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What It Would Take to Increase the Number of High School Astronomy Courses: A Survey of Principals and a Comparison to Astronomy Teachers, and a Prescription for Change

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Abstract

A survey to principals of high schools without astronomy points to the conditions needed to increase the number of high school astronomy courses and acceptable justifications for adding in a course. The former includes the need for more and better trained teachers, changing the perceptions of higher officials from local administrations to Federal-level legislators and education department officials, more funds, locally a need for students to show enough interest as well as a curriculum that helps with high stakes testing and Adequate Yearly Progress (AYP) scoring. Good reasons for having a course include helping increase options for students needing science electives or fourth year courses, and astronomy reinforces prior learning that helps raise AYP scores and increases student interest in science with material not taught in other courses. Some inhibiting influences include the timing of the course is usually after AYP testing, standards may not exist or limit new electives, and a dearth of astronomy teachers locally. Results of this study include a list of competing electives, typical procedures and a prescription for adding in courses.

1. INTRODUCTION

A 2007 pair of teacher surveys (Krumenaker 2009a, 2009b) found that only 10–12% of all high schools offer even a single section of astronomy. This created a research question “What would it take today to put an astronomy course into a school that did not have one?”

To answer the question, the author surveyed in the spring of 2008 a set of principals of high schools that were expected not to have astronomy courses (The Principal Survey). To gather the survey respondents, we contacted state principal associations and state departments of education to either obtain lists of high school principals or to have a survey invitation broadcast on e-mail mailing lists or listserves or other media such as newsletters. All invitations to individuals were sent via direct e-mail. On our general broadcasts, the invitation specifically requested schools without astronomy. A total of 80 responses were received from 15 states.

Despite our invitation plea for only schools without astronomy, 20% of the responses indicated that the schools were already offering, or had scheduled for the next year, astronomy courses. This value is interesting because the ratio of schools *with* astronomy in the earlier teacher surveys was on the comparable order, 12–15%. We cannot produce an overall rate of response since we could not ascertain how many principals were notified in each state association with their own broadcasts for us. For the four states in which we had been given mailing lists (TX, NC, SC, and AL), our response rate was 1–4%. (For a better comparison, the percentage of responding schools with astronomy in these four states 18%, so we feel confident that this is a valid ratio over the whole country.) The lists ranged in size from 295 to 991 principals with e-mail addresses provided who were clearly in high schools.

We did not send any surveys out by postal mail. All surveys were accomplished via a questionnaire on a webpage. Answers were obtained over a period of 6 weeks.

2. THE POPULATION SPECIFICS

Although we have been calling this the Principal Survey, in fact, 28% of the 65 useful no-course-in-the-school “course deciders” were not principals. The second most common title for who decided if an astronomy course could be in the schedule is the Assistant Principal. On rarer occasions, it might be the science department chair, the Superintendent of the district, and occasionally one of the science teachers. (Despite this, we will continue to discuss the pool of respondents, for simplicity, as Principals.) On average, they are in this decider role for about 6 years (*s.d.*=5.5). 31% are former science teachers; of those, they are roughly evenly divided between biology/life sciences, chemistry, and physical science teachers with a few others mixed in. A few had taught astronomy but were not former astronomers or astronomy majors.

The schools in this survey are all public schools. They are also much more rural (58%) in geographic distribution than the aforementioned teacher surveys, which were more suburban (46%) than rural (25%). In terms of Adequate Yearly Progress (AYP), the schools without astronomy are comparable to the schools with astronomy, with 76% passing versus 79%. However, the schools in this survey are smaller and much closer to the U.S. average high school in size, about 810 students (*s.d.*=774), whereas schools with astronomy average between approximately 1400 and 1600. With a few exceptions, the schools all contain grades 9–12.

The male/female proportions among the students are 49–51 whereas males slightly led females in the schools with astronomy. Racially/ethnically, these schools have a bit more minorities, Whites being 63% as opposed to the earlier surveys showing Whites at around 75%. The leading minority group is African American, at 18% of the aggregate of the whole pool of schools. Nearly a third would be classified as high minority schools, much higher than the schools earlier surveyed.

