A LIVELY ELECTRONIC COMPENDIUM OF RESEARCH, NEWS, RESOURCES, AND OPINION

Astronomy Education Review

Volume 5, Apr 2006 - Nov 2007
Issue 1

Astronomy Podcasting: A Low-Cost Tool for Affecting Attitudes in Diverse Audiences

by **Pamela L. Gay**
Harvard University Science Center
Aaron Price
American Association of Variable Star Observers
Travis Searle
American Association of Variable Star Observers
Received: 03/06/06, Revised: 04/21/06, Posted: 05/30/06

The Astronomy Education Review, Issue 1, Volume 5:36-52, 2007

Abstract

Communications and mainstream media are entering a new age of on-demand content. As digital video recorders, like TiVo, change how we watch television, podcasts are taking the spoken word in its own on-demand direction. Astronomy podcasts allow listeners to get up-to-date content on a variety of topics ranging from what's in the sky to what's in the news. In August 2005 and January 2006, we conducted surveys of astronomy podcast listeners and producers. Using the results of these studies, we examine how to create a podcast, who is listening, and how astronomy podcasting is affecting its listeners' attitudes toward astronomy. The article cites the *Slacker Astronomy* podcast as an example astronomy podcast throughout.

1. INTRODUCTION

Podcasting is a new form of communication that is quickly filling the hard drives of tech-savvy youth and adults around the world. Alternatively referred to as *audio blogging* and *Internet broadcasting*, podcasting consists of nothing more than posting an audio file formatted as an MP3 (short for MPEG-1 Audio Layer 3) on the Internet and partnering it with a bit of code to facilitate automated download onto the listener's hard drive.

Although the idea of placing audio files on the Internet is nothing new, the software that allows users to subscribe to audio feeds and automatically gather content from the Internet onto their hard drives (a process called aggregation) is new and based on new Internet protocols. In June 2003, Stephen Downes

(Institute for Information Technology, National Research Council, Canada) demonstrated with his Radio Ed software that Extensible Markup Language (XML) and Really Simple Syndication (RSS) could be used for syndication and aggregation of audio files (Downes 2003). XML is a tag-based markup protocol like HTML, but unlike HTML, it has a flexible set of tags. RSS is a specialized subset of XML tags used to create Web feeds that supply content (or summaries of content) together with Web links to full or related versions of the content.

A few months after Stephen Downes' demonstration in September 2003, Dave Winer (Berkman Center for Internet & Society at the Harvard Law School) created an RSS-with-enclosures feed for Harvard's Christopher Lydon to use to release audio interviews (Winer 2003). An RSS-with-enclosures feed directs aggregator software to download media, such as MP3 audio files, in addition to text-based content. This feed inspired Adam Curry—techno-geek turned MTV Video Jockey turned Internet media promoter—to work on developing software with an easy interface that anyone could use to aggregate audio feeds.

While Curry learned to program, the RSS-with-enclosure MP3 feeds that were sprouting up across the Internet were given a name. The first printed use of the term *podcast* appears to have came in a *Guardian* article by Ben Hammersley on February 12, 2004 (Hammersley 2004). A combination of the words *iPod* and *broadcasting*, this name stuck and appeared in messages from podcast proliferator Dannie Gregoire (Podcast Networks) in the fall of 2004. When Curry completed his aggregator software, he named it iPodder, and a phenomenon was born (Curry 2004). By October 2004, articles on how to podcast began springing up across the Internet, and creative thinkers began to use this new communications medium to reach out and touch the tech savvy everywhere.

The first of what would become many astronomy podcasts listed in the primary directories—Podcast Alley and iPodder—was the *Slacker Astronomy* podcast (Price, Gay, & Searle 2005a; Price, Gay, & Searle 2005b; Price, Gay, Searle, & Brissenden 2006). Launched on February 14, 2004, this three-person collaboration has worked to draw attention to science through humor. Since their launch, *Slacker Astronomy* has been joined by many other astronomy podcasts that demonstrate a diversity of style, content, and institutional/commercial backing (or lack thereof). As of the writing of this article, 45 podcasts were listed under the search word *astronomy* in the iTunes podcast directory. NASA produced five of these podcasts, two came from ESA, and two were from major observatories. The podcasts in this list also included student productions done as class projects, classroom lectures, outreach initiatives, and a variety of astronomy and science news shows. The diversity of these shows implies that there are hungry audiences looking for a wide range of astronomy audio and video content.

