human endeavor.”

One more trait suggested: that teacher keeps up to date on astronomy (by frequently referring to websites, and other media) and attends summer workshops.

More professional development suggestions:

- “Attend college lectures”
- “They should audit a college level class in astronomy for a semester to get a feel for the topics covered.”
- “(I have) …through professional development, in particular the Wright Center at Tufts, have pursued mastery of the content.”
- “I took many NASA classes in Colorado Springs and Space Camp for Educators in Florida and over the years had it up to nine full sections in one year.”
- “Go to a Hands-On Universe workshop, if possible. Alternately, get trained on-line. (Recent funding cuts may have eliminated both of these options.) You will become inspired! “
- “If you are a novice like myself, try and attend workshops and teacher training as much as possible. You will find it very valuable later on.”
- “Attend workshops such as those provided by the Astronomical Society of the Pacific and the CAPER team at University of Arizona.”

Finally, in a form of “let me take you aside and tell you something,” the responding teachers handed out some mentoring advice. The warnings:

- “Plan to cover less material than you originally intend”
- “Be ready to adjust for student abilities and discovering what works best.”
- “This is much more difficult than you imagine. It is not like other science classes you've taught.”
- “make sure that the burden of another prep doesn't burn you out”
- “Do not be afraid to be wrong.”
- “Be prepared for long hours of work”
- “I(t) can be hard being the only person teaching a course”
- “Seek an alternative. The administration is not open to changes”
- “I still don't understand why this wasn't offered at our school before.”

- “TOO HARD”
- “This course will not compete well against other, easier science courses. It also won't compete against AP courses where kids can get college credit.”

  It was hard work the first 2-3 years; generating student interest, creating a vaiable curriculum, obtaining supplies (telescopes are expensive), solicit donations. It took me about 4-5 years to get the curriculum where I wanted it to be. --- Teacher in a 1.8K students public high school in Arizona.

  The good stuff:

- “enjoy the enthusiasm of those students that are in your class”
- “If you enjoy the subject then it is worth the efforts to implement the course.”

And the total collection of Exhortations and Cheering On includes (without quotes)…Do it. JUST DO IT. GO for it. Just write it up! Just go ahead and do it for the kids! Go for it! Absolutely do it. Do it. Go for it! Have fun with it. Go for it! Go for it! Do it. Go for it. Do it!

I decided that if I made it a popular class that the number of my preps would go down . --- Teacher in a large 3.8K students Needs Improvement high school in Wisconsin.

<u>Defending the Course</u>

If you should have to defend or justify the course at some future date, what arguments would you use? Why?

Even though a previous question indicated that quite a few teachers have managed to avoid being on the NCLB radar, there are documented cases within this study of courses being cancelled. These have been because of the need for school-wide remediation or other reasons ostensibly due to this Act or related state reactions to it. Some teachers have defended the course successfully.

There are a grand total of 428 responses in the survey. This works out to be an average of 1.8 different responses per teacher. Some teachers, as one might imagine, contributed considerably more than one type of defense response/advice.

There are six primary themes in which answers fall. Table 58 lists them; percentages do not add up to 100 because of rounding.

Table 58
Themes Teachers Use to Defend the Course

Theme	Number	Percentage of Responses
Defending with the nature of the course	137	32
Defending with effects on students	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 group might be called "Defending with the nature of the course." There are 137 responses, or 32% of the whole set of responses, in this one primary group. Found here are answers using aspects of what the course is, what the course does, and what these do for which groups of students. The largest single answer by count in this subgroup is the fact that this course is so interdisciplinary, involving math, other sciences, logic, history and more. "An integrated course" is given as all or part of a response 46 times, a full one-third of all the Nature of the Course responses.

The second group of the six, totaling 88 responses or 20.6%, might be called "Defending by current and past effects on students." Here is the largest response by count, that students are interested in astronomy, often more than for any other science, so we should teach it. Forty-seven responses had this theme, fully 53% of the category.

The third largest group would be “Defending the course with its cultural linkages,” with 78 responses. This group contains historical, sociological and philosophical arguments and intangible connections that astronomy has with human thoughts and societies. A common defense here 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, the foundational science, appears here extensively. Other linkages are more tangible, such as astronomy is part of everyday life, for example, as cultural myths, origin of the calendar, and so on.

The next largest group would be “Astronomy helps improve students, school, and AYP measures”. Fifty-four responses (12.6% of the response pool) defend the course with arguments on how well it helps meet state standards, helps students pass state end-of-course and school graduation tests, and provides options for students who have troubles with the BCP science courses.

The last three groupings are all roughly equal in size.

“Defending the course with traits of the science” has 24 answers that include its accessibility to students, how it is perceived as less static than other sciences, and so on.

“The Institutional Defense’s” 22 responses promote the idea that astronomy courses help the school, its image and economics.

A final group includes 25 responses that do not fit any of the others, including a few negative comments, comments unrelated to the question or otherwise unintelligible, and a small number of unique defense strategies.

Each of the six primary groups will now be examined in detail.

Nature of the Course

A number of critical and repeated themes make up this group of responses.

First of all, and highest in response count as noted before, is the justification that this science, unlike others--in the teachers' opinions--is an integrated course. Involved in it are mathematics, literacy and language, the other sciences of chemistry, physics, various life sciences and even geosciences. While these others can incorporate astronomy, if the teacher so desires, only astronomy seems to be the capstone that inherently incorporates them all or at least as many as the teacher wishes.

> It is a solid college-level introductory course that provides students with a way to 'Integrate many facts, processes, and sciences together because of its broad, multi/interdisciplinary nature' --- Astronomy-only teacher at a very large 3.8K-students Illinois public school.
>
> 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 students 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.

Further listings of these cross-curricular and multidisciplinary aspects include:

- "Astronomy is one of the few courses where the math, science, social science, and writing demands can be applied and proven through the period of a semester."
- "It integrates aspects of physical science, Earth Science, and Chemistry."

- “emphasizes a tie between science and language, …”
- “Practice using math, mythology, communication, computer skills, social sciences in real applications…”
- “really synthesizes all the other sciences. If students have time for one more course, Astronomy brings in Physics and Earth Science.”
- “*It integrates modern science with basic knowledge*Its history component makes it interdisciplinary*”
- “As stated earlier, astronomy is the ultimate in culminating science courses, as it combines history, math, technology/engineering, chemistry, physics, acoustics, quantum theory and much more into a single unit. Students are forced to think across disciplines and approach science in a new way: astronomy often isn't a science done in a lab.”
- “The course integrates a lot of valuable reading and math skills.”
- “Two, Astronomy is an interdisciplinary science that examines our place in the universe and provides a context to the real world, history, and the future.”
- “Extends students experiences in physical sciences -- adds breadth to standard physics and chemistry courses.”

Not only can the course be taught in its interdisciplinary way, it also reinforces prior learning.

- “it utilizes concepts and processes that were previously taught in our science curriculum.”
- “The Astronomy course reinforces math and other science disciplines (e.g., Physics and Chemistry)”
- “The course reinforces solid science thinking, …”
- “Provides a strong opportunity for students to apply the basic science skills acquired in physics, chemistry, and earth science courses.”

It can even substitute in some states for these other courses…

- “Content - teaches almost as much physics as our physics class.”

  our district does not teach Earth Science at the high school level. Astronomy is as close to satisfying some of the Earth Sci. standards as we get. --- Teacher in a Wyoming public high school.

Knowing that what we know about the universe has changed rapidly over the years, and that elementary and middle schools may not be teaching astronomy with up-to-date knowledge or textbooks, the high school course may be the last chance to correct students' knowledge bases. It is also content, in some states, that isn't taught anywhere else in their curricula at all.

> Much of the information students learned about astronomy in elementary and middle schools is now out of date. --- Former teacher from a 500 student Wisconsin public high school.
>
> There are many misconceptions about astronomy - many adults cannot easily distinguist astronomy from astrology - more and more students (and adults) are doubting we even went to the moon!! Schools should provide a course which sets the facts straight and provides some concrete knowledge of what they are seeing in the night sky. --- Astronomy-only teacher in a 1.7K-students public school in Pennsylvania.

This course also incorporates, or teaches, many skills.

> Getting students engaged in the work is the first step to making them hypothesize, research, make inferences, and draw conclusions. These scientific methods are applicable in all areas of life. --- Optimistic teacher in 2.5K student public high school in Texas, even though course was no longer being offered.
>
> We don't just memorize facts in class, we model, calculate, debate, and discuss the evolving nature of the science of Astronomy. All of these practices are meant to mold syudents into better critical thinkers-- one of the high goals of science as a discipline. --- Teacher at a 1.5K Passing Wisconsin high school.
>
> Promotes curiosity, creativity, awareness, cooperative learning and is a good forum for problem and project based learning. --- Teacher in a 1.5K, high minority public school in Indiana
>
> The course then develops students' logical thinking. Many of today's data has to be analyzed and conclusions have to be drawn. Through this course, students can create their own projections and perhaps, become interested in an astronomy career. --- Teacher at a large 3.2K student New York public high school.

Other skills mentioned include:

- "Skills for decision making as they employ the process of science;"
- "Foster student imagination and creativity--many more"
- "Development of critical thinking skills"
- "Practices deep/abstract thinking skills"

- “More than any other science course that our school offers, my Astronomy course forces students to use real life skills in gathering and reporting information.”
- “My approach to it also fosters the development of other skills such as writing and computer usage.”

In style, the course can be more hands-on than most…

Astronomy is basic to inquiry science. All aspects of astronomy lend itself to the inquiry method of science. --- Teacher of an all grades astronomy class in an AYP Failing, 800-student, minority Oregon school.

- “It is an excellent lab based science course that promotes critical thinking skills.”
- “not memorizing.”
- “We teach the course through inquiry learning and look at the changing nature of science through better instruments, data, and theory in astronomy through time, from Aristotle to today.”
- “Astronomy is a course built around discovery. It is a way to get students to think outside of the box and realize the potential of the future.”

Here is an argument for which there are two possibilities, more rigor or less rigor. One apparently needs to choose the one that would work in your own situation:

Using the Investigating Astronomy course from TERC, which is inquiry-based, I am making astronomy a more rigorous course. ---Teacher at a 1.7K students, Needs Improvement, high minority public school in Arkansas.

it is a less rigorous option to chemistry, physics, and biology, which appeals to some students; --- Teacher at a 500 student passing, minority, public high school in Washington.

Note that the Washington state teacher was self-described as “somewhat optimistic” and the Arkansas one used the description “somewhat pessimistic.”

While the subject matter, unlike chemistry, physics or earth science, may be physically distant from the students, it is still with relevancy to their everyday lives.

> As future voting members of our society, I believe it is crucial that the students have an understanding of the place of humanity in the Universe. Particularly critical right now is that students grasp how the Earth is not replaceable and we need the plants and animals to survive. To grasp that our survival depends on caring for Earth and to learn how to move to find other Earths is vitally important to the survival of life as we know it. --- Teacher at a 1000-student, high minority public high school in Texas.

- “Astronomy is today's science, make it relevant, see the papers, …”
- “Understand news, current events, and earth's role in the Universe better”
- “Astronomy allows immediate access to the issues and situations that are at the cutting edge of Science.”
- “Everyone needs to be aware of what is going on and how the gov. is spending money or not to move the ability to discover new info.”
- “Astro students gain access to the roots of some of the major trends in modern society through the history of astronomy.”
- “Hopefully, this will allow them to make considered judgments about any activity that has an effect on our planet.”

Astronomy interest has no academic level restriction…

> I also think it is a course that is great for students who struggle with science because it is a different kind of science and one that always seems to hold people captivated. --- Teacher of a future course at a private 500-student school in Pennsylvania.

> The is a course that ANY student can be successful in because so many of the concepts can be understood at many different learning levels. --- Teacher at a 1.2K-students public school in Connecticut.

- “A lot of success with lots of upper level kids.”
- “(allows low students a way to succeed at something,…)”
- “This is a science class that is taken by students who do not always feel strong in science and math.”
- “It accomodates students with a variety of learning styles due to being in a planetarium.”
- “It is available to students regardless of their math skills, and …”
- “Good for academic students AND students who are struggling. Good for traditional and non-traditional students”

Though the survey recorded many complaints about students placed in the classes without the proper preparation, some teachers noted that it can work with at-risk students, too.

> It is more interesting for students especially those at risk or who have IEPs. --- Former teacher from a small 700-student Passing Arkansas public high school.

> 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 more than relevant, it can be tangibly beneficial. Some teachers have arranged it so that the students get transferable college credit.

- "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"
- "Astronomy is a popular freshman course in college and our students can be better prepared if that have had some exposure to it."
- "Students often leave and take astronomy courses at local colleges and universities to fulfill their COLLEGE science credit and do well. They do well even though we did not cover all the content of a college course."

Nature of the course arguments that can be used to administrators include:

- "Increases science literacy;"
- "We are teaching our students science by doing real science "
- "It is a college prep course that gives our students an idea of what they may expect from a college level introductory science course."
- "This class is constantly evolving because we discover things every day that add to or alter our understanding of our solar system and our universe. It is current!"

Course Effects with Students

> Students should be able to gain the skills and thinking abilities they need to be successful in any context in a course that interests them. --- Teacher in a Needs Improvement, 800-student high school in Michigan.

Astronomy courses have some of the highest interest and appeal rating among students, these teachers find.

