High School Planetariums: Results of a Survey


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Abstract: Results from a 2007 survey of high school astronomy teachers include statistics on numbers, percentages and usage rates of fixed and portable domes and "planetarium software" in United States high schools. A snapshot is made of a "stereotypical" high school astronomy class with a planetarium available. Planetarium teacher backgrounds are examined in order to generate a standard for "highly qualified" under No Child Left Behind.

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How many high schools have and use a planetarium with an actual astronomy course? What influence are portable planetariums in the high school venue? What are the parameters that describe the related astronomy course, such as course size, school specifications, and teacher backgrounds?

These were some of the research questions behind a spring 2007 survey of high school astronomy courses (henceforth called simply the Survey) that made up the author's doctoral dissertation at the University of Georgia (Krumenaker, 2008). Nearly 300 high school astronomy teachers, including a number of International Planetarium Society (IPS) members, responded to an invitation to take part in the 55-question mixed-methods survey which had quantitative, categorical and qualitative questions asking teachers to describe their high school astronomy courses in some detail.

Among the circumstances investigated were the makeup of the student body; background information on the instructors; course characteristics such as duration and frequency; effects of the No Child Left Behind Act (NCLB) and its Adequate Yearly Progress (AYP) yardstick[1]; and what materials such as textbooks, planetariums, and telescopes were used. In this article, results of the planetarium portion are presented.

Some History

Of the many planetariums installed during the heady years of the space age, there are now only around 1100 active in the US, of which only around 350 are in high schools today (Peterson, personal communication). The 2005 IPS *Directory* lists about 275 planetariums that are clearly in high schools (IPS, 2005), though if an astronomy course is taught there cannot be directly assumed. Only planetariums that clearly indicated they were in a grade 9-12 high school were counted; it is possible that we missed some because they simply listed themselves by school name (i.e. Central School) or by just the district name. The *Directory* is not complete; others were found on the listing of planetariums on a web page of *Sky & Telescope* magazine, www.skyandtelescope.com/community/organizations, for example. Portable planetariums are harder to pin down, but we got some help from Starlab sales representatives and others. We believe the figure of 350 may well be about right.

Jeanne Bishop (1980) reported that there was almost a one-to-one correspondence in high schools between the existence of fixed planetariums and astronomy courses offered in the 1970s. In Bishop's time portables were new and rare, and one wonders what effect this number of portables has on the existence of a high school astronomy course today, and even if high schools are using them. Of the 275 high school planetarium listings we tallied in

1 The No Child Left Behind Act of 2001 was designed to provide some kind of accountability in schools for the level of education of their students. Schools are rated as Pass, Needs Improvement or Fail depending on the level of achievement on high stakes testing and some other factors, and this is called the Adequate Yearly Progress (AYP) status for the school. Every year the accountability bar rises until in 2014 all students are supposed to have 100% achievement levels. Math and Language Arts are the primary tested areas though science was to be instituted into the measurements by 2008.

the 2005 *Directory*, 10% were portables clearly owned by the school itself. The natural question, then, is does Bishop's finding still hold today and do portables have the same influence on course existence as fixed domes?

Portables owned by a district (or area educational organization, such as a museum or board of cooperative educational services) available on regular loan may help the teacher but one could also hypothesize that it will be of a lower influence on whether a standalone course exists, akin to field trips, i.e. "borrowing" another facility for a day. One can hypothesize that 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.

A 1986 survey by Harvard's Philip Sadler (1992) was the most recent look at high school astronomy courses before this study, but planetariums were not examined in his research, though some of his general findings would be of useful comparison.

The Survey

The Survey, performed primarily over the Web, used a number of sources to identify planetariums to include in the study. A primary source was the 2005 IPS *Directory* located in the Fernbank Science Center library in Atlanta. We also had an invitational message posted on the Dome-L mailing list and one in the 200,000-subscriber newsletter for the "Starry Night" software program and the newsletter to Starlab portable planetarium operators. Other planetarium astronomy teachers saw our announcements on other listservs, such as ESPRIT (an earth science mailing list), various National Science Teacher Association and American Association of Physics Teachers' regional listservs, and more.