Astronomy podcasts are popular. On January 5, 2006, 5 of the top 10 science podcasts in the iTunes Music Store were astronomy shows (see Table 1). There are several thousand shows in the science category (6,431 shows as of April 20, 2006). These "top 10" shows regularly float in and out of the general "top 100" list of all 25,000+ podcasts listed in the iTunes directory (Apple 2006a). For example, on October 17, 2005, *Slacker Astronomy* was ranked 28 overall, placing it in front of both *Business Week – Cover Stories* (31) and *NewsHour with Jim Lehrer* (32) in the ratings. The popularity of astronomy podcasts, considering that they are in direct competition with mainstream, commercially produced podcasts from mass media outlets, demonstrates that podcasting is a competitive way to attract audiences to astronomy.

Table 1. Top 10 Sciences Shows Listed in the iTunes Music Store on January 5, 2006

Rank	Title	Published by	Topic
1	Nova scienceNOW	WGBH Science Unit	General science
2	Nature Podcast	Nature	General science
3	NASAcast Video	NASA	Astronomy / aerospace
4	Slacker Astronomy	A. Price, P. Gay, T. Searle	Astronomy
5	New Scientist Podcast	New Scientist	General science
6	Ask an Astronomer	NASA's Spitzer	Astronomy
7	Quirks and Quarks	CBC Radio One	General science
8	The Naked Scientist	C. Smith	General science
9	Science @ NASA Feature Stories	NASA	Astronomy / aerospace
10	NOVA | PBS	WGBH Science Unit	General science

In this, the first article in a series, we will discuss how podcasts are produced, promoted, and paid for; who is listening to podcasts; and how podcasts are affecting people's attitudes toward astronomy. In a subsequent article (Price et al. 2006), we evaluate the efficiency of podcasting as an education and public outreach (EPO) tool to disseminate astronomy information, using the *Slacker Astronomy* podcast as a specific case study.

In this article, we will discuss the results of two listener surveys and two podcaster surveys. Listener Survey 1 (LS1) and Podcaster Survey 1 (PS1) were conducted August 15–September 1, 2005, and Listener Survey 2 (LS2) and Podcaster Survey 2 (PS2) were conducted January 20–February 8, 2006. In PS1, we e-mailed the producers of all podcasts listed under "Science" in the Podcast Alley podcast directory that included astronomy in their description, that did not promote creationism, and that typically produced three or more shows a month. We used similar criteria in PS2, but used the new iTunes Music Store's podcast directory instead of Podcast Alley. To obtain as complete a sample as possible, we sent at least three e-mails to slow and nonresponding producers and made at least one phone call to United States-based podcasts with listed phone numbers to solicit participation. In PS1, all podcasts except *Star Date* responded, and in PS2, 17 of 21 podcasts responded. We asked all responding podcasters to complete our listener and podcaster surveys, to post links to the listener surveys on their sites, and to mention it in their podcasts.

Our goal in asking everyone to promote our surveys was to widely sample the astronomy-podcast-listening community, but in the final results of both surveys, 91% of all respondents (347 people in LS1 and 570 in LS2; this number is 4% of Slacker Astronomy's audience for both periods) listed *Slacker Astronomy* as

one of the podcasts they listened to. Although this could be interpreted as saying that most people who listen to podcasts that include astronomy listen to *Slacker Astronomy*, we believe that a more accurate interpretation is that listeners do not like to fill out surveys associated with podcasts that they do not listen to. (See Appendix A for complete details on the listener surveys and Appendix B for details on the podcaster surveys.)

2. TECHNICAL

2.1 How to Listen

There are two basic ways to download a podcast: listeners can either go to the Web site that hosts the podcast, or they can use podcast aggregator software to subscribe to podcasts. The number of listeners using aggregator software is on the rise (see Table 2), and the most common way that users download podcasts is via iTunes. Most types of aggregator software automatically upload podcasts to a portable media player (the iPod is currently the most popular brand). To quickly debunk a misconception: **Listening to a podcast does not require an iPod**.