3. WHAT IS NEEDED

3.1. The Process of Dropping and Adding Astronomy Courses

Of the schools that did not have astronomy, we first tried to ascertain the reason for its absence. The principals were asked if the lack of an astronomy course was

- 1) because an existing course was dropped,
- 2) they wanted to offer an astronomy course but permission was denied, or
- 3) to their knowledge the school never had one.

The third characterization accounted for 76% of all the schools. For those that stated the course was dropped (choice #1), the reasons were quite varied including lack of interest in the student body, teacher who taught the course left or changed job, low enrollments, movements toward more bio/chemistry/physics, and a change in education initiatives. For whatever reasons, the course had last been offered generally 3–6 years earlier. Only three people chose option #2 but no explanations were provided.

An anonymous reviewer suggested that it might have been interesting to investigate the process by which new courses and programs are added to the curriculum successfully, especially in light of the context of state standards and district guidelines. We agree that it would be interesting but did not pursue any investigation of how the principals of schools with astronomy that replied to this survey got their schools to possess such a course. But there is some insight we can provide.

In our earlier two surveys, we had a few respondents, all teachers, give us their successful arguments in favor of a course. We refer readers to those articles, already cited. Additionally, in Appendix A, we have listed the arguments here as a Prescription for Change. In many cases, we were given some insight into the process itself. Almost always, there was a curriculum committee, sometimes within the school, sometimes at the district level, sometimes both. Of course, the school principal would have to approve it.

The process appears a bit different here among the principals' viewpoints. While not written into the surveys themselves, we often exchanged e-mails in the course of asking clarifying questions or attempting to fill in missing data. The following comments illustrate the main points of the process:

- Alaska: "The course was proposed, approved by me, sent to Curriculum review, revised slightly and approved on a pilot basis for next fall."
- Arizona: "You understand that I would be a year away from offering a section of astronomy because right now in March, when I'm interviewing new teachers, next year's course description book is already in the hands of students and they are signing up for next year's classes. I would also have to get Board approval for the new course and that's done here in January."
- Texas: "Curriculum Council and the curriculum director make decisions regarding courses added to our schools' course catalogs. We can make bring forward courses to be considered for addition to our catalog."
- North Carolina: "Recommendations for new courses that are not part of a state or system mandate are usually the result of student need or interest. Teachers or departments submit elective course descriptions for consideration by the school administration and Leadership Team. Courses that are approved at the school level are then submitted to the Associate Superintendent for Curriculum. The final decision rests with her."

These findings parallel well with the few articles available on implementing other new courses. [Garibell \(2003\)](#) relates a similar process to creating a new technology course. In his report, it took 2 years of research and planning for three science teachers on a school planning team. A proposal was made to a central office, and 6 months later a course outline for the district curriculum council. The Board of Education approved that 6 months later and another half year saw the first group of students. [Lambert and Sundberg \(2006\)](#) describe the reasons and barriers to inserting ocean science courses into school offerings. There are few trained teachers coming out of marine science college programs and inquiry materials are few and far between. Not all school systems consider it a valid science course, and those that do perceive it as "easier," a difficulty astronomy shares. But as [Lambert and Sundberg \(2006\)](#) claimed, ocean science does cover many standards in national curricula and is an integrated science, which is a popular theme used by adherents of astronomy courses.

[Shields \(2007\)](#) reported how principals did not care for a technology curriculum called Project Lead the Way. A major factor was cost (as we will soon see, astronomy teachers and our principals in the study also very much argue for funding for astronomy courses). [Cavanagh \(2008\)](#) reported in a case study of Arizona schools when they were mandated to provide four years of math instruction, that they faced the problem of finding more math teachers as there were not enough, and those that they found were not trained in the new alternative courses for those not going on to college yet were advanced enough to be beyond "consumer math" courses.

The exact details would be an interesting topic to investigate but it was not a concern of this survey.