- “Students may not be excited about the number of neutrons in a carbon atom, but show them a picture of a galaxy and you get their attention.”
- “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 are excited by astronomy topics in a way that they don't seem to be about other science topics, and …”
- “Any time I have ever spoken of space in my classrooms, regardless of the age, students are always attentive. It is an intriguing subject…”

Because of this it attracts students that don’t normally like science; it has been seen to change students attitudes, to bring students into science, even to cause them to become scientists.

> I don't need to do this at all but my justification usually is that astronomy represents a course that is still very interesting to many of the kids who have been turned off to science and for that reason represents a 'foot in the door' possibility to teach a large segment of kids thay would otherwise not take another science course. ---Teacher at a 700-student private high school in Florida.
>
> Often times it sparks an appreciation for science in students who may not have enjoyed the subject up until now. --- Nearly full-time astronomy only teacher at a 1.2K Wisconsin public high school.
>
> Besides the logistics and necessity for a low level semester course in our school, I would justify this course as an attempt to improve the affective attitudes of students to learn science. Their has been a decrease in numbers of students persuing the fields of science, mathematics, technology and engineering. Astronomy is a field of science that can be used to inspire the next generation of explorers. --- First year as astronomy teacher at a Needs Improvement, 2.8K-students Pennsylvania school.

Additional comments include:

- “Students enjoy the course; it is sometimes the only advanced science course some students take;”
- “I feel that there is a need to offer elective science courses to meet the interests of our students, and to encourage them to take Science courses which are widely regarded as difficult and unnecessary.”

This “interest factor” is good material for a teacher to use…

> I can take that interest and use it to teach astronomy, integrating physics and chemistry into an interesting course that considers one of the greatest philosophical questions faced by humankind throughout history - our place in the universe! --- Teacher at a 1K students public Wisconsin high school.

Students may be more motivated to succeed in astronomy because of this interest than in other science courses. It can improve students academically, and affectively.

> The astro course at [school name deleted] is mainly taken by non-sci majors....It provides these students with an opportunity to excel at a science and develope a positive self image about thier capacity to do science --- Teacher at a small Massachusetts private school.

A benefit for the teacher, the appeal and extant interest in astronomy ought to help keep (or get) a course going.

> easiest to get enrollment, relevent --- Self-described pessimistic, former teacher of a 10-12th grade astronomy course in a 1.9K student, Arizona high school.
>
> Students are naturally curious about the universe so what better class to get them excited about science. --- Teacher at a private 1000 student high school in Arizona.

Students can be a very strong source of support if a course is need of defending.

> I would solicit comments from my former students to help justify the course to the Board of Directors. --- Teacher at a 1.2K private school in Minnesota.
>
> I'd prpbably use former students comments and get them to state how important the class was for them. --- Teacher at a high minority, Passing, 1.8K-students public school in Texas.
> Student surveys reveal substantial numbers of students who would not take another science course if this one was not offered. ---Full time astronomy teacher at a large 3.4K students, high minority, California Passing public high school.
>
> I would present the success of my former students in their college studies, as that is perhaps the strongest argument I can offer. --- Teacher in a small 300 student public school in Ohio that is Passing.

The ultimate reason to use student attitudes as a defense justification may be that since they like it, they really want to take the class.

> But mostly, it is a science class many students really want to take, rather than have to take. Even some who do not like science. --- Teacher at a 2.8K public high school in Texas.
>
> Classes that interest students keeps them motivated. School should not be all about the three R's. --- Teacher in a Needs Improvement, minority 1.8K-students public high Washington school.
>
> Finally, national studies again and again when surveying students discover that students normally list space science and dinosaurs as their favorite areas of science. Is it any wonder that students get turned off by science when they can't study what they enjoy about it? Astronomy can be used to gather interest in the subject and introduce more difficult aspects of science in general under the guise of astronomy and help create a love of science that can entice students to go into more difficult aspects of science. --- Teacher at a 1600-students public high school in West Virginia.
>
> And this one is hard to argue against…
>
> For some, it could be life changing. How many courses can offer that? --- California teacher in a 1.9K student, minority public high school.

Cultural Linkages

We all do it. We all look up at some time or another. Unlike other sciences, this science can be done all one's life, at home, with your family.

- "It promotes wonder."
- "What child has not wondered about their place in the universe? Who has not wondered if there might be life elsewhere? Who will live their entire life indoors?"
- "an appreciation of both the wonder of the universe and the ingenuity of scientists."
- "It is stimulating to appreciate what men did so long ago without what we think is necessary today."
- "Adds to students knowledge of self and relation to universe. Helps teens look at things differently."

Astronomy is also the ‘first science’, the oldest, the mother of all sciences, the grandmother of all sciences, and other similar phrases. How compelling that argument is with administrators isn’t made clear, though the argument is commonly expressed by the survey teachers.

> Astronomy is the most fundamental science of them all. From the time of the earliest humans we have been looking to the night sky with curiosity. Now that we have the technology to answer many of the questions our ancestors asked, it would be a shame to stop wondering. At its heart, Astronomy is about who we are, how we came to be, and where our place in the universe lies. The sense of wonder it engenders is one of a kind. --- Teacher at a private 500 student school in Connecticut.
>
> The history of astronomy as a pursuit of understanding offers like no other course can an understanding of how we have evolved intellectually, including the complex roles that societal politics, culture, and religion play in the pursuit of understanding our place in the grand scheme, giving us a glimpse of what is to come as well. --- Teacher in a minority, 1.9K students, California public school

Paradoxically, it is considered both advanced, the frontier, the future, and also the least developed…

- “Astronomy is perhaps the most primative (sic) science and in many cases is the most reproducible under those original conditions.”
- “Astronomy is probably the beginnings of modern human thought.”
- “Astronomy and space exploration may be the future of mankind.”

Astronomy is a part of every culture, not just Western…

- “Man has been looking at the stars since the dawn of the human race. It is something that crosses cultural boundaries.”
- “Close connections to astronomy in culture and history.”
- “It has direct ties to ancient cultures”

Knowing astronomy, to some even today, is still the same hallmark of being educated that it was prior to the time of the Committee of Ten:

> I thought it was so amazing last year when some students really didn't understand that the moon rotates around the Earth creating phases or that the constellations appear to move across the sky through the seasons. I feel that these are very basic concepts that all people, no matter the age should know!! Not only the discussion of stars and planets should be taken into account but the whole discussion of the calendar and time. You would think that such basic principles would be known but so many students haven't had Astronomy since 3rd grade. --- A teacher at a 2K-students, Needs Improvement Georgia school.
>
> Most will never be scientists but all should be science literate citizens. --- Astronomy only teacher in a 1000-student Pennsylvania public high school with a planetarium

It also seems to be considered valuable in a philosophical way…

> In learning about space, we learn about ourselves. --- First year teacher at a 300-student Illinois public school.

- “Finally, it helps students put life in perspective when we see what our role on Earth is, what role Earth has in the solar system, what role our solar system has in the galaxy, and what role our galaxy has in the universe.”
- “It is important to develope a Cosmological perspective in our students.”
- “Students need to have an understanding of Astronomy. There is an interesting 'world' out there that is just being”
- “Important for student to have a cosmic perspective on science and their 'place in space.' ”
- “Big picture needed for human perspective.”
- “It is ultimately a search to understand ourselves and our world better.”
- “makes them aware of our place in the universe.”
- “It offers our students a chance to expand their minds and wonder about the origins of their universe.”
- “This course offers perspective and understanding like no other course can. … Even a basic understanding of Astronomy offers those who do a deep sense of connection to something grand and far greater than themselves, and yet at the same time makes clear how precious and amazing we are as a human race.”
- “Understanding the universe helps to put our world in perspective.”
- “It helps people to understand what they see about them.”
- “A student who takes Astronomy and truly understands what was taught will never look at the night sky or themselves the same way again.”

- “The answers to our exsistance (sic) and where we came from can only be answered by studies in astronomy. The future is in the stars.”

  It has direct relevancy to modern society…

  Technology that comes out of the space program has benifited (sic) the country. Students need to be informed of this. They will be voting for these things in the future. --- Teacher in a 1.4K students public school in Wisconsin.

  Space age technology has been around for over 50 years and has an effect on our lives. Astronomy and its physical principles are part of that technology. --- Teacher in a large 3K students, high minority, Texas high school.

  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' (sic) 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 students public school in Massachusetts.

- “The things that they learn one day may not hold true in 3 years due to the imagination, thinking, and discovery of people. The technology component reminds students of where we are and also where we have come from.”
- “Space is just now opening up to us and you will see all kinds of jobs in the near future dealing with space.”
- “…as well as the discussions regarding ethical use of space and of the public's impact on the space program.”

  Three interesting arguments for the course, two modern, one ancient…

  The only program that created more advancements for society that didn't come from war was the Apollo and Mercury astronaut programs. Any progress to society not gained via war is a subject that everyone should explore. --- Soon to be astronomy teacher at a Needs Improvement school in New Jersey.

  Students want it, it's in the state standards, and this nation has a commitment to space exploration. Any school board wanna-be would be gone if they disagreed with those 3 reasons. --- Teacher at a planetarium equipped, Needs Improvement school in Indiana.

  Astronomy compels the soul to look upwards and leads off from this world to another. Plato. I couldn't say it better! --- Former teacher from a 1.9K student Texas public high school.

Helping with AYP Issues

With science soon to be a factor in determining AYP status, schools seem to be seeking more options. Teachers have noted that.

> 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.
>
> These students would fail for the year and get no credit instead of possibly .5 credit. These students would cause behavioral issues if they remained in Earth Science.Some of these students turn themselves around the following year because they were given a chance to change their work ethic and attitude --- Teacher of a freshmen level astronomy course in a 1.8K students, high minority public high school in Virginia.
>
> My particular school needs general science classes for non science majors. This class provides s classic education in all of the sciences, the history of science, and astrnomy and space sciences as well. --- Teacher in a private, 200 student Maryland high minority school.
>
> Also, in the last 2-3 years, our district has mandated that students graduating from high school have 3 years of science. Offering Astronomy will provide another year. --- Teacher in a 2K students public high school in Colorado

- "It is something different, unlike Bio and Chem, it's a good alternative to Physics for seniors …"
- "it gives students a non-AP option for their fourth science course (only required if they are getting an advanced diploma),"
- "Need for an additional non-math oriented science"
- "Non-science oriented students need this course to fulfill a science graduation requirement."
- "not all kids can handle chemistry and physics"

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

> An astronomy course can cover a wide number of benchmarks and standards (i.e. chemistry, physics, biology standards)due to its interdisciplinary nature. Astronomy is well suited to long term science projects. --- Teacher at a Maine 1.2K students public high school.

> 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 students 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.

- "The way it is taught focuses on the standards of NSTA, especially inquiry and science as a human endeavor"
- "It's a course that offers practical understanding of the universe that 'increases awareness/literacy of how science works and improves attitudes towards science.' " (uses quote from Benchmarks of Science)
- "It also reteaches some of the PSSA standards for Earth/Space Science."
- "I have correlated it with the existing science frameworks that are published by the Arkansas Department of Education."
- "The WI state standards have astronomical topics included and not all are taught elsewhere."
- "Also, the are several space science state standards required and only 1 chapter on space taught to only the 10th grade students who take physical science."

It also can be more valuable than an administrator may think towards helping students pass state end-of-course tests or graduation exams. Note that no state was indicated that had an astronomy end-of-course test but many astronomy concepts do appear to be in other courses' tests.

> 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 students Passing public high school.

- "with the science PSSA's coming out, it is the only Earth science that studetns have a chance to experience before the test if they take it in their Junior year"
- "There are Earth Science and Astronomy questions on the WASL."
- "gain knowledge for the scientific method part of the state science test. "
- "There are objectives on the ACT that this course covers."
- "CLEP test prep."

- “The course does cover Ohio Graduation Test objectives in earth and space science which are not covered in other classes.”

Since AYP status depends on language arts, astronomy can play a role in that…

- “The students are required to produce research papers and other analytic essays. ”

Institutional Benefits

Sometimes it is good to be in the newspapers for a positive reason…

[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.

A very common response in one particular group of teachers – those with planetariums—

is not to waste such an expensive resource!

At our school, there has always been a strong showing of interest by both faculty and students in the astronomy program. A multi million dollar observatory complex would be a shame to waste: It is routinely used by programs all year long on each clear night, and not only from within our school. Interschool collaborations and other projects from high schools and universities have used the fascilities. --- Teacher at a private 1K students private school in New Hampshire, teacher teaches only astronomy, with a portable planetarium and an observatory.

- “You spent how much on the planetarium???”
- “WE HAVE A PLANETARIUM. It would be stupid for us not to use a million dollar facility.”

Teachers note other things that would (or are) going to waste:

- “(cancelling the course will mean the school) does not utilize (telescopes, nature center for observing, local planetarium, etc.).“

- “We have the texts and equipment being wasted in storage.”
- “have one of the largest video and library collections and materials for the course.”

Teachers are resources, too.

I would definitely argue that it is my specialty and that the school should use me for what I'm good at .--- Soon-to-teach first astronomy course teacher at a 500-student Pennsylvania private school.

- “I have a passion for teaching it, and am more than capable.”
- “Do you want me to continue to be a teacher here?”

It also makes school-shopping parents consider your school more closely.