Table 2. Method for Downloading Podcasts Responses

Responses	LS1		LS2		Change
	N	%	N	%	
Manually download	32	9%	36	6%	-3%
iTunes aggregator software	219	63%	435	76%	13%
Other aggregator software	96	28%	93	16%	-11%
Not responding	0	0%	6	1%	1%

On June 28, 2005, Apple Computer began to include podcast aggregation among the standard features in its iTunes software. Simultaneously, Apple launched a podcast directory within its music store. Because podcasts are free, listeners do not need an account with the Apple Music Store to subscribe to or download podcasts. Users can generally subscribe to any podcast using iTunes or similar aggregator software in five or fewer mouse clicks. Aggregator software exists for all major operating systems, including Linux and Palm, and Web-based aggregation tools also exist. The beauty of podcasts is that they are free for anyone with access to a computer with an Internet connection.

Once a user is subscribed, aggregator software like iTunes downloads new shows to the listener's computer as the shows become available and automatically uploads them to any attached MP3 players. All the listener must do is subscribe once and periodically press Play. MP3 players can be as chunky as a desktop computer or as small as a pack of gum. Many portable MP3 players are inexpensive. The iRiver 700 series MP3 player / FM radio / digital audio recorder used by *Slacker Astronomy* to record interviews starts as low as U.S. $79.99 MSRP. According to LS1 and LS2, listeners most often listen to podcasts

using portable MP3 players. An average of 61% of users listen on MP3 players, 27% listen on their home computers, and 11% listen on their school or work computers.

Podcasting is a remarkable medium that allows scientific knowledge to be passively obtained, passively absorbed, and actively enjoyed. Podcasts are listened to anywhere—at work, while commuting, at the gym, while futzing around the house. Podcasts keep listeners' minds busy and educate them while they do mundane tasks and thoughtless work. Podcasts are available for immediate consumption and, like digitally recorded television, they can be saved to be savored later.

Shortly after podcasts were introduced into the Apple Music Store, users began subscribing and listening to podcasts in droves, with the number of podcast downloads markedly increasing, and subscription numbers from iTunes topped one million in just two days (Apple, 2005). Download numbers reflect the sum of the number of people who manually download shows and who subscribe to them via aggregator software, a number that reflects the entire listenership just as newsstand sales and subscription sales together reflect a magazine's entire readership. Both our surveys took place after iTunes added podcast support, but we still see a continued increase in the number of podcasts listened to. The typical respondent of LS1 listened to a median of eight podcasts. Today's listener, however, typically subscribes to a median of 10 podcasts and spends an hour a week listening to these shows (see Figure 1, which shows a histogram of the number of podcasts listened to vs. percentage of respondents).