We also made our own collection of names to contact using lists of planetariums found in print and online, such as from the *Sky & Telescope* website, from some of the Starlab dealers, and several American regional planetarium groups' web pages. We also found lists of high school astronomy clubs with contacts, some of which had otherwise "unlisted" planetariums.

During our solicitation periods we occasionally received lists of people to contact directly and some of these were planetarians. We used "snowball sampling," getting more names from people who already had chosen to answer the questions. Overall, the list had 600 names with email addresses.

Additionally, we accumulated about 2200 postal addresses which were used in a later survey. Although not all responses were complete enough to use, still our 237 usable survey responses constitute a 40% return. Though we clearly have a minimum of 2800 high school astronomy teachers, the number is actually larger; we state without proof at this time that the number of high school astronomy teachers is actually closer to 4000, with 3200 being what one might call regular classes..

In the Survey, teachers were asked if their school either (1) owned a fixed planetarium that they could use anytime, or (2) if they used a fixed planetarium elsewhere, and for both, how often did they use it per course. Also, (3) did they use a portable planetarium and, again, if so, how often and who owned the unit? Finally, (4) did they not use a planetarium of any kind, or (5) was there some other option that was not listed? (The "other" category gathered some new information, but also received a lot of answers that really belonged with the given choices.)

The proportion of "own fixed planetarium" is quite high. If 26% of all high schools with astronomy classes had planetariums, there would be around 900 high school planetariums in the country. This is three times what is known to exist. This survey clearly oversampled the planetarium part of the high school astronomy population, but this should make the statistics derived here more statistically valid, truly representative of the reality.

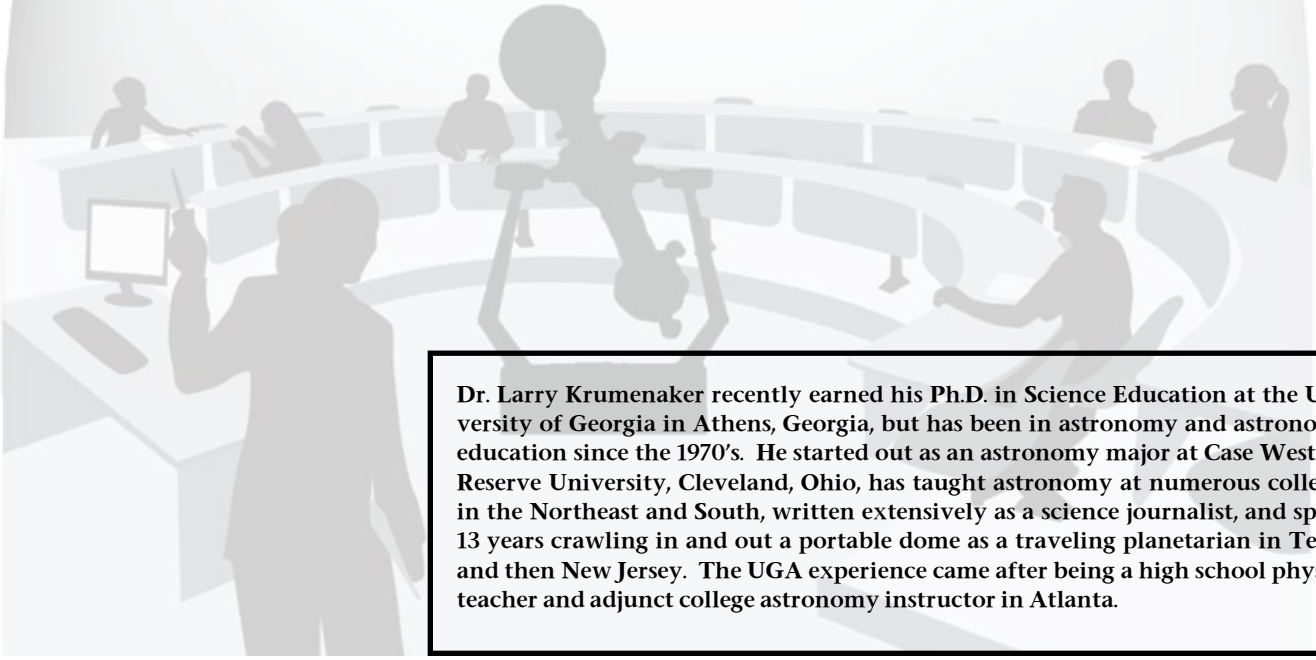
Only two "owned fixed" schools reported usage statistics, and those were "every day" and "15x per course."