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

Upper-level courses such as astronomy are essential in competing (that's what we really are doing!) with private schools (they often cannot offer a specialty course such as astronomy) --- Teacher at a large 2.4K students public school in Ohio with a planetarium.

A pair of teachers present a possibly typical scenario…

I’ll explain the course’s value to our students and society, but the administration will politely tell me that students, parents and citizens don’t care anymore. --- Self-described somewhat pessimistic teacher at a large, 2.2K students public high school with a planetarium in Wisconsin.

… and solution.

The course is a very effective way to counter the anti-science and general apathy rampant in the public today. --- Self-described optimistic teacher at a similar school in Tennessee, 1.6K students, with planetarium, teaching in first year of course.

Another scenario ‘pairing’…

Unfortunately, money wins and I doubt this course will be offered again in the future (its been two years now since the last offering). --- Self-described pessimistic former teacher from an AYP Passing, 400-student Wisconsin public school.

…and a possible solution, too.

…students from surrounding schools enroll into our course. Because they do not attend our school, we can count their presence and receive partial state aid. Economics are always a good argument. --- A teacher at a 1.8K students public school with a planetarium in Michigan.

The Science Itself

content is vast and it allows student creativity and imagination to expand. --- A first year, and only time teaching astronomy, Georgia, 1.6K students public high school teacher.

I would say that astronomy is not a niche science, it's the foundation science from which all other sciences emerge and no other science class can better prepare students to see the interconnectedness of the different science disciplines & the connectedness of themselves to the world that we live in. --- Teacher in a Needs Improvement, high minority, 2K students New Mexico high school.

Additionally…

- "It offers richness to the student's knowledge base and …"
- "Students learn about the nature of science and inquiry as well as astronomy content which allows them to better understand the world around them."

The science is more accessible to student minds than some other ones…

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.

One of the few courses that students actually take away skills and information that they can use and remember (directly) for the rest of their lives, especially if they spend any amount of time in the out of doors. --- Planetarian/teacher at a 1.3K student, Passing, Wisconsin public high school.

- "Astronomy is relevant to students because all students have access to the night sky."

- “Students can experience original discovery by repeating acts from thousands of years ago.”
- “I teach physics and physical science, as well, but these disciplines seem 'static'.”

Astronomy is the rare science where 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 high school students can 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.
>
> We've contributed to the body of scientific knowledge by discovering 3 supernovae, over 20 asteroids, and by providing followup measurements on nearly a hundred Near Earth Objects. --- Teacher at a public North Carolina, 2.5K-students high school with no observatory.
>
> We involve our students in real research with astronomers. For example, we are currently one of 14 classrooms involved in a joint study between GAVRT and the Spitzer Infrared Space Telescope studying AGN of various masses to see if there is a correlation between the radio frequencies and infrared data collected. We are collecting real time data and archived data using both instruments. --- Full-time astronomy teacher in an 2.2K students Oklahoma public school.

Some Strategies

> The sky will be there for a long time...your entire lifetime...and you will know it better by taking this course. --- A Georgia teacher at a large 2.8K students, minority school, with a portable planetarium.
>
> I'd give my class evaluations, which are generally very positive. I'd state how we don't really have any expenses to keep the course running, besides of course my salary. (I teach 5 mathematics and this 1 science class). And, perhaps most importantly, I'd reiterate the justifications I gave when first proposing this course: that its subject matter is intrinisically interesting, that it provides a great way to review and use much of the

science and mathematics that was previously taught, etc. --- Teacher at a 600-student private school in Ohio.

I would talk about this integrated science brings physics, chemistry, earth science and mathematics into the student's repertoire and that this helps us meet the state goals in science. --- Teacher at a small 300-student Illinois public high school.

Some strategies are just unique.

Three, we have an Apollo astronaut [name deleted] who graduated from our school. --- Teacher at a Michigan public school.

I teach this course to many students who are interested in science through science fiction. Many of these students may not go to a traditional 4 year university. Many will go to a 2 year technical college. This course prepares them for the critical thinking needed in the course work at those institutions. Many students are turned off by science in general, but are extremely interested in astronomy and space science. Students who enter in the freshmen year comment that they learn much chemistry and physics in the class that it makes it easier for them to take these classes as upper level students. --- Teacher at a 1600 students public high school in West Virginia.

Results should count!

Continued strong student demand and support for the course speaks for itself. --- Teacher in a 1.1K-students private New Mexico school.
Plus…

- "Several past students have become astronomers."
- "Some wonderful research projects have been done over the years, several students have taken projects all the way to the California State Science Fair."
- "We have high science scores relative to the rest of the school."

<u>Increasing the Number of Astronomy Courses</u>

What would have to be done to increase the number of astronomy courses in the U.S.?

One might think that answers to this question would be similar to those on how to start a class. There are some similarities but there are more differences, plus there are echoes of ways to get around the effects of NCLB on the courses.

A total of 280 suggestions were received, slightly more than one per teacher. The areas in which the answers are found fall into five areas:

- more teachers, training, funds,
- changing perceptions—in the public and in administrations,
- requiring more astronomy in coursework, tests, and standards, thus elevating astronomy to near equality with the main three sciences,
- more outside influences on the schools,
- changes to curricula and available resources to make it more attractive a science.

The three most common themes were: (29) more training was needed to make more teachers (and this includes changes to certification), (24) making more astronomy in national and state tests and standards, and (23) more funding (though not for teacher's salaries!).

Require It/Offer It

Increasing the number of science courses required to graduate will help put more astronomy courses into the schedule. States where the number of courses required are only two need to make it three, three required years need to go to four.

> Increase the number of high school graduation requirements for science. If it were done at my school, I would have more sections --- Teacher in Wisconsin, teaching one section in a 2000-student public school

- "Increase elective requirements for science or decrease requirements for other electives."
- "Increase the number of required years of science in high school, change the culture of kids settling for minimum standards in terms of their education"

One might wish to be able to simply force the issue….mandate that astronomy and earth science be included as required courses in the high school curriculum across the nation. A more likely way might be to make a course required by having more astronomy standards in state frameworks, and on tests. If that happens, astronomy courses will almost certainly survive and grow.

> Help people to realize how astronomy can be taught as an interdisciplinary course that can satisfy many of the National Standards. --- Teacher at a Minnesota, 1.2K students private school.
>
> From an AR point of view, not having a state set of Frameworks is a major reason there aren't more classes. So, I suppose, having a written set of published frameworks would help. --- Teacher in a small 250-student Arkansas public school.
>
> Good question! Perhaps if the national curriculum emphasized the earth and space sciences as a foundational area. --- Teacher at a 1.6K student public high school in Wisconsin.
>
> Ask states to encourage the suggestions given in Project 2061. --- Teacher in an AYP Failing 1.7K-student West Virginia school.

One teacher pointed out a truism…that some of the state curricula are written by other than astronomy enthusiasts. Historically, back as far as the establishment of college requirements with the Committee of Ten, to more recent Project 2061 and local efforts like in Texas, astronomers and astronomy educators have poorly, if at all, spoken up when the standards have been created.

There is also a perceived need to convince powers higher than state level.

> Benchmarks and learning results are driving curriculum - someone with some influence at a national level would need to see the importance of an astronomy course. – Teacher in a 1.2K-student Maine public school.
>
> Unfortunately, testing seems to drive many of our course offerings. Until there is increased testing of astronomy concepts, few courses will be created. --- Teacher in a 700-student Kentucky Needs Improvement public high school.
>
> Make it part of the state tests that are required by NCLB. --- Teacher at a 1.7K-students Passing Washington state public high school.
>
> The TESTING scheme in the US forces science students into boxes, leaving little room for innovative science courses, like astronomy, marine biology, etc. The emphasis on testing needs to shift. --- Teacher at a Passing, 2.5K-students minority public school in California.

We've already noted that some teachers lose their classes because of the effects of NCLB and high stakes testing. A few teachers, in various ways, indicated that getting away from high stakes testing would allow courses like astronomy to be options for students. That is not likely to happen.

Changing Perceptions

To make the course required, or at least more frequently offered, it is clear that the education community must educate the people who make choices (school boards, administration) who design the school curricula to see the merits of astronomy education. This would require a change a change in how Americans view science education in high school which is typically just bio, chemistry and physics, a situation where it has been for now over a century.

> Advertise to administrators as to how easy it is to fulfill science requirements using this integrated course. --- Teacher at a small 300-student public high school in Illinois.
>
> Make school administrators understand that astronomy is important, part of most state standards, is undertaught, and everything taught kids doesn't have to be 100% about the 'test' --- Teacher at a 1.8K-students Missouri public school.

There is strong need to change its present perception as being a 'filler' in high school curriculum.

> I see it as just as important as chem and physics. --- Teacher at a 1.3K-students, Passing public Washington high school.
>
> More emphasis needed on the value of astronomy as an enhancement to science education, the wonder factor, may lead to careers, commitment to science. --- Teacher at a Georgia 1.7K-students public high school.

Some other factors need to be brought to administrator attention…

- "Recognition of its attraction to young people"
- "School systems need to understand that many students DO have an interest in this field of science."
- "For the administrators there would be issues to making space in existing schedules and freeing up teachers to teach."

Another way to increase the number of courses is to have its perceived status upgraded by being accepted by universities as a lab science.

> Curriculum changes need to be made where astronomy would be counted as a course on the same level as physics, chemistry, and biology. Many administrative people in public schools do not understand the content of a course in astronomy and pass it off as not being a tough course. The change must come from higher levels of decision making on the national and state level. –Full-time astronomy teacher at an Arkansas 1.5K public high school.
>
> The tie-in with physics is the key. By having more districts/states require physics and getting astronomy approved as a basic physics course, the number of courses taught nationwide will increase. --- Teacher at a New Mexico Needs Improvement, high minority 1.8K-students high school.
>
> Make it acceptable as a core science course along with physics and chemistry… --- Teacher at a 1.6K-students public high school in West Virginia.
>
> Make it a course that is recognized as a science class by the various state departments of education. --- Teacher at a 1.1K-students public Tennessee high school.
>
> Have govenments and universities recognize it as a legit science course related to physics. I have problems with attitudes that do not think it is hard core science and that it is an earth science/geology course (which it is not) for 'rock jocks.' I teach a great deal of classical and modern physics and chemistry as part of this course. --- Teacher at an Passing 1.2K-students Washington state high school.
>
> Get Universities to accept astronomy as a legitimate lab science in admissions. --- Teacher at a high minority, 3.4K-students California Passing high school

More…

…Teachers:

There are just not enough teachers to teach astronomy courses anyway. The great majority are from physics, geosciences and life sciences, on top of there being a lack of those specifically astronomy-trained. Often teachers have no training in astronomy, and teach on the basis of their hobby interest or a course or two in college. Even if they are well-versed in astronomy, it is still a matter of *having* a teacher who *can* teach it!

> not enough teachers because they've never encountered it. --- Former teacher at a 500-student Maine public high school.
>
> Have more teachers major in the Earth Sciences. There are simply not enough to go around! Most science teachers are credentialed in bio, chem or physics. --- Teacher at a 2.2K-students Passing school in Michigan.

Some teachers thought the field should hire teachers with backgrounds and interests in astronomy. While that would certainly make more teachers more qualified than the current population, there are few schools where astronomy education is taught, and virtually all university astronomy departments do not encourage their students to go into high school teaching, as evidenced by the small population of high school astronomy teachers with any degree in astronomy.

What also needs to be done is to make more teachers interested…and less fearful of astronomy.

> To increase astronomy education, we will need to make the profession worthwhile to entice researchers and professors to come into K-12 education. This would require high teacher salaries and respect from parents and school boards. A Ph.D. in astronomy is not going to work for $30,000 a year and put up with parents complaining about failing grades when the student is not doing the work. --- Teacher at a Passing 2.5K students Texas school.
>
> Most are afraid of the content, or at least I know this to be the case here at my school, and I don't know the reason for this. My guess is that most teachers are unaware of how well astronomy concepts can be intergrated into their current curriculums. --- Teacher at a 1.4K-students public high school in Kentucky.

Fear can only be reduced with good educational training, which is the second item in this section.

…Training:

There's an almost universal acknowledgement that astronomy teachers are ill-trained in this pedagogical content knowledge, in technique and content in astronomy education. Both current and prospective teachers need more workshops. The absence of any astronomy education programs is acute. At least one course should be taken by pre-service science teachers.

> 1) More secondary science teachers need a deeper and broader exposure to space sciences, especially stellar astronomy. Their knowledge of solar system astronomy is generally good. (…) 3) Introduce & train teachers in planetarium simulator programs and to space-flight simulators like Celestia. 4) Introduce & train teachers in software such as Hands-On Universe; where students can make real discoveries.5) Introduce & train teachers in low-cost telescope & astrophotography programs, so that students can take their own photographs. Nothing connects a student with space like a high-quality photograph that they have taken themselves! --- Teacher at a 1.8K-student, Passing Ohio high school.
> Require at least one astronomy course of all high school science teachers as preservice coursework preparation (just as currently, states require coursework in chem, bio and physics for certification) --- Former teacher at a high minority Connecticut public high school
>
> Add more astronomy courses into science teaching curricula. That is, get courses in the teacher education programs around the country, and make them required courses. My current student teacher did not take an astronomy course! --- Teacher at an Indiana Needs Improvement school.
>
> In order to get these instructors I would suggest that several universities across the county offer a masters program in astronomy for *educators at little or no cost.* --- Teacher at a small Arizona Passing high school.

