The following is an excerpt from the dissertation of Lawrence Krumenaker, prepared especially for participants at the NSTA Boston meeting. If you refer to it, please cite it as Krumenaker, L., (2008). *The Status and Makeup of the U.S. High School Course in Astronomy in the Era of No Child Left Behind.* Unpublished doctoral dissertation., University of Georgia, Athens.

Note that quotes have not been corrected for spelling and grammar flaws.

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."

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.

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."

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.

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."

Final results….

> 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.

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