It is interesting to see how many portables show up in the sample. We have already noted that the 275 high school planetariums in the IPS Directory contained about 10% portable units. Out of our 28 "used a portable"

Table 1 - Planetarium Ownership (Number, Percentage)

The final tabulation is in the table below ("plm" is abbreviation for "fixed planetarium"):

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



Dr. Larry Krumenaker recently earned his Ph.D. in Science Education at the University of Georgia in Athens, Georgia, but has been in astronomy and astronomy education since the 1970's. He started out as an astronomy major at Case Western Reserve University, Cleveland, Ohio, has taught astronomy at numerous colleges in the Northeast and South, written extensively as a science journalist, and spent 13 years crawling in and out a portable dome as a traveling planetarian in Texas and then New Jersey. The UGA experience came after being a high school physics teacher and adjunct college astronomy instructor in Atlanta.

results, 8 were owned by the school which brings the percentage of high school-owned portables in our sampling equal to 11% of the total of "owned plm" plus "owns portable."

The correspondence between the proportions in our sample and the *Directory* gives confidence that the Survey results do reflect reality. Even if the *Directory* is incomplete on portables, and/or there were more fixed domes there than we tallied, clearly the proportions of "missing" domes must be similar, so one should be confident in concluding that the proportion of portables directly attached to high schools about 10%.

We conclude that owning a portable unit is a fixture of a minimum of about 3-4% of all high school astronomy courses and they are used at about one-third the rate of fixed domes in courses of astronomy.

Twenty-six of the portables-using schools reported usage rates. These were 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 "first one, two, or three weeks of the course" and various multiples of "5 days" that appear 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 used frequently at a similar rate to a fixed planetarium (where the astronomy class does not normally meet in the dome).

The Response to Field Trips

In the "other" category were found numerous references to field trips, with the implication in some, and the explicit statement in others, that these were to other planetariums.

Quite a few responses included the fact that this was no longer a good option. Out of 12 such statements, 5 mentioned irregular usage if at all, and 7 mentioned 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."

Of those that clearly indicated they used a planetarium elsewhere, 36 used 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.

There were 14 remaining "other" categories of which 3 were a combination of the regular choices and 9 were a new choice we hadn't used on the survey, the use of sophisticated computer software, so-called "planetarium emulation software" on large-screen projections, televisions or monitors, or interactive boards. This software projects the night sky, provides 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 were Voyager 4 and Stellarium. Table 2 lists sources and data on the software.

The Classrooms in the Planetarium

Does a planetarium make any difference in the makeup of an astronomy course? Does having one help a school's AYP status? What are the backgrounds of the instructors? In the results that follow, the information refers to those courses and instructors that use planetariums and teach a high school astronomy course.

The statements may not hold for those planetariums where the planetarian serves everyone else but the instructor does not teach any actual classes of his or her own at the high school level.

This subset of the Survey was divided into four groups:

- those with fixed domes for their class use (fixed domers),
- those who have onsite and accessible portable planetarium units (own portables),
- those that borrow a portable from some other owner or site (borrowers), and
- those who used software as their planetarium. This last group is too small for any good statistical value and won't be considered further.