Beyond this, many current teachers decry the lack of sufficient astronomy content and pedagogy workshops. Those of the ASP and NASA are not reaching large numbers of the population.

- "Develop more astronomy-capable teachers through workshops …"
- "…(need) professional development for teacher(s) interested in teaching astronomy courses"
- "develop national national teacher workshop initiatives (such as Project SPICA) to increase awareness of astronomy as a high school course."
- "more free workshops with stipends for high school instructors"
- "Invest in training teachers by offering free courses, materials, stipends, or some combinatin of the above."

…Certification:

A major issue since NCLB came into effect is having 'highly qualified' teachers. But nobody offers a certification in astronomy. Just as above in which there are no college programs and degrees in astronomy education, there is a need to create and offer high school certification in the science.

> Astronomy is not a certification area and I think that many teachers are afraid to teach it due to their lack of knowledge. I only had 1 class in astronomy (that I did not like by the way) as part of my undergrad. ---   Former teacher from a very large 2.6K Ohio school.
>
> Departments of Ed at Universities and State Boards of Reagents must change the way potential teachers earn their certifications. It is very difficult for a recent teaching candidate to have the broad-field certification to be employable and have content knowledge of astronomy. --- One year only astronomy teacher in a Passing Georgia high school.
>
> Create appropriate certification options (Astronomy majors should be able to teach astronomy without an earth science degree.) --- Teacher at a high minority, 3.4K-students Passing California school.

…Funding:

As an elective in a time of educational crisis, astronomy is woefully short on funds for equipment. Its budget is most likely an afterthought after the major lab sciences get their funding.

> Money! Astronomy is tough to teach without equipment. A good scope is also the easiest way to get kids excited about the course, but they are expensive. It's a vicious cycle as well. Less funding means less students become involved, which means less teachers for the next generation. --- Teacher in 500-student, Connecticut private school.

> This goes for professional development as well.

- “increase support financially (teacher workshops; etc).”
- “funding for workshops to improve teachers abilities to teach the subject”

> 1. Provide more workshops or summer programs where teachers can come to learn. These programs need to be fully funded. Increasing the current knowledge base of teachers and exposing them to various curricula is a wonderful 'shot in the arm' to grow as a teacher. It also opens up networks to share ideas. 2. Require these teachers to return to their own states and get the same process going locally or to conduct workshops through their local astronomy clubs and state science teachers associations. --- Teacher at a Passing Oklahoma 2.2K-students school.

Outside Influences Needed

Comets and eclipses have historically been a source of fear. But astronomy teachers can use them as a source of inspiration to create their classes.

> Need an outside event, an eclipse, a comet. Forensic classes increased when there were more TV shows on the topic that caught interests. --- Teacher at a 1.6K-students, Passing Massachusetts school.

> People have to be reminded of the importance of things out there, the sun--GPS's are affected, so Astronomy is essential. --- Self-described pessimistic, course-terminated teacher at a Passing 1000-students Michigan school.

Another forum to convince is the business world…perhaps, as one teacher wrote, someone needs to have “some perceived need when comparing to other countries (China, India, etc.).”

> For one, the business sector would have to show an interest in more courses in schools. If the labor market of tommorow needs this backround, then corporate america needs to demand more of it from the public institutions. --- Teacher at a 1.5K-students Wisconsin public school.

> Make astronomy a priority with some federal or corporate support for a national program. --- First time astronomy teacher at a 1.4K-students private California school.

Pleas for an increase in NASA activity, resembling the glory days of the Space Race, is very evident.

> …national move toward increased science and math education (similar to what happened after Sputnik) --- First time astronomy teacher in a 1.8K-students Texas public school.

- “A greater national interest (i.e. PSSC movement stemming from Sputnik)”
- “I hope that the current push to return to the moon and then Mars increases interest (and funding!) in science education.”
- “reassert how technological ambition and dominance worldwide in a math/science push in the school similar to those that happened in the 1950s and 1980s.”
- “Another Sputnik”
- “Renewed interest in NASA and space in general.”
- “Another SpaceRace, Mars colonization, discovery of life outside of Earth's biosphere.”
- “Increase funding for NASA projects. When NASA does something big, it sparks interest in the general populace. If NASA could function at the level it did during the late 60's, more folks would be interested in and promote astronomical studies.”

Significant political/governmental change is needed to increase societal support of science education.

> A push by astronomy organization, especially the AAS and local clubs. --- Teacher at a 1.1K-students, Needs Improvement, public school in Ohio.

Curricular Changes and Resources Needed

Astronomy-related content standards could perhaps be required in middle schools. It would create interest in taking a course when the students get to high school.

> Improving the level of elementary and middle school mathematics and physical science knowledge. These levels are usually taught by teachers untrained (and often afraid) in the physical sciences and math. --- Teacher at a small minority, 200-student Mississippi private school.

> Feeder schools need to teach it so students demand MORE when they get to high school. --- Teacher at a 1.2K-students Wisconsin public high school.

> Math instruction would have to be in synchronization with astronomy instruction. In other words, students have to begin taking math classes earlier in their career. --- Teacher at a small 300-student Passing Ohio school.

There is a repeated theme that a consistent pre-developed astronomy curriculum that is high school appropriate needs to be made.

> Gather interested people to put together an inquiry-based series of modules that engage students rather than talk to them. Preparation for this type of course is immense and teachers need help in implementing them. --- Teacher at a 900-student Maine public high school.

> Perhaps if a national organization developed an astronomy course SPECIFICALLY to address as many national standards as possible and piloted it with teachers and it were successful, then administrators at a local level could be convinced to offer the course. --- Teacher at a 1.2K-students Maine public high school.

A high school level textbook is needed. Again, if there is a better text, then more teachers might have a good enough resource to encourage administrations to offer a course…

- "Develop GOOD HS texts, I only found really basic JH texts and College Texts... both need to be supplemented."
- "Also, high school level textbooks might help those teachers who are nervous teaching wothout a text."
- "Also make high school level text books available to low learning students. Most astronomy texts try to be as thorough and usually as difficult as college level texts."
- "I think that there needs to be a very good high school text written for astronomy that has the right blend of exploration, physical science, history, perspective, and math that encourgages students without having the science too open ended, too deep, or too superficial."

Funding is needed not only for professional development but also for basics:

> Better funding to schools would help. With tight budgets, small classes get cut and more students are crammed into overcrowded classes --- Teacher at a 500-student, Passing Wisconsin school.

These needs include

- “Funding would be necessary to support basic laboratory supplies”
- “give governmental funding to obtain high school text books or related materials”
- “Increase funding for handons opportunities such as planetarium upgrades and opportunities for schools to visit other schools with planetariums.”
- “Dedicated funding for equipment, teachers, and facilities.”
- “Funding for more online accessible programs, field trips for schools like ours that are removed from major metropolitan centers, collaborative opportunities with schools/colleges that DO have observatories or planetariums.”
- “Pay teachers more”

While this survey shows that a high percentage of every school where astronomy is taught has an average of three telescopes, a number of teachers pointed out that more, and higher caliber telescopes, are needed.

- “Provide networks of remote control telescopes for schools to use to minimize captial outlay.”
- “More observatories need to be built at schools.”
- “Also have regional observatories and/or planetaria where economies of scale can have these learning/teaching/fun facilities available where individual school systems could not/would not invest in these costly facilities.”

More planetariums in high schools are needed to go along with telescopes and supplies:

> Re-activate or build planetariums at more high schools, or have portable planetaria available (possibly shared among several geographically close districts). --- Teacher at a planetarium-equipped Passing, 1.8K Ohio school.

Other Ideas

A grab bag of ideas….

Electing a former astronaut as president ;-) --- Self-described somewhat pessimistic, teacher at a Failing, 1.5K-students Georgia school.

- “Astronomy educators must unify their vision for high school astronomy and provide strong arguments for including astronomy education in high schools.”
- “Have parents request it out of the school.”
- “An grass roots effort would eventually need the endorsement of state/NSTA”

An idea to pursue….
An AP astronomy course might be nice; though I would hate losing this rare moment of autonomy as a teacher. --- Teacher at 700-student private school in Florida.

also they could make an AP exam for it, i guess .. students just love overloading on AP classes.. ---Full time astronomy teacher in a large 2.5K-students Virginia public high school.

Then there are these two ideas from private school teachers:

Perhaps borrow a page from art, drama, and music educators, emphasize that it's more than a science, that to lose astronomy is to lose something of our humanity. --- Teacher at a 600-student private school in Ohio.

We have to rethink how we teach science (all courses) in light of new cognitive and technological breakthroughs.- play on the 'processess of science' as the main goal of science courses,; rather than a focus on the content. astronomy then becomes a core course, as its history is tightly bound to the history of scientific thought through Newton, more loosely bound through Einstein... and still influential now. - start to illuminate the place that science has in the evolution of our thinking as a species. As astronomy was the 'ultimate science', leading to Physics becoming such (and now biology replacing physics),the issues and concepts that astronomy can bring to a students mind through the content, can help us understand why Western society 'believes' in science generally, understand the issues that underly what science is and what it believed to be in the present time, and the political/cultural ramifications of continued commitment certain types of belief.- A beginning of what I could say. --- Teacher in a 400 student private school in Illinois.

And to finalize the section, some teachers’ advice to the writer…

- “Help individuals advocate in their districts. Produce website or print material entitled: 'How to propose and initiate an Astronomy course in your school' Or something like that!”

- "But the most important thing anyone can do is to do a study that results in supporting the idea that astronomy increases high-stakes testing scores in a more efficient manner than other high school science and math classes."

Administration Viewpoints

It was not possible with this survey to check out 'the other side', the administrations' views on astronomy courses. That is a job for the future. However, we did get two opportunities to get a small, if statistically insignificant, insight. We had an exchange with a retiring Supervisor of Science in Texas and a state Department of Education official in North Carolina.

The Texan's main comment concern not too few choices but too many.

> …except we do not offer an astronomy course in our district. As you can imagine, given lots of alternatives, students can opt to wiggle around courses that would prepare them better for standardized assessment and career goals after high schools. There are alredy too many science courses for kids to choose.

The North Carolina official told us that in her state, there are fewer elective options. In North Carolina now, she says, there are three required science courses, biology, physical science and an elective, in that order. Either of the latter two could be astronomy. In 2001, Earth or Environmental Sciences became the third course option, in 2004, the middle choice became physical science, physics, chemistry or principles of technology. Because of this two-course strongly suggested sequence, the upshot is there are now fewer electives to choose from. Astronomy is harder to schedule. Only some kids take a fourth college class, and that is usually an AP class. The physics people in North Carolina want more astronomy, and moving to block scheduling allows more sciences to be taken.

These two may illustrate a dichotomy existing among administrators. It does not say what it may take to put an astronomy course in the schedule. Both of these topics need further research but it was deemed worthwhile to put these two cases here.

CHAPTER 6

DISCUSSION

What is the typical form of a high school astronomy course today? The research questions posed at the start of this investigation shall now be answered.

The Schools

What are the typical kinds of schools that do offer astronomy, in terms of public versus private, block or period scheduling, status in AYP (Adequate Yearly Progress)? (And…how many are there?)

The high schools that offer astronomy courses tend to be larger ones (though not exclusively) averaging just under 1600 students in the public venue and just over 700 for the private, give or take twice the national average of sizes for both private and public schools. Most range between two and four times these average sizes. School with astronomy also tend to be more urban and suburban than rural though at about the same proportions as schools in general. Schools with astronomy are also found in proportion to the general percentage of public versus private schools in the country, which is generally about 88% public and 12% private schools.

The astronomy course is almost as likely to be in a block scheduled time-slot as in periods. Overall, schools with astronomy operate on periods, outnumbering schools on block, 51% to 41%, but in public schools traditional periods wins over block only by 48% to 44%. In private schools, these numbers are 77% versus 23%.

There are astronomy courses in high schools in every state, but they are larger in quantity in certain ones; survey response was high notably in Pennsylvania (a state especially rich in schools with planetaria, having about 25% of the national inventory), Wisconsin, Ohio, and

Michigan. Other sources indicate the survey undersampled California, New York, and Illinois. It can be estimated that there are about 2500 schools with astronomy, proportionately split between public and private high schools. There is also a hidden mass of schools and teachers, contributing at least 20% more, that raise the number of schools to over 3000 with very little increase in the number of students because these classes teach fewer than nine students per class, even as few as 1 to 3. Overall, around 12-13% of all high schools teach astronomy to around 80,000 students, or about 3.5% of all students.

If the public high school isn't passing AYP, it probably isn’t going to have an astronomy course. In all likelihood this may be because a school AYP Failing may terminate the course to work on remedial courses whereas a Pass school may be more lenient, perhaps even more enthusiastic about offering beyond the basics or core courses of the big three of science--Biology, Chemistry and Physics--and math and language arts courses. Seventy-seven percent of schools with astronomy in the survey were Pass schools, 20% were Needs Improvement, and only 3% were Failing. Both of the first two percentages are above national values for AYP.

There is every indication that school size and AYP status are independent factors.

There is some evidence that the factors “AYP status” and “minority proportion” are related. This study found that minority schools have Pass/Not-Pass AYP status’ at the same proportion as the nation as a whole but non-minority schools (defined here as 35% or less minority) Pass at a higher percentage. Minority schools with astronomy were found in larger numbers in Texas, California and New Mexico, and half were minority because of Hispanic populations, with African Americans, Asians and Pacific Islanders dividing up the rest.