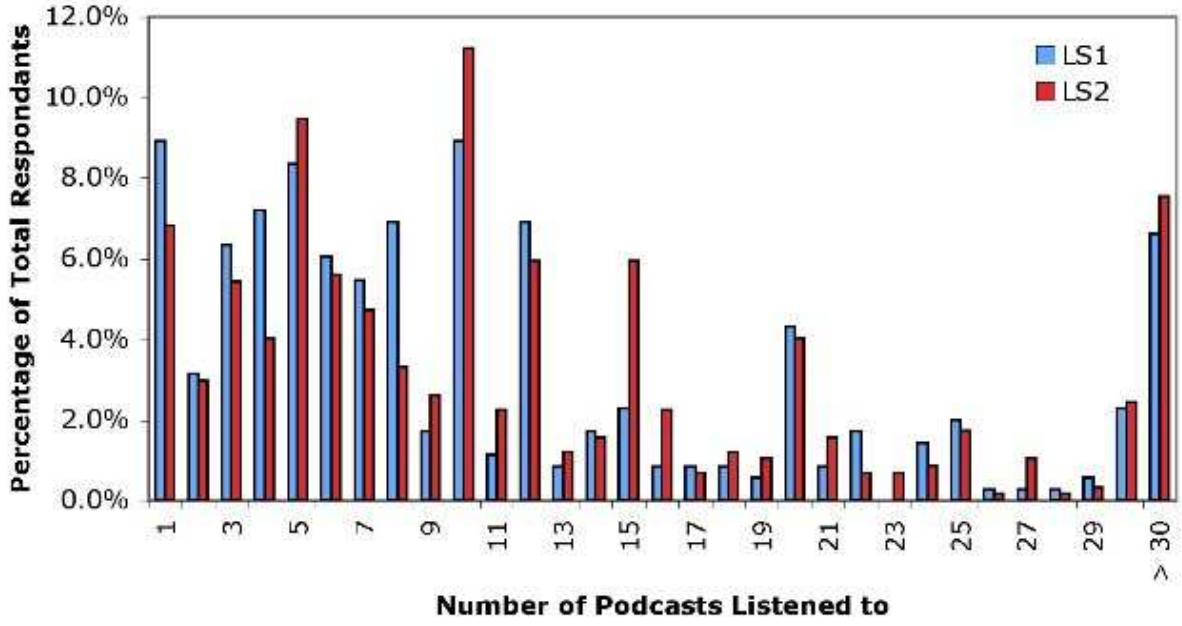

Figure 1. Comparison of Number of Shows Listened to in LS1 and LS2. For LS1, the average is 12, mode is 1, median is 8, and max is 99 podcasts. For LS2, the average is 13, mode is 10, median is 10, and max is 90 podcasts.

2.2 How to Record a Podcast

Boiled down to its most basic elements, all you must do to produce a podcast is record an audio file or video file, upload it to a Web server, and write the associated XML file. Although this sounds simple, many nuances affect every step of this process, and creating a high-quality podcast that will attract subscribers takes a bit of effort. Although both video and audio podcasts exist, this article restricts itself to audio podcasts.

A good podcast starts with a good microphone, but it does not require a great microphone. *Slacker Astronomy* uses two standard configurations. For our regular shows, we record using a laptop computer with an m-Audio MobilePre USB preamp microphone-computer interface, and generic condenser microphones. Because the audio will eventually be compressed, a high-end, high-quality microphone is not necessary. We have also had good results using a much cheaper Griffin Lapel Mic with a Griffin iMic, which has a built in preamp. Our portable recording setup is an iRiver 790 or 795 with a Griffin Lapel Mic. These setups work with both Mac OS X and Windows operating systems.

Once you have your raw audio, you will likely want to edit it and add metadata. Many audio editing packages exist. For ease and cost, we recommend either GarageBand (for OS X) or the freeware program Audacity (OS X / Linux / Windows). Metadata, such as show title, keywords, and authors, are stored in ID3 tags. ID3 tags are a standard way of encoding information at the end of MP3 audio files. A list of standard tags and how they are used in podcasts is shown in Table 3. These tags can be edited in both Audacity and GarageBand, as well as in iTunes. It is also possible to associate graphics with MP3 files. Many MP3 players display associated images, called "album art," while a song is being played, and the more advanced MPEG-4 Part 14 audio file format (referred to as an M4B file when applied to podcasts) allows multiple graphics to be attached so that album art changes at specific time markers in an audio file.

When saving final versions of shows, it is recommended that you use 32 kbps (kilobytes per second) compression or smaller for spoken-word audio and 64 kbps to 128 kbps for shows with music. The lower kbps used with speech-only files smooths irregularities in the audio and conserves disk space, but also muddies any music. A typical MP3 music file is ripped to disk at 128 kbps. File compression can also be done using iTunes.

Table 3. Standard Podcast Keywords and Their Most Common Uses

Keyword	Use	Example
Name	Typically the episode name	"Interview with Dr. Sally Oey"
Artist	Author names or collaboration name	Slacker Astronomy
Album	Typically podcast name	Slacker Astronomy Bonus Features Feed
Year	Year	2006
Genre	Set to "Podcast"	Podcast

The majority of podcasts are MP3 files, but as noted, M4B files are used as well. Listener e-mail shows a strong preference for the M4B file type (podcasts in this format are called enhanced podcasts). Although they require extra steps to produce, M4B files, which are most commonly used for audio books, allow the addition of "chapter" markers in the file so that users can skip between chapters. Chapter markers also allow users to stop and return later to any spot in a podcast. The M4B file structure makes it possible to include a separate graphic with each chapter, a trick that allows astronomy podcasts to include multiple images and technical diagrams with audio content. Typical M4B files combine an ACC format audio file (a standard used in most software) with XML that indicates where chapters begin and what graphic is associated with each chapter. In addition to ACC files, other file types can be used, including MP3, Celp speech files, and SAOL midi files. Most of the dominant media players play this format, including Windows Media Player Classic, RealPlayer, iTunes, QuickTime, and Nero Media Player. However, although growing numbers of audio players support M4B audio files, not all audio players support these features (Voxmedia 2006). Chapter creation software is evolving too quickly for us to make any specific software recommendation other than GarageBand.