Those survey respondents who do teach an astronomy course with a fixed dome are the majority (64, counting a couple of "other" that use fixed and portables), which makes their statistics more likely to be significant. In terms of geographic distribution, more than half of the fixed domers are in suburban schools (55%), which might be expected as suburban schools are likely to be more affluent than urban (29%) or rural ones (10%). This differs little with our overall Survey.

Those high schools that own portables have a distribution almost identical to fixed domes but those that borrow are more than three times likely to be in rural districts.

The Survey found astronomy classes in a pool that is 87% public schools and 13% private, nicely the same ratio of all schools in the U.S., whether they have a dome or course or neither. However, fixed domes with courses attached are nearly always public schools (94%) and portables are owned more often by public schools than private ones, by a 2:1 ratio.

Borrowers in this sample were strictly public schools. Private schools with astronomy courses seem to either own a dome or don't use one at all.

Large Schools Offcer Classes

High schools with astronomy classes are large. The average Survey high school size was about twice the U.S. average (1581 students versus ~800 students). Fixed dome-equipped schools with courses are even larger, averaging 1792 students; even portable-owning high schools are large, averaging 1400 students.

Whether with or without a planetarium, the class sizes are not so large—22 students per class. The few portable owners' classes are smaller, only 17 students.

Adequate Yearly Progress (AYP) status for the schools, with or without a planetarium, are comparable. Regardless of which of our subgroups we looked at, they are all close to or above the Survey's 77% AYP Pass rate, which in turn is higher than the U.S. Pass rate of 60% for the time period.

High school astronomy teachers are a solitary lot, whether they are planetarians or not, and usually don't get to teach astronomy full time. Generally he or she teaches 1.8 sections of astronomy courses, and rarely teaches with another astronomy teacher. We found an av-

Table 2 - SOFTWARE CONTACTS

Starry Night
Published by Imaginova, Inc.
www.starrynightstore.com
800-252-5417

Voyager
Published by Carina Software
www.carinasoft.com
information@carinasoft.com
+1925-838-0695
+1800-493-8555

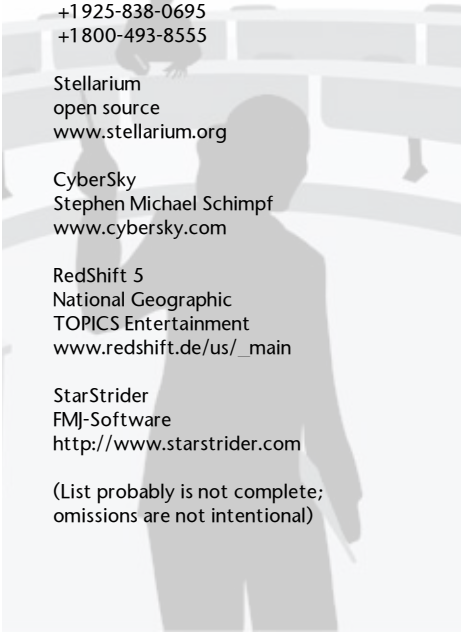
Stellarium
open source
www.stellarium.org

CyberSky
Stephen Michael Schimpf
www.cybersky.com

RedShift 5
National Geographic
TOPICS Entertainment
www.redshift.de/us/_main

StarStrider
FMJ-Software
http://www.starstrider.com

(List probably is not complete; omissions are not intentional)



erage of 1.3 astronomy teachers per school, which translates into about two-thirds being solo teachers.

Since clearly most teachers do not teach just astronomy courses (in the Survey, only perhaps 1 in 7 are "full time astronomy teachers"), what do they do for the rest of their paychecks? In Sadler's day, astronomy was a bonus on top of physics classes. Today, the number one "second course" slot for planetarians is filled by earth science; indeed for fixed domers, 38% list this as a course they teach and this is also true for 50% of the dome borrowers.

Only for portable owners does physics still come to be their "second course," at 50%, but the statistical bases are small for portable users anyway. A third place tie between physics and physical science exists for fixed domers, and chemistry comes last.