This then supports our contention that public high schools with astronomy are equally or more likely to be Pass schools than the national norm. This also gives support to studies that say that electives like astronomy are cut out when a school does not pass AYP and, speculatively, it could give support to the argument that to help a school pass AYP, electives like astronomy are actually helpful. At the very least, Passing schools have the luxury of choice to offering astronomy.

The Courses

What are the specifics of the courses themselves? What do they cover, how often are they taught, how many sections, how long is the course in time? What prerequisites are the gatekeepers for students who wish to take the course? Does the course have standards set by the state?

The courses are overwhelmingly all-inclusive, stars and the solar system together, for nearly 7 out of 8 courses. On the rare occasions where the course boundary stops or starts at Pluto, stellar studies outpace solar system in private schools two to one whereas in public schools, the reverse is true. Overall, though, planets lose out to stars, by nearly two to one.

Astronomy courses running on a semester basis account for 55% of all astronomy courses (yes, let's teach you the entire knowledge of the universe in only 4 months!). This rate is even higher in the private schools, 63%. Eight percent of public schools run on some other schedule such as quarters or trimesters, the rest are year-long. There is no correlations between block/period and year/semester, block and periods about 50-50 for both kinds of academic durations There is only some difference between the numbers of courses offered in fall versus spring; the number does drop over the course of a full year a bit.

As shall be described in detail further down, most schools have but one astronomy teacher, and most of them teach just one section.

Only 15% of all schools offer a second astronomy course, but private high schools offer a second course proportionately twice as often as a public school.

As an elective course (it is required only in the tiniest fraction of schools), the largest prerequisite…is none; 26% have no requirements to take the class. The next largest prerequisite is one prior science, 16%. Eleven percent of schools required one prior math course, 9% two prior science courses and only six percent required one of each. There are a few cases where the prerequisites are more stringent; sometimes you have to have certain score on a test or final course grade. The score can be above a certain level or *below*, as in the student has to have failed a course to take astronomy!

It is difficult to say if the various states have standards specifically for high school astronomy courses but it is also clear that even in states with a dearth of astronomy standards available, course standards *can* be cobbled together from other courses and national standards to justify course content.

The Teachers

> What is the background and teaching situation of the average high school astronomy course teacher, in terms of education, amount of astronomy training, entry point into the field, longevity, other courses taught, contact with the rest of the field, what they do for professional development and 'keeping up'?

Teachers are generally a very educated lot. More astronomy teachers have masters degrees (79%) than in science teaching in general (46%) or physics teachers (60%). The problem is they aren't as educated in astronomy as a physics teacher may be in physics. Part of the problem is that there is no state that has a certification in astronomy and there are perhaps only four colleges or universities in the United States that offer a masters in astronomy education (and two of those are allied with, or are totally online courses from, non-U.S. universities).

Unlike the other sciences, astronomy teachers only come out of undergraduate astronomy majors 8% of the time (in terms of the teacher population). Astronomy majors don't go into high school teaching. At the undergraduate level, 65% of the teachers do have science-related degrees.

But most came out of the biosciences, followed by the geosciences. Physics ranks third, making up much of the remainder of the science-originating teachers, along with a few chemistry and physical science/broadfield science trained teachers. Sixteen percent (16%) come from science-specific education programs, such as geoscience education. This leaves 19% teaching ‘out of field’ in regards to their undergraduate majors.

At the graduate level, 36% hold science masters and 27% hold science-specific education degrees. But that leaves 37% ‘out of field’. Geoscience and Biology still surpass physics.

At the college level, physics is, and historically was, the home of astronomy but in high school teaching, physics places third in terms of degrees and majors.

If so few astronomy majors opt for high school teaching, the next best hope one would want is for an astronomy teacher to have had astronomy courses. On that score…28% have never had one at the undergraduate level. If they do take one, they average at least two. At the masters level, only 56% took an astronomy course, but those that did took more than three. Half of those masters holders who took a course did so so as to make up for their lack of a course during their bachelor degree programs.

In public schools, you must have a teaching certificate. There is no certificate in astronomy so a teacher must be certified in something else. Here again, teachers holding certificates in physics do not rank first. Geoscience certificate holders outnumber them. The number of biological science certificates drops to third highest in the ranking.

At least we can indicate that 70% of our teachers have a certificate *and* an undergraduate major in a science, even if not astronomy.

What is a change is that these teachers are not so overwhelmingly male. The percentage of male teachers has shrunk from 88% to 67%. More females in proportion teach astronomy than teach physics (31%).

There are, now, an estimated 3200 astronomy teachers.

Most often, teachers, male or female, get into teaching astronomy because they want to teach it. As more astronomy courses are created by the teacher, not inherited, clearly having the interest is a key ingredient to making a course happen.

Half the teachers have been teaching astronomy more than seven years, half for less, and fully one-sixth of them are new to the course. Less than one-sixth can be said to teach astronomy full time. In general, they teach physics classes, or a geoscience course or physical science. Only here -- other courses taught -- does physics still reign on top, but just barely; geoscience courses are taught nearly as often. Geoscience could easily overtake physics here as geoscience courses take in more of the astronomy teaching load. Despite biosciences being the leading source of astronomy teachers, biology is taught only half as often as physics by our astronomy teachers.

As astronomy teachers, these people are the only such instructor in the school 68% of the time. This is little different than it was nearly 25 years ago.

Professionally, the astronomy teacher tends to keep up with astronomy using NASA Websites and astronomy magazines and books. *Sky and Telescope* and *Astronomy* are nearly tied for most usage. <Spaceweather.com>, <space.com> and Astronomy Picture of the Day are the most used websites. Also contributing to their knowledge of current events in the science are non-NASA Websites, newspapers, and various NASA and others' workshops, conferences and programs.

Professional development in pedagogy comes mostly from NASA, its websites and its educational programs, so teachers indicate. Some other conferences and workshops help, as do association newsletters or magazines. Hands-On Universe is by far the greatest help in pedagogy among pedagogical astronomy programs.

As noted above, the astronomy teacher tends to teach alone, and not often. 55% teach just one section, and 80% teach just one or two. This is also only a little different from nearly 25 years ago.

In keeping with their isolated status, a large percentage don't have much contact with other astronomy teachers. Workshops and conferences are the most prominent ways of meeting others and talking shop.

About half belong to NSTA but general science regionals (as opposed to physics- or earth science-specific regionals) are about as equally popular. The physics teacher group AAPT, the Astronomical Society of the Pacific, the Planetary Society and planetarium groups are the predominant astronomy or related groups teachers belong to but none rise to the level of NSTA in terms of membership.

The Students

What is the nature of the student body of the class? How representative is it of the school? How many students take the courses, and are the numbers changing over time?

The average class size is about 23 students overall and in public schools; this parameter is about 17 in private high schools, with all standard deviations about 7 students. This average does not change with course duration or frequency.

The number of students taking astronomy has been slowly increasing since the early 1980's, from a low of 1% to the current 3.3% of all graduating high school students. The class average is up just under one student since Sadler's study. The trend in recent class averages reported by teachers is declining. It may be that the number of students is growing because there are increases in both the number of students and schools but the number of sections offered/students taking in classes in individual schools appears to be declining, possibly due to budgetary and NCLB influences. It is likely that the growing total number of students is over-compensating for any reduction in individual schools' class sizes but the trend augurs ill for astronomy classes.

There are a significant number of classes being offered of far lower class sizes than average. These 'single-digit classes', where teachers are teaching 1-9 students, account for about 20% of all classes, but do not add significantly to the total number of students.

The course is taken most often (75%) as a junior/senior capstone elective. It is next most often as a 'Median" class, that is, made up mostly of sophomores and juniors (or sophomores through seniors, all equally represented) 16% of the time. It is rare, only four or five percent each, that it is open to all four grade levels or is just an underclassmen course.

Generally, because most astronomy classes involve the use of science critical skills and math skills of at least Algebra I levels, the student abilities are considered by teachers lower than required when the course is offered to the lower grade levels or in courses when all grades are mixed in.

There are more males than females in these classes, 53 to 47 percent. This is no different from the usual physics classes but still a slight gender gap to national percentages where males are 49% of the population. Demographically, the proportions of races and Hispanics are close to the national census values, with slightly fewer students among Asians and Hispanics. This is very different from the demographics of physics classes. Classes are not usually different from the school demographics, whether or not it is a minority school. There also appears to be no significant difference between the percentage of minorities in astronomy courses measured against all the nation's schools.

The Curricula and Facilities

What curricula and facilities are available to teach the class, including textbooks, curricular packages, the use of the internet, planetarium and telescope availability? How much does the course material cost and where do the monies come from? What are the ongoing problems teachers perceive with the course?

A most common complaint is the lack of a high school level textbook. That doesn't mean textbooks aren't used. The text, Astronomy Today, by Chaisson and McMillan is the most popular but it is only used by 25% of those using books. One has to add up the next four other textbooks mentioned in popularity to have a frequency equal to Astronomy Today. A quarter of all schools do not use a commercial text, very much lower than what was claimed in 1986. Teachers often use dated editions and other books from the trade press, presumably because of lower costs.

In terms of non-textbook curricular materials, several programs are commonly mentioned, Project Star the most, but materials from the Hands-On Universe program and the ASP's *Universe at Your Fingertips* are mentioned multiple times. Like websites, quite a few other packages are out there being used but mostly by individual teachers, not the overall pool of teachers.

The most common sources of materials….are the Internet in general, and NASA centers, programs, and websites in particular.

Planetariums are still a factor with astronomy courses. Though known planetariums were oversampled, we can estimate that nearly 10% of all high school courses likely have a fixed dome planetarium available for frequent use. There may be a nearly 1:1 ratio of the existance of an astronomy course if a planetarium exists, but not the reverse. An astronomy course does not guarantee the existence of a planetarium. An almost equal percentage of schools find funds to go to planetariums elsewhere once per course, though there is evidence that this is a diminishing option for financial reasons.

More than 10% of this survey population use portable planetariums with about one-third of those being owned by the school itself. The rest borrow from the district or other portable unit owners. When a portable is owned by the school, it is used as often as a fixed facility. If this proportion holds for the whole population, there may be one-third as many schools with portables as there are with fixed domes, 3-4% of all. This 10:3-4 ratio is quite different than the ratio of 90:10 that was found with the several-year-old IPS directory; it is possible that the IPS directory of planetariums under-reports the portables usage as many schools may not consider it in the same way—"yes, we have a planetarium facility"--as they would a fixed dome in a building.

Rising rapidly in number and possibly equal to the number of portables in proportion are the schools using 'planetarium software' such as Starry Night. These programs place realistic two-dimensional sky views on screens or computer consoles and are programmable to reproduce accurately sky phenomena at much less cost than a portable or fixed planetarium facility.

While high school observatories are relatively rare, telescopes are not. The average school with astronomy has 3 portable telescopes (if it has any at all, about 1/4th do not), usually of the six or eight inch size reflector. Some schools have discovered using remotely operated telescopes via the Internet (both visual and radio telescopes).

Generally, unless a teacher is good at getting grants or gets a one-time largesse of money to start a course, the average class runs on less than $500 for supplies. Just over half get this within the science department budget, half of that again get money explicitly just for astronomy.

Teachers generally are concerned with a lack of time (for teaching and/or for preparation) followed mostly by concerns with various student factors. Of the latter, how students get put into their classes is a concern, particularly in regards to students with a lack of preparation in math or language skills. Wanting more funding actually ranks lower than teachers expressing No Problems. As teachers of an elective, the problems are generally opposite to those of a teacher of a required or at least commonly taken science course.

The Reason Courses Exist

What are the raison d'etres for the course? What are the teachers' original justifications or purposes stated for the course's creation? And who created it?

By a factor of nearly two to one, courses in the schedule have been created by the current teacher instead of someone else. When the teacher created it, it is at least half the time because the teacher wanted to do so, he or she had the interest. If it was created by someone else, it was because more science courses (for advanced work or for an easier elective) were desired. This justification for the course is, naturally, more popular for courses created by the administration. Generally, it seems that if you can create one, you can teach it for as long as you wish; there is evidence that when the teacher retires or otherwise leaves, the course goes with them.

The Purposes of the Course, Historically and Today

Is there any evidence for historical influences on what the purpose of a course would be during other time periods than the immediate present?

Historically, there have been a number of purposes, reasons why a person should take an astronomy course, ranging from 'all educated persons should know this', the predominant theme for when it was a required class in 19th century schools, to empowerment. It was thought there might be echoes of these purposes in the teachers who began teaching in different time periods, the last several being the years of introductions of the NSES, Benchmarks, and NCLB. But only three of eight possible purpose choices are popular with teachers and, while there are fluctuations, overall the numbers and distribution of choices did not change much over time. By far the most given reason is appreciation of the Universe, space and our place in it. A third of the teachers chose this and, when examining its frequency over time periods, this choice is number one for all teachers even as far back as those who started in the classroom in the 1960s. Mental improvement is a consistent second purpose, astronomy helps you to think. Usually, but not always in all time periods, the multi- and interdisciplinary aspects of astronomy, how it connects with other sciences, language, history, and math, is close behind improvement of the mind.