Principals in this survey were asked three open-ended questions to obtain answers to *our* research question about adding courses. The answers to these were then coded using Grounded Theory qualitative analysis techniques ([Strauss and Corbin 1997](#)). In a brief description, Grounded Theory is a qualitative tool designed to be an analog of the quantitative scientific method of inductive reasoning. The analysis is an iterative process by which the analyst becomes more and more "grounded" in the data and develops increasingly richer concepts and models of how the phenomenon being studied really works. As the categories of themes emerge, the investigator links them together in theoretical models ([Ryan and Bernard 2000](#)) which in this survey's case, the embedded minor "themes" become the "categories" we discuss here.

3.2. What Would It Take (i.e., What Conditions or Requirements Have To Be Met) for You to Okay an Astronomy Course To Be Offered?

Nearly half of all the principals said the primary need to satisfy in order to offer the course was having a teacher who could or would teach it (27 out of 64). Second, enough students, either in sufficient enrollment to keep a course going or having sufficient interest to start a course, account for 17 of the responses. Interestingly, the third highest response was money (9) but for what was not stated. Following these three are other reasons which included adding room in the schedule, getting approval by higher levels of administration (local, district, or state), various material and curricular needs such as a textbook, approved curriculum, classroom space, and alignment with tests or standards (Figure 1).

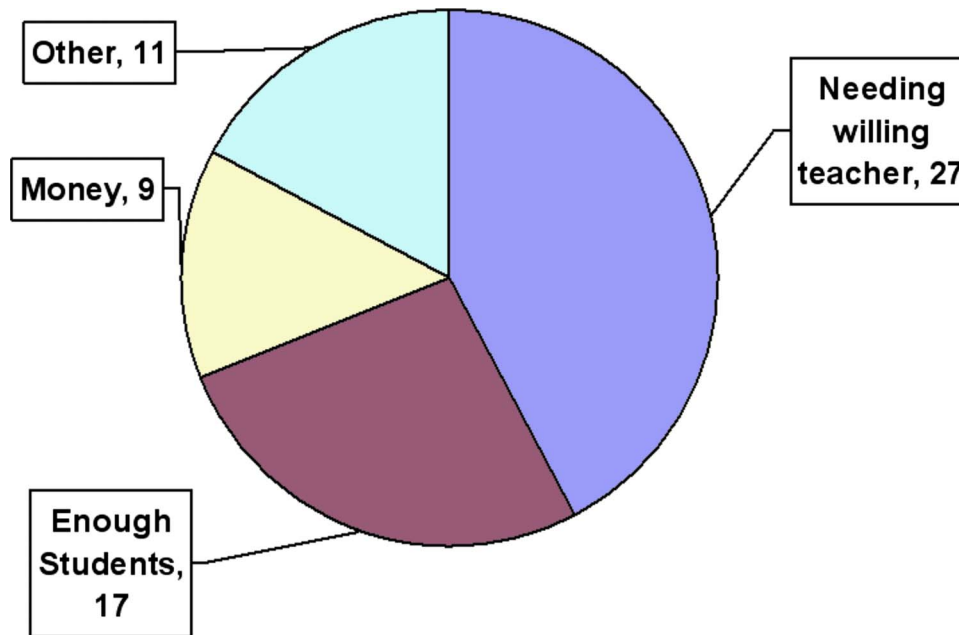


Figure 1. What principals say is their primary need in order to offer an astronomy course

Room in the schedule is affected by a variety of factors. One of those factors is other competing courses, first evidenced to us by teachers informing us about other electives diminishing the pool of available students (Krumenaker 2009a). We asked our principals for the names of all the other science electives they offered and these are listed in rank order in Appendix B.

Some of the comments provided in additional space on the questionnaires are enlightening.

- Adding an astronomy course would be easier if it could count as a laboratory course.
- To offer the course, test scores must be higher.
- To offer the course, test scores must be lower(!).
- A better student-teacher ratio would free up teachers to teach the course.

3.3. What Objective, If Any, Would an Astronomy Course Meet in Your Curriculum? What Would It Do for Your School or Students?

By far, the largest educational objective that astronomy could meet would be that it would add an additional science elective to the school offerings (31 mentions). As an additional elective, it would “increase course offering diversity and enrich curriculum” said one survey respondent. In some cases, astronomy would add a fourth year science. Since in Krumenaker (2009a), it was shown that astronomy often is a capstone course rather than an introductory course. This is a natural pathway for creating an astronomical fourth year course. In six cases, the additional course would be used as an advanced science or a laboratory course.