But in actual second place for "thing to do" for fixed dome teachers is being the planetarium director, doing shows for other teachers' classes.

Bioscience courses rank second for anyone who teaches with a portable.

For the Survey as a whole, physics was still barely in the lead, 39% against earth sciences at 35% and physical science teachers numbering 27%.

In conclusion, it appears that planetarians come mostly out of the earth sciences and then the physics/physical sciences domain, unlike the teachers of Sadler's day or the rest of high school astronomy teachers today.

NCLB and Highly Qualified

The No Child Left Behind Act has created a need for teachers to be "highly qualified." No state offers teaching certification in astronomy, so other definitions need to be used to determine whether a teacher is qualified.

If this is defined by the undergraduate major, then from 75% (the portable owners) up to 90% (the fixed dome teachers) of these planetarians are highly qualified, having majors in the sciences or science-specific education areas, comparable to the whole Survey's teacher pool's 83%.

Many fixed domers and portable users have masters degrees (77 and 100 percent, respectively)—we counted any kind of masters degree, even if not science or education; 63% of the borrowers have earned master's degrees. This means they are more educated than some other teaching groups, but doesn't make them "qualified.""

The number of doctorates is very small in number, a mere 8% of the Survey and 6% among the full domers, the only subgroup large enough for valid statistics here. This is not "highly qualifying," but that's not uncommon in any field of science teaching.

In the Survey, only 8% of all high school astronomy teachers were astronomy majors, i.e. possess an astronomy bachelor's degree. Five percent of the fixed domers had an astronomy major but some non-majors went back and earned masters and even doctorates in astronomy, making 11% of this subgroup "astronomers" in credentials.

None of the portable owners were astronomy majors, but a third of them earned master's degrees in the subject. Borrowers are comparable to the Survey, at 6%. By this standard, most astronomy teachers are not qualified.

However, of key interest to the planetarium world should be not just the undergraduate major but the amount of astronomy training, and therefore content knowledge. In Sadler's survey, most teachers of high school astronomy got their knowledge from a hobbyist perspective, not from a major or coursework.

In this Survey, the situation is vastly better; 85% have taken at least one course in astronomy at undergraduate, graduate or both levels. But this leaves 15% of all high school astronomy teachers never having taken an astronomy course at any level. Inside the domes, the numbers are better—and worse.

Portable owners do not show even that well, with 25% never having had an astronomy course in college at any level. Given that 33% of them went on to get masters degrees, portable unit owners are dichotomous; they either have a lot of astronomy or they have none.

By this standard, most teachers are "highly qualified,"" though, in general, most teachers take only two courses of astronomy. There is, though, a significant minority that has not, and thus should be considered not highly qualified.

The Advantages of Planetariums

Planetarians have at least two advantages over those not so equipped. First, they have a much higher classroom budget (excluding equipment purchases and other purely planetarium-operation aspects), averaging $1159 for a fixed dome classroom and an amazing $1929 if the school owns a portable. By contrast, the average high school astronomy teacher has an average budget per course of two to five hundred dollars.

Secondly, more often than not, the current planetarian teacher inherits an existing course. Only 40% of the fixed dome teachers created their course, compared to 65% of non-domed teachers. Portable users, whether borrowers or owners, are much closer to non-domers, 53 or 64 per cent, respectively, in the act of creating their astronomy course, which might be expected as they otherwise are classroom teachers.

The Survey also queried these teachers on their perceptions of the future, for their own local situation (school) and for courses nationwide as a whole (nation). They were asked to choose an attitude on a five point Likert scale ranging from 1 for pessimism up to 5 for optimism. If anything, planetarians in fixed domes or with their own portable units are as optimistic or more optimistic for their own courses' futures than the whole Survey pool. For the nation, they are not quite as optimistic; generally the "center of mass" of the attitude spectra is just barely above neutral.