However, that *dominance* of appreciation may have taken a hit with the introduction of No Child Left Behind. The proportion of teachers claiming this dropped nearly in half after the Act was legislated, with other more 'accountable' purposes all gaining percentages, especially literacy, empowerment, and 'all educated' should know this' (and for the school's sake, needs to know it).

<u>The Effects of No Child Left Behind</u>

What positive or negative effects have the typical high school astronomy teachers seen in their courses from No Child Left Behind (NCLB)?

Yet, astronomy has not been hit as hard as other courses. A majority of the teachers report being able to continue along as they have been. Most of the remaining teachers have had negative effects which include the above change in purpose for the class, plus dropping course enrollments and occasional outright cancellations of their courses. The latter two may be more because students are redirected more towards remedial courses or more required courses which limit their abilities to add in the astronomy course. There is more pressure towards putting students into the traditional biology, chemistry, and physics courses. Astronomy courses that manage to stay in the school schedule have seen a decrease in student abilities, and especially an inclusion of special education students despite math and science prerequisites that might exclude them.

Many teachers have claimed loss of status for their courses, and as such, they have even less money budgeted for the class. Previously available funds are being diverted towards the core courses of math and language arts. This inhibits their abilities not only for purchase of supplies but also for outside resources. Fewer astronomers or astronomy club services can be utilized even though such resources are often necessary for the success of the class. It is also evident in the reduction of outside planetarium usage in another portion of this study.

Other negative effects seen include such an emphasis on passing the test that teacher collaboration, interdisciplinary tie-ins and cross-curricular activities are curtailed as well in schools under NCLB pressures.

Teachers themselves may be commandeered from their astronomy courses to teach remedial coursework. The highly-qualified requirement of NCLB has in some schools caused teachers to be unable to teach even their many-years long-established courses; it is hard to be highly-qualified by virtue of certification when there are no particular tests for certification they can take in the subject area.

There are a few positive effects seen. Some teachers have been able to increase math and literacy activities in their courses. More telling, enrollments have sometimes increased because students need a perceived-to-be-easier-than-physics, chemistry or biology science course and are directed towards astronomy. In some cases, this is a mixed blessing; more students take astronomy at the lower level in geosciences but the astronomy course itself is cancelled.

Thus, when a school is not Passing AYP, the course is endangered as resources are turned towards reversing the AYP status. The course enrollment may drop, or it may be cancelled outright. If it hangs on, it will face an almost certain loss of funding and status compared to other science courses. It likely will also see an decrease in the academic levels of its students as administrators and guidance counselors steer more students in need of graduation credits to the astronomy course and bypass or remove math and science prerequisites.

An astronomy course may be insulated from NCLB effects because there are enough other teachers to cover remediation or if the course is taken primarily by students past the danger points of NCLB or high-stakes state testing. Neither having nor not having standards in astronomy does not seem to be a certainty towards survival, though the odd situation of having no standards is slightly more conducive than having them. Having standards AND including more math and language arts activities may raise the odds of survival even higher.

Though science is supposed to be also a factor in determining high-stakes testing and AYP in 2007-2008, the effects of this, financially and otherwise, are not yet determined and are effects not yet evidenced in this study.

In short, astronomy's continued existence in a school while NCLB is in effect depends not on effects on the course itself from NCLB or high stakes testing of astronomy but more strongly on how well the other sciences, math, and language courses fare. It is speculated that an astronomy course's existence may depend on a) if a teacher with interest and enthusiasm is available, b) if science doesn't become a major factor in determining AYP status for if it does, then when other sciences fail to pass AYP, remediation in science courses will eliminate astronomy and other science electives, and c) in the opposite direction, as more schools add more years of science to graduation requirements, astronomy becomes more important, almost back to the level of being a required subject. If so, its thriving then may be inhibited by the lack of suitably trained teachers, and training programs in astronomy education. Which way the balance will tip between choices (b) and (c) can not be predicted.

Teachers' Perceptions of the Future of Courses

Are the teachers optimistic or pessimistic for their school and for courses nationwide, and why?

Attitudes concerning the teacher's school

For local schools, teachers are on the optimistic/somewhat optimistic side, 162 to 55. Of the five possible attitude options (optimistic, somewhat optimistic, neutral, somewhat pessimistic, pessimistic), the optimists are far more numerous than the other options, with a count of 117 and a overall percentage of 49%. The somewhat optimistic have the second highest total. Overall the balance (with pessimism = 1 and optimism = 5) is 3.9, essentially somewhat optimistic but very skewed towards a peak at optimism.

Several themes are found throughout the listings as major explanatory factors for teacher attitudes. They can act both as good predictors of attitudes in others and as ideas to be prescribed for developing a successful course in schools.

The biggest factor numerically anywhere in this spectrum is student interest. If the students have interest in the course, the attitude is most optimistic. Second was increased enrollment. A lesser indicator is teacher enthusiasm and interest, and the interests of other teachers in their course. Increasing state standards and requirements, and increases in the number of science courses at the school aid in making teachers optimistic towards the future. Optimism is strong when there is support by the administration and community.

The major negative influences are dissatisfaction with student academic levels and attitudes, and these are found in all attitude choices.

To improve the outlook for astronomy courses in schools, one must apparently create and enlarge student interest (thereby increasing enrollment) and administration support, find and hold on to enthusiastic and interested teachers and improve the pre-class preparation of students.

Attitudes about the nation's courses

The grass is greener at home. High school teachers perceive the national future less optimistically, and their opinion is equally spread through all but the pessimistic view. Indeed scaling the counts as we did above, the balance is 3.4, closer to neutral than to somewhat optimistic. In truth, there is not a spread of attitudes but three groups: optimists, pessimists, and people who don't know enough to say. Teachers expressed more reservations in prognosticating the national scene than for their own familiar surroundings.

For the national astronomy course interest, one could characterize an Optimist's attitude as derived from seeing the benefits of NASA programs and influence of astronomy news in the media, from noting the new emphases of STEM in education (Science Technology Engineering and Math) and increasing amounts (perhaps just locally?) of numbers of courses being offered and enrollments. They are optimistic because they see value and use in the integrated nature and wonder of the science, because student and community interest abounds for them, and they see ways to show administrators how astronomy helps them meet standards.

Pessimists can be characterized as having none of the above, as teachers bemoan the loss of status and value for their course, and for sensing a general decline in the education system. They also feel the way they do because of a lack of interest in astronomy by their students and by the public at large. Standards, or the lack of them, seem to inhibit their astronomy course activities or prohibit the course all together.

All teachers express three worries that dampen the attitudes no matter what attitude the teacher holds: courses being cut, funding lacking and not enough teachers. The more pessimistic the teacher, the more these explanations are mentioned. Three more explanations are dichotomous, they exist positively or negatively depending on the attitude. These are the amount of public interest, the amount of student interest, and the existence of standards for astronomy—does it help with AYP.

A prescription for improving astronomy courses' situation for the whole nation would be to show the value of, and utilize even more, the multi- and interdisciplinary aspects of the science, promoting and using NASA (and other organizations') programs and the large amount of astronomy in the news and culture, tying into the STEM movement in education, and keeping the interest in astronomy in students and the community. Restoring status and value to teachers of astronomy, restoring courses cut not because of their own failings but because of outside influences, and providing more funding also will improve the situation.

Defending a Course

What would current teachers use to defend or justify the course in the present time?

Ammunition for defending an astronomy course from outside influences that want to take it off the schedule involve arguments in several areas.

The course is the most interdisciplinary science there is, with cross-curricular aspects that help the student advance in his or her thinking skills, in synthesizing knowledge within the science and with other domains of knowledge. These areas included mathematics, history, use of technology and language skills. The course can be designed to work with all levels, from special education to Advanced Placement (though not all should be in the same class at one time). It reinforces concepts and skills taught in prior classes, and adds concepts that may be taught nowhere else, and new skills in critical thinking and communication, among others. The course is enormously flexible and can be as rigorous or not as desired, and can be run in a hands-on, discovery-based, inquiry-guided style.

There is a high interest factor for astronomy among students, even among students who are turned off to science. Students want to take the class, as opposed to taking it because they have to take it. Teachers can point to former students who have taken the class and performed better in college than others, even gone on to careers in science.

Astronomy is part of world culture and much of our everyday lives incorporate aspects of astronomy. Much of the technology that interests students have been developed because of national commitments to space. Calendars and other commonplace things are astronomical in origin. It is a common factor in many cultures, present and past. There are also more intangible and philosophical arguments that can be made, if appropriate and useful, such as astronomy causes wonder, that educated persons ought to know our place in the universe, and so on.

Astronomy can help a school's AYP standing. It involves math and language arts, which are the current bases of determining AYP status, therefore the course is not irrelevant to the cause of passing AYP. Many graduation, state, end-of-course and national tests include concepts in basic astronomy, and many (though not all) states have astronomy standards that can only be met by this course; the content isn't taught in physics or earth science courses completely enough.

There are institutional benefits to having this astronomy course active. There are economic costs in shutting down planetariums especially but also other resources that have been purchased. There is funding to be gained by having a course, such as from out-of-district (or from schools within the district) students coming in and taking it. It helps compete against other high schools and private schools that may not offer it, bringing in increased state funding along with increased enrollments. Astronomy courses bring in good publicity, keep teacher morale higher, and combat anti-science attitudes and apathy while improving science literacy.

Finally, the science of astronomy not only broadens students knowledge bases with its own rich content but also is more accessible than other sciences, and students can actually make contributions to the science.

It will be seen that many of these arguments appear in the advice for starting a class in the section following, in the justifications section. Of course, advice on curriculum, equipment acquisition, and support aren't as relevant in defending the course, but in both situations, the student interest and the multi-disciplinary aspect of the course are rated as highly important, the latter being most important in both starting and defending a course. The fact that one can teach the course on a variety of levels also appears in both defense and starting a course. Student interest is rated much more important in defending or supporting the course than in creating it.

The fact that astronomy can be helpful in AYP matters seems more a strength for defending the course, but it is neither as prominent in defending or starting the course as it might appear. Perhaps astronomy teachers have not yet become so concerned because science has not yet been as big a factor in AYP as math and language arts and astronomy courses have not yet been so directly affected. That could change in the next year or so.

Making More Courses

What advice would teachers give to another teacher as to how to set up a course or to increase the number of schools in the whole country that teach astronomy?

Starting a course in a school

Teachers who wish to start an astronomy course need to prepare well, and well in advance. It may take 1-3 years to get the course off the ground, and up to 5 years to get it in satisfactory shape. You will need to plan for support, for materials, for students, and first before everything, for the kind of course you want to teach or offer. Should the course is math-intensive like a physics course or conceptual? Should it be stellar, solar system, or both, capstone or introductory, for many students or for few? Are you teaching a course for high achievers or low? Your choice of prerequisites will help determine that.

Support needs to be obtained from students, colleagues, guidance counselors and administrators. Student support can be obtained from activities like astronomy clubs and public star parties (which helps get students' parents involved), providing astronomy instruction early on in other math, science and history courses. Do astronomy in your current classes as much as possible and then invite specific students who have expressed interest to request an astronomy class, and to sign up for it through their guidance counselors. Make a brochure. If possible, arrange college credit. Colleague support can also be gathered through your visits to other classrooms for interdisciplinary teaching. Be sure to get your department head interested.

Guidance counselors may be able to help give you support if you can get from them the numbers of students who need (or would be interested in) another science course, and the types of courses that they feel are needed. A fourth elective beyond the basic three? An easier elective for students who aren't doing science well? The science department may have the information, or canl do a survey to get them.

Administrators will need heavier arguments than discussing astronomy as the future or the 'mother of all sciences'. Firmer justifications would be needed of which there are several available. The multidimensional aspect is a strong argument. The strongest arguments for interdisciplinary work are that astronomy can cover a range of electives and as a capstone it covers math, biology, physics, chemistry and history, with flexibility for the range of students and interests. There are tie-ins all over the educational map. Showing astronomy will teach various standards and help with high stakes testing is better. If the state is lacking in astronomy standards, standards can be pulled from a variety of other disciplines and from national standards if those, too, are incomplete. If a teacher has some idea what is on the state tests, the teacher should show how they can be taught with astronomy. And, though it probably won't do the job on its own, showing student interest in a science course, when science course attendance tends to be heading downward, is a good argument to use. Interest among the students as well as colleagues will likely push the course from 'maybe' to 'let's try'.

The course needs to be as ready to go as possible, which means a curriculum needs to be put together. Resources, textbook, and other things are needed. But two things *must* be done: design as many inquiry and hands-on activities as possible, and do as much as possible to provide real observational experiences, especially night time ones. Check school or district policy on these, and field trips, but without these the course will be less than optimal.

To begin finding resources, network! Get help from local astronomy clubs, local college astronomers, various associations. There are small groups of astronomy teachers around the country and several moderate-sized national ones, and planetarium associations will help the non-planetarians. On the Net are various astronomy and astronomy education user groups, with listserves that are active. Visit any other local astronomy teachers that can be found.

It is no longer necessary to just photocopy stuff from old magazines and books. In fact, there aren't many high school level curricular packages, though there are lots of individual labs and devices you can use. Hands-On Universe and the Astronomical Society of the Pacific offers handbooks filled with materials. For everything else, use the Internet. It has countless varieties of free materials from which you can make a curriculum. Labs, reference materials, syllabi are all there for the taking. It is not necessry to start from scratch, but it is necessary to have a plan and then research on the Net to find things to do on the choices of topics. In fact, many class activities can also use the multitudes of interactive websites. Research, pick, and plan accordingly, and include lots of interdisciplinary activities, such as using music or art, historical materials, and so on.