Smaller numbers of responses to this question include that it would help the school and its AYP status, especially in the few schools that mentioned that astronomy is in the state standards or state tests. It stimulates student interest in science and students have requested it.

An astronomy course could accomplish other good pedagogical functions; specifically mentioned were good use of local sky, teach applications of science, teach content that is not taught elsewhere, and helps the student understand the real world around them.

An unexpected result was a listing of the variety of influences that inhibit having the course meet the objectives:

- The course is an expense.
- As a fourth year course, it would be beyond some states' testing times therefore of no help to AYP.
- There are not enough teachers, or "enough interested teachers" to do the job even if the school wanted it.
- Standards need to be revised, they are not in the standards at all, standards in fact limit new electives.
- It (astronomy) is not relevant to high schools.

3.4. What Can Be Done (or Would Have To Be Done) To Increase the Number of Astronomy Courses in the U.S.?

Thinking beyond the local scene, the survey principals' responses fall into two main areas and a miscellaneous grouping. In order of importance they are as follows:

1. Making astronomy important and acceptable to various groups: Astronomy needs to be seen as important, most notably by Federal- and State-level personnel, including both Department of Education officials and legislators at both levels. Colleges were felt also in need of seeing the science as something of value. At least one response indicated that it would grow in enrollment numbers if the Advanced Placement (AP) people made an astronomy course. Clearly the principals responding feel as disenfranchised as teachers by the imposition by the state of testing, reporting mandates, and applications of standards that lead to straight-jacketed curricula. Their freedom to act is hampered just as much as teachers'.
2. More teachers and more help for teachers: More teachers are needed nationwide, and more help for them, including higher salaries and money for course supplies and, even more, more workshops, preparation and certification.
3. Other: The Other category included more collaborations with colleges, more technology support, and more astronomy on exams and in standards, improve the prior science and astronomy knowledge of students before they get to high school or take the course, and some curricular changes, such as easing tight schedules in other science courses, and fitting into the overall curriculum of science in schools.

4. THE TEACHER'S VIEW

As stated earlier, this survey of principals was the third of a set of surveys on high school astronomy courses. The first two were to high school astronomy teachers, the primary differences between the two surveys were their times, about 6 months apart, and the methods of solicitation and response. The first was via e-mail and webpage, the second mostly by postal mail.

Only one of the principals' three open-ended questions was essentially identical on both teacher and principal surveys and that is the last of the three questions above, regarding what is needed to increase the number of astronomy courses nationwide. From the larger teacher survey ([Krumenaker 2009a](#)), the teachers' answers fall into the following six broad areas (Figure 2):

- more teachers, training (by far the biggest issue of any), certification,
- changes to curricula and available resources (notably, better textbooks) to make it a more attractive science course,
- requiring more astronomy (and showing that astronomy is already) in standards, tests, and in schools in general, and thus elevating astronomy to near equality with the main three sciences,
- changing perceptions—in the public and in administrations, especially,
- more funding, and
- more outside influences on the schools.