Summary

In summary, our survey of high school astronomy courses indicated that about 10% of all astronomy courses have regular access to a fixed dome planetarium. Another 3-4% have continual access when desired to a portable dome and a similar, and rapidly growing, percentage use computer "planetarium software" as a substitute. When a dome, fixed or portable, is owned by the school housing the course, it is used up to 3 weeks per semester of the course. When a high school course doesn't have a planetarium but does get to use one elsewhere (or owned and borrowed from elsewhere), it is usually but for a single lesson.

In a summary form, high schools with astronomy courses and some kind of in-house planetarium usage are generally suburban, more in public schools than private ones, and generally in schools as large or larger than

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*(**High School**, from page 21)*

those that have classes without planetariums, and larger than the average U.S. high school overall. They exist in schools at least as AYP Passing as the entire Survey pool, which in turn is higher than the U.S. school norm.

Teachers teach approximately two sections of astronomy classes, rarely teach alongside other astronomy teachers in their school, with classes averaging 22 students, except in high schools that own portables where classes are smaller.

Teachers are highly educated, the great majority having masters degrees and with science or science education undergraduate majors. But few are astronomers by their degrees and beyond those, most of the rest took two or fewer courses in astronomy; from 11% to 25%, depending on category, (that's 22% overall) have had no courses whatsoever, which puts increased pressure on their "highly qualified"' status.

Beyond their astronomy classes, the instructors teach mostly earth sciences, with physics usually a strong third place and physical science or biosciences making up much of the rest. An exception is among fixed domers, for whom being the planetarium director, operating the planetarium for others, is the second most likely other activity they do after teaching an astronomy class.

Planetarium instructors are generally even more optimistic for the future of the courses in their local school than they are for the average non-dome-equipped teacher, and they are a little more optimistic for courses throughout the nation than most, but not by much.

Finally, did we reach a statistically representative sample such that we can make these claims with assurance? In regards to planetariums, the top four states in the 2005 IPS *Directory* are Pennsylvania (81), Indiana (25), Ohio (21), and New York (17). Our Survey's top states in terms of responses are Pennsylvania (11), Ohio and Indiana (6), Texas and Wisconsin (5). In this regard the survey matches the IPS proportions rather well.

On the basis of the geographical distribution and the matching proportions of portable and fixed domes in the Survey and the *Directory*, we feel this study's findings are truly representative of high school astronomy courses that use planetarium equipment in any of the three categories.

Final Thoughts

It seems to be that portable planetariums have not had the same influence as fixed domes in high schools, despite more than two decades of availability and their lesser cost. Yet, when they are owned by a school, they are used as often as a fixed dome, therefore one can conclude that if a teacher can get access regularly to some kind of dome, it will be used significantly for education and not a novelty.

Borrowing a portable is no better than a field trip, a change of pace but not likely to be a useful tool overall. Therefore, it seems no surprise that "planetarium emulation software," a relative newcomer to the astronomy teacher's arsenal and easier to obtain, is already up to the same level of usage as portables.

It would be facetious to say that having an astronomy class (or a planetarium) will cause the high school to Pass AYP even if high schools with this status are a higher percentage than the U.S. norm. It is more likely that astronomy courses disappear when a school Fails AYP. This doesn't mean it can't hurt to have an astronomy class in such a school; the known interest and enthusiasm among students with the addition of more language arts and math activities within the class can likely help the school get back to AYP.

This author is aware of a few cases where high school astronomy teachers lost their positions because they were not highly qualified. Since no state offers a teaching certificate in astronomy and there are few, if any, masters of astronomy education, a new definition of highly qualified needs to be made that can satisfy a state licensing board or school district.

Declaring that a highly qualified teacher needs to have a major in astronomy would be a disaster for the field; having at least a science or science education major is a good start. Having a teacher with no astronomy coursework at all, regardless of major, cannot do a field well.

Among teachers in planetariums, there is a significant percentage who has never taken a course. We propose that the combination of having a minimum amount of coursework and an appropriate science content or science-domain specific education (e.g. physics education) degree should make a teacher highly qualified.

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