Some districts require textbooks for classes. Unfortunately most are college level textbooks. Many teachers have been able to go without a textbook, or use them just for reference work. If possible, be sure to pick one that won't turn off students. The better choices come with electronic augmentation, such as CDs and website access. These can be for students at home or for use on your computers in class. Regardless, the prevailing opinion is that textbooks are helpful but not necessary.

Planetariums, if they are available, should be exploited as much as possible. If you have none, is there one nearby? If not, can a portable planetarium be bought? If not that, does the district or some university or other organization have one that can be borrowed? Quite a few people are now using planetarium software, computer programs that display the sky on a computer and can be used to show many phenomena in nature under teacher-controllable situations. If one selects this route, try to get one permanent computer and some kind of display device like a ceiling mounted LCD projector.

Telescopes and/or sets of binoculars are also helpful and should be obtained, but for an interim period, see if someone else's is available, get the local astronomy club to visit periodically or take students to them on field trips. Look into access to several remote, Internet controllable telescopes, like Tzec Maun or SLOOH or Telescopes in Education. There are also remotely accessible radio telescopes.

Then there is the issue of money. A good amount of startup money may be available the first year but after that the course probably won't have much funding. After the course is going, learn about grants and apply for them.

And take local college courses in astronomy, attend lectures, find out and attend astronomy education conferences and workshops. By all means, you, the teacher, must be enthusiastic and knowledgeable or the course will likely never get launched or become permanent.

Increasing the number of courses nationwide

In order to have more astronomy classes in American high schools, a series of conditions need to be fulfilled, and almost simultaneously. The most important condition is to elevate the status of astronomy in the national perception. National, state and local officials must see astronomy as important as biology, chemistry or physics. Administrators need to be convinced that astronomy is more than a filler—it is an enhancement, a way to meet national and state standards, and of more than passing student interest. It can lead students to science careers and science literacy.

This elevation of status would come if:

1. Astronomy, already in some national standards, can be made part of state standards. It is known that there are varying amounts of standards for astronomy across the fifty states for elementary and middle schools (Palen and Proctor, 2007). The amount of high school standards specifically astronomical as opposed to borrowed from other sciences is unknown. This survey showed that less than 50% of the teachers were aware of standards in their states, and some states appeared to have even no standards, based on the low percentages of teachers using standards. Quite a few states use the NSES for

their standards…and the NSES is slim on astronomy at the high school level. At least one teacher recommended that the Project 2061 standards are vaster in astronomy.

2. Astronomy must be put into those high-stakes tests in greater amounts. At least one teacher has noted that there are astronomy questions in the ACT. Some end-of-course and graduation tests have astronomy questions which teachers complained are not being taught in non-astronomy science classes.
3. States need to require more science. If astronomy is made as required as the main three sciences, more students would presumably take it. If a third or fourth year becomes required in states that only require two or three, then astronomy becomes a viable third or fourth course. This would be true even if the course was one of a series of electives but with the high student interest in astronomy it should have its share or more.

In addition, it would drive up enrollment if astronomy were to be more accepted as a lab science by universities, which means it has to have a more unified curriculum with more hands-on and inquiry…and labs.

Since teachers are quite often the originator of an astronomy course in their schools, having more teachers of astronomy would be beneficial to the goal of increasing the number of schools that have astronomy. But there are some issues here that need to be dealt with. Unlike math, physics, chemistry, life sciences and geosciences, there are virtually no schools that teach astronomy education. The science, yes, but not the pedagogy and without The Paper. Without a program to do this, two other things are therefore needed:

1. There needs to be a vast increase in the number of workshops and training programs for teachers. A teacher can take a course on the science at a local college but that does not instruct on how to *teach* the subject to high school teenagers.
2. An effect of NCLB is the increasing stringency in teacher requirements…and there is no state that offers certification in astronomy. Certification standards and courses need to be created. Getting broadfield certification or physics or chemistry does not adequately prepare a teacher to teach astronomy, either in content or in technique.

Not all the efforts can be done locally. External influences can have a strong role to play.

1. Powerful can be the influences of NASA and the business world. NASA has already been seen to be a powerful force for teachers, for obtaining materials, for being on the news and increasing interest, for workshops. Should NASA get more funding, it would also benefit teachers who want to create courses.
2. The business world, especially in schools working on 'a business model,' might be more inclined to be helpful if it can be shown that the benefits of an astronomy class, such as improved problem solving, science literacy, communication and research skills, give what the business world wants. They then have to make that known to the educational powers.

An improved and unified curriculum plan would greatly improve the chances of creating a newer and higher status astronomy course. There is no apparent general curriculum for astronomy, unlike physics, biology or chemistry. Consequently it is taught at a wide spectrum of ways, from simple lectures to student-run research 'labs'. It is inconsistent. Survey respondents wish for a national curriculum, for a high school level textbook, for funds for equipment that is too dear in times of reduced budgets and cut courses, more planetariums and more telescopes.

Finally, perhaps science teachers do need to take on the tactics of other sciences. An effort to push astronomy towards AP status would almost certainly increase the number of courses being offered. And in an age where students and PTAs are frequently sent around in fund-raising efforts, as one teacher put it, astronomy teachers need to raise awareness for astronomy in ways that rival the claims of arts teachers when music and art are cut.

CHAPTER 7

WHAT *IS* THE STATUS AND MAKEUP OF THE MODERN AMERICAN HIGH SCHOOL COURSE IN ASTRONOMY?

Summary

At the start of this investigation it was written: “The purpose of this study is to investigate the influences of the past, the status in the present, and the teachers’ perceptions of the future of high school astronomy courses.” This work will now be concluded by stating what the past, present and future of astronomy courses appear to be, and discussing plans for the future of this study.

Astronomy courses, at least in the United States, do not hold a prominent place in the current American system. Over a century ago, astronomy was often required, as it is still in many other countries, especially those in Europe (Trumper, 2006). When the course was required, it was something all educated persons should know. Since it became a mere, though of popular interest, elective, appreciation of the Universe is and was the main reason of the course, with a high amount of ‘mental improvement’ thrown in. It was also taught almost exclusively by male teachers using few if any textbooks or materials as there were too few realia and curriculum packages for astronomy to generate teaching supplies.

Now, most courses are created by the teacher who has interest in the subject, and by some administrators for the practical reason of having an easier (by perception) elective or a second or more advanced science elective.

The course today is primarily an all-inclusive look at the whole universe, and most often taught in just half a year. Standards for astronomy courses are haphazard, often cobbled together from other courses and standards rather than existing as a structure on its own. It is only required by the tiniest of fractions of the schools, and only about one in seven offer a second course.

Of our estimated 3200 regular class teachers, the course is taught more often by a male teacher but only by a 2:1 ratio, a great improvement in the gender gap since Sadler's survey time. The teacher, though, has less training in astronomy than probably any other science courses' teachers. This is primarily an influence of the lack of state teaching certificates in astronomy and college level astronomy education programs. Most teachers, while possessing majors in science, come from the biosciences and geosciences, not astronomy. Few astronomy majors in colleges turn to the high schools for employment. Astronomy teachers are better educated than most—nearly 8 in 10 have masters degrees in something (rarely astronomy), but have taken only 1-2 courses in astronomy at either the undergraduate or masters levels, if they took one at all. A large minority did not. If 'highly qualified' is defined as appropriate training in astronomy, most astronomy teachers are not; if the definition is broadened to be just a science degree (any science) and certification, then many teachers are highly qualified but there is a large out-of-field group teaching astronomy.

Ongoing content and pedagogical professional development after getting the job is often as little as ever. "Keeping up" comes primarily from certain websites and workshops, notably NASA's, astronomy magazines and books, and some association conferences. Teachers are notoriously isolated from training and each other; most astronomy or astronomy education organizations aren't reaching the high school teachers.

The teacher in this classroom is most often the only teacher of astronomy in the school, and he or she teaches just one or at most two sections 80% of the time. Like the solitary telescope operator, he or she teaches in isolation. Only perhaps one in seven gets to teach it full time. Most are teaching a physics course or geoscience course to make their paychecks.

The students are generally representative of their schools in gender and race and ethnic groups, though Asians and Hispanics are a little less than the national percentages. There is a small gender gap, a few percent difference between the national numbers and the school population. The students are most often taking astronomy as a capstone course; it is rare to be an introduction to science course at the freshman/sophomore levels.

The courses are found in larger than average schools, two times or more than the average sized high school (though some small schools do teach it) and in similar proportions between private and public high schools. Indeed, around 12% of all high schools have the course, but it is more often just one section, by one teacher. The schools tend to be more urban or suburban than rural, despite the clearer night skies of the latter…and though it was found that there is a hidden group of classes—single digit classes—that may be more often in rural schools than urban ones.

The use of textbooks is up dramatically in the past 2 decades but the complaints on their suitability have not lessened. The texts are generally written at college level. Materials for the curriculum, though, now come often from the World Wide Web; certain packages from the ASP and elsewhere can be found in some number. Planetarium numbers may have dropped over the decades since the heyday of the Space Age but at least 10% of all high school astronomy courses have immediate access to a fixed dome and 3-4% more may own portable planetariums. A growing amount of at least that last same percentage have adopted the use of ‘planetarium software’ for use in classrooms and on computers. Telescopes are less a concern, most schools have an average of three portables they can use and some have used their Internet access to not only use websites but also use remotely operated visual and radio telescopes.

High school astronomy classes may number as many as 4000 nationwide, but schools with regular sized classes number about 2500, 12-13% of all schools but only teaching to just over 3% of the students (80,000 ± ~3000), a growth of only ~10,000 since the early 1980s. (Compare that to 35% of all students taking physics, 60% chemistry and more than 90% biology.) But class sizes have held steady since that time or peaked a bit hgher and may have started to decline in recent years because of course cancellations and other outside influences, such as No Child Left Behind. Schools with astronomy are found in a higher proportion of schools with an Adequate Yearly Progress status of Pass than the general population. This may indicate that schools with astronomy do better because of it, or those with astronomy that Fail have the course knocked off the schedule. Affluence or other factors may also affect this situation.

The future is uncertain. Astronomy has not been as deeply effected directly by high stakes testing and NCLB as math and language arts because until now science has not been included in the AYP analyses. That is supposed to be changing. Indirectly, astronomy courses have faced dropping enrollments and course cancellations because the NCLB-directly effected courses in math and language draw away the students and teachers into remedial operations. The pressure to put students into the traditional science courses in higher numbers is also draining away the students and teachers, and causing disappearing courses. If science becomes a major AYP factor, then the remediation efforts seen in language arts and math with the subsequent elimination of other non-core courses will almost certainly drive astronomy to near-extinction.

The teachers themselves are generally optimistic about the future of astronomy in their schools, but only barely so for the nation as a whole. Astronomy teachers have seen their courses and themselves become lower in value and status, and in practical matters of enrollments and funding. Astronomy holds on only when there is a teacher with knowledge and enthusiasm, support from their departments, administrations, students and the community, and how well the other courses are doing in the school. It helps if the teacher can incorporate and show both standards and astronomy helps AYP status levels with its integrated nature.

On the other hand, there is also pressure to add more years of science to the students' curriculum and that means astronomy teachers and courses may become an increasingly demanded commodity. If more schools require it or offer it, it may return to higher status, numbers and prominence. And more teachers will be needed and they will need training and certifications that do not exist. More unqualified or out of field teachers will find employment.

Future Work

Future work falls into three categories: continuing to mine the current data, add to it with future survey data, and take the results out into the educational community.

Future Analyses of This Survey Data

There are a number of interesting ways this spring survey data can still be investigated. At one time the presence of a planetarium meant an almost 1:1 relationship to the existence of a course. How does the presence of a planetarium affect various measurements now? The data can be stratified into groups depending on planetarium ownership, including comparisons between portables and fixed units, and the use of same by ownership or 'borrowing/field trips'.

We can identify not only a new teacher category—single digit classroom teacher—but also what we call full-time teachers. We can see also a third kind, the 'power teacher'. This group are those that are almost zealous in their astronomy and can be identified by their attendance and use of the major programs such as Hands-On Universe and RBSE (Research Based Science Education). While we did some looking at the first two groups (less for the second), we have not looked at the last group yet. Because of the amount of training they seek (and often give) and the ‘higher plane’ of their courses, they might be a good model for what a teacher can do for better professional development.

Is there a bias in what way teachers respond? We shall look to see if there are any significant deviations because a teacher used a Word file to respond rather than the Web form, and when the Fall 2007 postal/Web survey is analyzed, see how the results are for questions in common.

Enriching the Data

A second survey, to a much larger pool, was done in the Fall of 2007. This survey was to people to whom we only had postal addresses. The majority of them come from the NRT list but we also used lists acquired after that, leftovers from the Spring survey data sources, and lists that came from some of the state DOE data sent to us to help analyze the statistics of the spring survey. In addition, a Letter to the Editor in *Sky and Telescope* magazine appeared in the October 2007 issue (which comes out around Labor Day) to gather teachers for whom this magazine forms the greatest part of their keeping aware of current astronomy and astronomy education. This idea was used by Fraknoi in his two-year college astronomy survey.