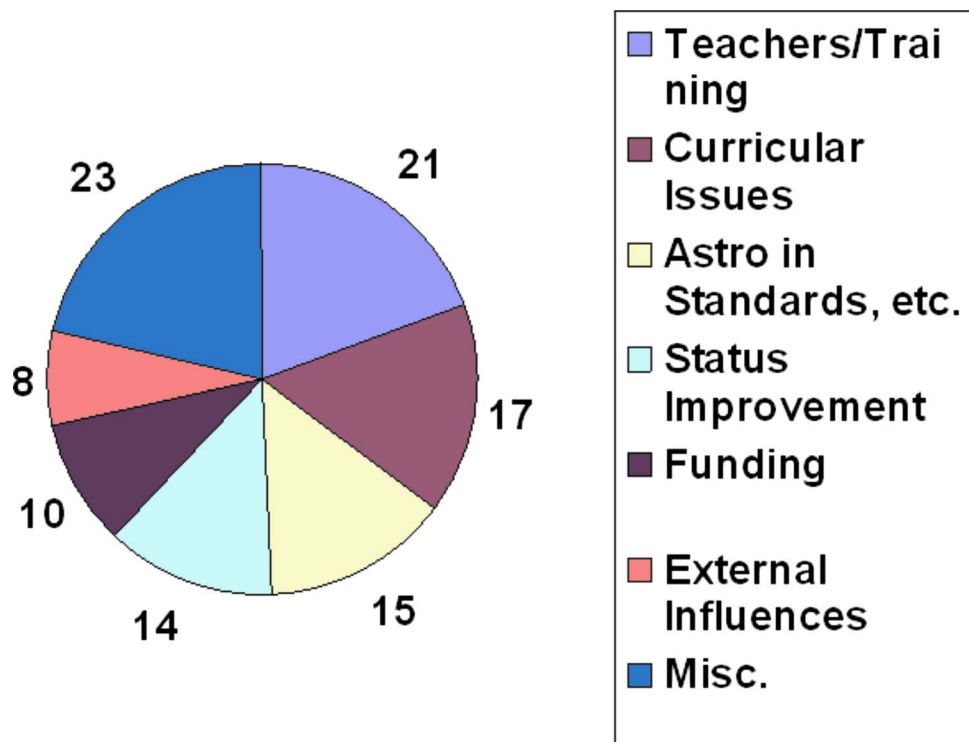


Figure 2. What teachers said were needed to increase the amount of astronomy in high schools, by percentages

In addition there was a miscellaneous grouping, the largest subgroups of which are parallel concerns about improving science and science education's importance and image in society and education, raising student interest, and finding more time and flexibility in scheduling astronomy in the tightly bound mandated curricula.

The single major different teachers' theme from the principals' is the need for more outside influences on the schools. A forum teachers believe needs to be convinced is the business world; perhaps, as one teacher wrote, someone needs to have "some perceived need when comparing to other countries (China, India, etc.)."

Pleas for an increase in NASA activity, resembling the glory days of the Space Race, are also very evident.

- "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."

Some individual comments for increasing the number of courses include making an AP astronomy course, getting more (and using more) remote observatories, both visual and radio.

5. RESULTS OF THE STUDY

We now will try to answer our research question "What would it take today to put an astronomy course into a school that did not have one?" There are two main requirements principals say are needed to be met for the number of courses in the United States to increase.

- 1) More teachers are needed, and training for them and existing teachers is very much needed.
- 2) Administrators at levels higher than the high school itself need to be convinced that astronomy is

important enough to add to the course offerings. These include district administrators, state and federal departments of education personnel (especially those who are involved in putting more astronomy into standards and high stakes testing), legislators, and colleges who insist that only the traditional sciences count.

Astronomy would increase course diversity in science though it often competes with other existing electives, can help with AYP efforts, and because it already has student interest, astronomy can increase student interest in taking science (Baram-Tsabari and Yarden 2009).

Locally, to put in a course requires finding a willing, enthusiastic, and knowledgeable teacher, proof of enough student interest, money, and room in the schedule. As mentioned above, it needs proper convincing of higher administrators to be able to be offered.

Some suggestions to accomplish these goals are listed in Appendix A.

Appendix A: A Prescription for Change

A school without astronomy can change that situation. The following is a general pathway that can be used by either teachers or principals, and the field as a whole, to increase the number of astronomy courses, nationally and locally. While based upon the three surveys' results, the solutions provided are the author's.

- 1) *No teacher, no course, ergo find the right teacher.* Whether stated by a teacher or an administrator, a knowledgeable, enthusiastic, and willing teacher is absolutely required. The problem is that there are not as many *trained* teachers available as needed to fill this requirement. There are few astronomy majors who go into teaching, no state certification in astronomy as for other sciences, and little other training available or at least reaching high school teachers who might be interested, with most teachers' training consisting of but one or two undergraduate astronomy courses (Krumenaker 2009a). Pedagogical training specific to high school astronomy is not reaching a large number of the teacher supply and few colleges teach astronomy education courses.

To correct this, a serious effort must be made to (a) find more interested and willing teachers, whether in the school, the communities, secondary training programs, and, as with other sciences, students in the astronomy departments; (b) be even more proactive than current efforts in finding training for non-college astronomy teachers. The American Chemical Society works extensively with high school chemistry teachers and elsewhere in the K–12 community; the American Astronomical Society appears to have little interest in K–12 programming; and (c) a certification program, perhaps online as in the Australian system, that provides more than just a couple of content courses might be a boon. There are numerous online universities that offer education degrees, but in the United States we know of only one, brand new astronomy teacher's online graduate degree specifically on astronomy education program, at the University of Wyoming.

- 2) *One needs enough interested students to enroll in the class.* Student interest in outer space is well documented (see, for example, Trumper 2006; Baram-Tsabari and Yarden 2009) A key component to this is making it easier for interested students to take the course, which will require alleviating some of the pressure to drive students into other electives or into the traditional three sciences. Numerous ways to attract students were given in the teacher survey (Krumenaker 2008). These include such techniques as designing brochures to pass out in other science courses, or teachers raising interest in freshmen-sophomore courses by guest teaching a topic (math or history, for example) with an astronomy flavor, coordinate with colleges for credit, or form an astronomy club and do public outreach.

Getting the students interest is but half the problem, though. How can efforts be made to alleviate the scheduling pressures? Part of this alleviation can come by having astronomy as the fourth year course but this is often past the hurdles of high stakes testing. Despite high school astronomy being typically a capstone course, it is occasionally used at the freshman level; astronomy's ability to teach in an interdisciplinary fashion could go quite far in such a course. Putting in a section for noncollege track students could also provide an avenue for a course; in this situation, following the college prep track of biology, chemistry, and physics makes no sense if the students do not go to college [and in general, around 20–30% do not (NCES 2007)].

- 3) *Approval by higher levels of administration (local, district or state).* Teachers and/or principals need to point out that there are national standards that include astronomy, that there are often state level

standards as well, and that (for example) a ‘tour of the solar system’ standard is not going to be presented in a biology course. Astronomy has been justified to administrators through calling it a version of physics (Krumenaker 2009b) or earth sciences (Krumenaker 2008). For any level, capstone or otherwise, justifications include the fact that astronomy reinforces prior learning, making it similar to an applied science elective course. Higher levels of administrations may be convinced with the argument that astronomy does not hinder but helps AYP scores because of the inclusion of math and literacy material, provided the course is open to students who have not yet gone past all the AYP testing hurdles. Further, by putting more astronomy into state standards [and they are often part of the standards that school teachers at elementary levels have to teach, average of about 20 standards per K–8 sequence (Palen and Proctor 2006)] should indicate more of a need for an astronomy course than usually attributed; astronomy is not just “fluff.”

Principals and teachers have both suggested that astronomy would be more tenable as a course offering if it could be morphed into a laboratory science, or an Advanced Placement course. Regardless, the status and the perception of an astronomy course needs to be raised, among students who fear it will look bad on their college applications to have had it, among administrators in the school and district who see it as a filler and unnecessary, among state and federal education departments who may regard it as not on the same level as a core science.

Appendix B: Electives That Compete With Astronomy

Among the pressures on having an astronomy course are other science electives. Principals in this survey were asked to list all other elective science courses that their school offers. In some cases, courses that might be expected to be mandatory were also listed as elective sciences.

Since the same course might be listed under different titles, we combined related titles into broader groupings. Table 1 lists the course groups as mentioned by the 59 principals who listed elective titles.

Table 1. Frequency of competing electives, by percentage of sample’s schools that offer them			
Percent of Sample	Course Titles	Percent of all AP Courses	
54	Anatomy and Physiology		
42	Physics		
40	Advanced Placement Courses		
		32	Biology
		32	Chemistry
		21	Physics
		12	Earth/Environmental
		3	Others
37	Chemistry		
27	Environmental Science/Ecology		
20	Geology/Earth Science		
19	Biology		
17	Aquatic/Marine Science		
15	Physical Science		
10	Forensics		
10	Biology II		
8	College/Online courses		
7	Mixed/Integrated Science		
7	Applied Science/Engineering		
6	General Science		
5	Advanced/IB/Honors Science		

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