The survey was similar to the Spring survey but had some questions dropped that had shown themselves to have either exhausted the response possibilities or had given us no interesting data. Some new questions were added, mostly on teacher style (teacher-centered or student-centered and the amount of inquiry) and a few tweaked questions, such as adding “professional development” as a Need, Wish or Gripe Option, and “planetarium software” under Type of Planetarium Access.

In order to increase the odds of response, we convinced several science education equipment suppliers and book dealers to allow us to add incentives. Over 2100 surveys went out with a business reply envelope so that the teachers would have no costs, but time.

The surveys were mailed out in mid-September and the survey lasted until Thanksgiving. A reminder postcard went out around November 1st. The surveys have not been examined as of this writing. It is intended to analyze them in time to add to publications on the Spring survey results.

Another survey that needs to be done are to schools identified as those no longer having astronomy courses, from our spring 2007 snowball sampling and through another voluntary response group acquired through listserv announcements to associations of principals and other administrators. It is intended to be done in the spring of 2008, purely via Web and Word versions. We intend to survey these people as to why they do not have an astronomy course and what would it take to create one now. The survey is expected to be smaller than the teacher survey.

Putting Results Into Action

This writer has undergone his own Copernican revolution. Having come from the hard science universe, a strong positivist, he now has at least one foot into the qualitative world, and with that has come the notion that research must not only be academically interesting, but also there should be some aspect that returns the results into useful actions. This survey has shown how isolated and alone and often untrained the astronomy teachers are and how astronomers and astronomy educators have not played significant roles in history in establishing the standards. This needs to be addressed.

Astronomy education also needs to come out of the cloisters and into the mainstream. Astronomy survives right now only on the backs of the enthusiastic teachers, and the sufferance of administrators who like the subject, as long as the school's AYP status is not Fail. Those things that make a course live are the teachers, the movement to increase the amount of science being offered, and the lack of science affecting AYP status…for now. The course needs to be inoculated against NCLB and high stakes testing, by making astronomy as required as biology, chemistry and physics, to have teachers who have more than a hobby interest and a single course back in college, and by creating standards with it that will help, not hurt, AYP status. It must not be allowed to be at the mercy of the other courses in the high school that ultimately do affect AYP status.

It is necessary to produce those conditions that will allow astronomy courses in high schools, the place where the fewest students are exposed to astronomy in all of K-16, to survive and to grow. The conditions needed are:

- to make administrations more agreeable to supporting the course, seeing its advantages.
- the teachers need an organization to allow them to network, to share, to get professional development.
- teachers also need a means to some kind of astronomy certification process.
- the schools and systems need to see that they need to offer the course even more than it is at present, that it should approach again its century-gone required status.
- standards need to be enlarged to have more astronomy in them, and accountability re-tooled to not knock out the courses that are not core. There is more to education than reading, writing and arithmetic.

To do this, I already promised the teachers who participated a summary of these findings. I intend to publish the How to Start, Increase, and Run a course material so that every teacher who wants to know can have these guides. Perhaps a periodical for classroom astronomy teachers may be possible to do as well; there are no publications that do substantial astronomy education – with pedagogy or classroom activities --for the high school teacher.

I also intend to try to form an organization of high school astronomy teachers, starting with the names I have. (At this writing in January 2008 I have already had scheduled a workshop and roundtable with Georgia teachers at the 2008 Georgia Science Teachers Association meeting). Teachers are too fragmented as well as isolated. Of the extant groups, AAPT and NAGT have astronomy or space science groups but they seem to do little other than at conferences. The ASP is active but small and primarily West Coast. The American Astronomical Society has long foregone its obligation to those below college level. Teachers belong in small pieces to each; there needs to be ONE group for all.

A future project will be to investigate what it would take to have certification programs in astronomy in the different states and what kinds of college level astronomy education degrees could be created, or if one national program can do it for all states. Another project is to look at the content syllabi of the teachers reached, to see what is taught and how close to a de facto national curriculum we already have

There needs to be an astronomy person in all future curriculum and ‘accountability’ undertakings, or else astronomy will cease to be a viable topic about middle school. We got into this mess starting when the Committee of Ten, most of the standard creators in states such as Texas, even the NSES and AAAS groups that created standards, had little input from astronomers. The only astronomer on the Committee of Ten….was used in one of the other, non-astronomy areas. Astronomy’s committee all but ignored the universe. This kind of eyes-to-the-sky-only has helped create the kind of unreal legislative ideology that is the basis of NCLB.

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APPENDIX A

THE WORD^{tm} VERSION OF THE SURVEY

Thank you for taking the High School Astronomy Course Survey! Please be sure to save your file frequently so that you don't lose any answers, and know where you saved it ("Desktop" is good and always obvious!). Answer boxes will expand as you type so you will always have enough room. Many fields with text already in them are drop-down boxes with answer choices.
When complete, email the file back to Larry Krumenaker at lkrumena@uga.edu (that's an "L," not a one) and to larrykrumenaker@bellsouth.net as a backup copy.

* Your name**:** Email address: Phone**:** Today's Date: **MM/DD**
* High school name: Street: City**:** State (e.g. GA)**:** Zip**:**
* Public or Private?: **public** * How many students are in the school?:
* On Block Schedule or Periods?: **block scheduled**
* Status on most recent AYP (adequate yearly progress) report: **pass**

INFORMATION ABOUT YOUR COURSE:

*** What should be the *primary* purpose of an astronomy course?**
0 Choose from these... If you chose Other Reason, explain here:

*** Fill in the table below about your astronomy course(s) (must be regularly offered courses, not a part of another science course):**

	Title	**Content**	**Course Length**	**Course Frequency**
Your general course		**solar system only**	**year long** If Other->	**offered every semester** If Other->
Other astronomy course	**none**		If Other->	If Other->

The following questions pertain to just your general course---

* Over time, what is the average enrollment of your astronomy classes?
+ The enrollment trend is **growing**

* In your most recent general class, using **actual numbers**, <u>not</u> percentages, what was the:

Class Enrollment	**0**				
Gender Mix	Male **0**	Female **0**			
Grade Levels	9th **0**	10th **0**	11th **0**	12th **0**	
Ethnic/Racial	White **0**	African American **0**	Asian **0**	Hispanic **0**	Other **0**

Please make sure your numbers on each line sum up to the same value as your class enrollment number!

* The academic abilities of this class's students are .

* How many sections are offered at a time? **0**

* What are the requirements or prerequisites to take the class?

* What course book, or curriculum from commercial or other sources, do you use?
* Are there state standards for this course? **yes**

* When (year) was the course first offered at this school (e.g. 1950)?

* Did you create the course (choose one answer)? **Choose one...**
  + Principal justification was: **Choose one ...**
  +Optional, for "Other" justifications**:**
  +If you need to explain anything further, or tell to whom the justifications were given, explain here:

***** What advice would you give to those who would wish to start an astronomy course at their high school?

We now return to a discussion of your astronomy courses in general.

* Is astronomy a required course in your school/system? **yes**

* What access to planetariums do you have? **Choose one....** Then….
  (For users of "fixed planetariums elsewhere": how many visits per course do you get?**Box 1**)
  (For "users of portable planetariums" only: how often, per course?**Box 2**
  Whose is it (school, district, someone else's, etc.)? **Box 3**)
  (For selectors of "Other situation," please explain here -> **Box 4)**

* What access to telescopes do you have **Choose one....** Then….
  (For schools that own small scopes: How many? **Box 5**)
  (If you selected Other, please explain here **Box 6)**

* How much do you usually spend per year for equipment, supplies, and materials (e.g. $1000)?
$ + Then, choose one of the following answers for your primary source of funds:
Choose one...

* Choose one of the following as your biggest problem, wish or need that you have for your astronomy teaching?: **Choose from the following...**
+If you selected, Other, or you have prominent secondary problems, explain here:

* How many other astronomy instructors are at your school? **0**
* 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?)

***** Choose your answer to this question: "I am **Choose one...** about the future of my astronomy course in my school." Now, explain why here:

***** If you should have to defend or justify the course at some future date, what arguments would you use? Why?

INSTRUCTOR INFORMATION – I want to know more about you as your school's astronomy teacher.

***** Please fill in this table on your educational background and how many astronomy courses you have had (leave blank if the degree is not applicable to you)?:

Degree	**Majored in**	**Number of astronomy courses taken**
Bachelor		
Masters		
Doctorate		

* What area specialization is your teaching certificate?:

* What got you into *teaching* astronomy? **Choose one...**
+ If Other, explain here:->

* What year did you first teach an astronomy course in any high school (e.g. 1950)?

* When was the last time (year) you taught a high school astronomy course (e.g. 1951)?
+ If you did not teach in the academic year 2006-2007, explain why you no longer taught astronomy after the time you listed in the previous question (i.e. you retired, moved, course dropped, etc.) otherwise leave blank:

* What other courses do you regularly teach? (check all that apply): ☐Physics
☐Chemistry ☐Earth Science, Earth/Space Sciences, Geology or GeoSciences
☐Math ☐Environmental Science ☐Physical/Integrated Science ☐Bio./Life Sciences ☐
Research Course ☐Other:->

The next three questions look the same but are slightly different. They concern how you keep up the science of astronomy, the field of astronomy education, and with other astronomy teachers.

* What ways do you use to keep up with the latest news in the *science of astronomy*? (check all that apply and fill in appropriate boxes, may continue on the next page):

☐Astro/science magazines (which?)☐**N**ewspapers ☐ News magazines i.e. Time☐
NASA education programs ☐NASA Websites
☐Websites other than NASA (list:)
☐Astronomy programs (like Hands On Universe, Micro-Observatory, etc.),
list here)
☐Listserves (list:)
☐Science/Education association newsletters/magazines/updates
☐Mentors or other personal relationships ☐ astronomy books
☐Attending conferences ☐Attending astronomy-related workshops
☐Astronomy clubs ☐I don't keep up with the science ☐Other:->

* What ways do you use to keep up with the field of astronomy *education*? Check all that apply and fill in appropriate boxes:

☐Astro/science magazines (which?) ☐NASA education programs
☐NASA Websites ☐Websites other than NASA (list:)
☐Astronomy programs (like Hands On Universe, Micro-Observatory, etc.),
list here)
☐Listserves (list:)
☐Science/Education association newsletters/magazines/updates
☐Mentors or other personal relationships ☐*Astronomy Education Review*
☐Attending conferences ☐Attending astronomy-education-related workshops
☐Astronomy clubs ☐I don't keep up with the field ☐Other:->

* In what ways do you network with other *astronomy educators*? Check all that apply:

☐Astronomy programs (like Hands On Universe, Micro-Observatory, etc.),
list here)
☐NASA education programs ☐Attending conferences
☐Attending astronomy/education-related workshops ☐Giving workshops
☐Science/Education newsletters/magazines/ association updates
☐Listserves (list:) ☐Mentors or personal relationships ☐Astronomy clubs
☐I don't keep up with other astronomy educators ☐Other:->

*To which science or science education organizations do you belong? Check all that apply:

☐NSTA ☐AAPT ☐NESTA ☐NAGT ☐State/regional science teachers assn
☐State/regional physics teacher assn ☐State/regional earth science teachers assn
☐ASP ☐AAS ☐Planetary Society ☐US Planetarium associations ☐IPS ☐AAE ☐None
☐Other:->

YOUR VIEW OF THE FUTURE....

* How do you feel about the future of high school astronomy course offerings nationally?
I am **Choose one ....”** Now, explain why here:

***** What would have to be done to increase the number of astronomy courses in the US?

If you have any other comments you wish to make, clarifications or expansions of earlier questions, please do so here!

FURTHER CONTACTS:

Can you point me to any other astronomy HS teachers? If so, please give as much information here as you can for contacting them.

Can you point me to a school(s) that *used* to have a course but no longer does? Or in which an attempt to create a course was made but was unsuccessful?

That’s it! You are done!. Thanks for taking the survey! Be sure you’ve saved your file where you can find it. Then send your file to me in your email program by making a new message, using lkrumena@uga.edu as your primary email address and larrykrumenaker@bellsouth.net as your carbon copy (CC) address. Attach the file, and send it!

There is the possibility that I may email or phone you for clarifications or more in-depth interviewing.

If you have any questions, please do not hesitate to email me at lkrumena@uga.edu.

Sincerely,

Larry Krumenaker
Department of Mathematics and Science Education
University of Georgia

APPENDIX B

TIMELINE OF PURPOSES/JUSTIFICATIONS

These answers were derived from discussions in Wall (1973), Bishop (1977), Bishop (1980), Bobrowsky (1996), Fraknoi (1996), and Percy (1996).

Prior to the 1800's, astronomy was something all **educated persons should know**.

1800's, **practical--** navigation, commerce, geography and general diffusion of knowledge and civilization.

1915 **mind training.**

1920-1950 **personal and social objectives** dominated. Science goals were to show relations between principles and life activities

1920 **practical** values.

1923 Develop imagination, transfer of training, **development of mental** discipline.

1957 through 1960's, competition of US and Russia in science, technology and education, caused purposes to became **content mastery** versus for personal and social uses.

1960's, a time of **process** over content, of a **multidisciplinary/interdisciplinary** purpose to learning science.

1970's **empowerment** became a means of using science for social justice.

1989-95 **Science literacy** for all.

2001 With the introduction of NCLB, did the purpose become **Accountability?**