2.3 How to Post a Podcast

What separates a podcast from an isolated MP3/M4B file is the XML file that it partners with. The XML file tells the aggregator software basic information about a show, such as title, description, and where each episode can be found for download. (An annotated example XML file for a podcast can be found in Appendix C.) Writing and maintaining an XML file that is compatible with iTunes can be very tricky, but helper software exists and can be found easily using Google. At this time, we can make no specific recommendations based on experience. Feeds can be tested by manually subscribing to them in aggregator software. Apple (2006b) provides detailed technical specifications on its Web site.

Many podcasts also have related Web sites for manual downloads. These sites often include additional information and graphics, and in some cases also provide a way for users to leave public comments, participate in forums, and otherwise interact with the podcast. Many of these sites are programmed in the PHP language and use MySQL databases. Free, easy-to-use Web site server software, such as Wordpress (http://wordpress.org), can automate the creation and maintenance of Web sites.

Once a podcast and its associated XML feed and Web site have been created, it is important to register the podcast with podcast directories. The leading directories are the Apple Music Store (within iTunes), Podcast Alley (http://www.podcastalley.com), iPodder (http://www.ipodder.org), and iPodderX (soon to be http://thunderstonemedia.com). Adam Curry's *Podcast Show* (http://www.podshow.com) also runs promos of podcasts. This show is distributed as a podcast and on Sirius Satellite Radio.

3. CURRENT ASTRONOMY PODCASTS

3.1 Show Format

Podcasting breaks free from the constraints of more mainstream media, and today's astronomy podcasts often remove the middleman between the listener and the science. Astronomers are making their own podcasts or calling on the help of the EPO staff they already work with to help them get their content straight to the public.

Phil Plait, a frequent guest on many different podcasts, put it best when he said, "There are a lot of obvious advantages to podcasting, but my favorite is not being held hostage by advertisers or the FCC. If I'm ticked off about something, I'll let it be known. And I tend to know the people doing the interviews–they're friends, acquaintances, and colleagues, so it's easier to play off what they're saying, be relaxed, be funny. And if you screw up, it can always be edited later" (personal communication 2005). Constroversial subjects, including evolution and the Big Bang, pop up frequently as many shows work to promote scientific reasoning and skeptical thought. With the freedom to go anywhere with content, the existing astronomy podcasts have taken on a diversity that might not have been possible otherwise.

According to PS1 and PS2, general astronomy and recent discoveries are the topics that dominate in the podisphere, and one of the primary ways of disseminating this information is posting interviews with scientists. Within the responding podcasts, approximately 44% of the show time goes to interviews, with 8 out of 10 PS1 shows and 7 out of 14 PS2 shows spending some to all of their time on interviews.

Ranging from short computer-generated podcasts, like *NASA Astrobiology Magazine* podcasts of press releases, to long interview shows such as *Skepticality*, podcasts come in a variety of shapes and sizes. With podcasts, there are no external limitations on show length or content. Nevertheless, although infinite variety is possible, astronomy podcasts do conform to certain typical formats. In surveying the field, we found that most shows are settling into a less-than-30-minute format; 5 of 10 shows in PS1 and 12 of 16 shows in PS2 were shorter than 30 minutes. The show lengths are born out of a variety of characteristics. At *Slacker Astronomy*, we base show length on the typical human attention span of 20 minutes (Pike 1994), the average American commute time of 24.3 minutes (Buckner & Gonzalez 2005), and how long it takes to completely flesh out a story.

There is also a rough split in format between scripted and unscripted, with the formats *majority scripted*, *majority unscripted*, and *completely mixed* having a ratio of 4:5:1 in PS1 and 8:5:3 in PS2. Often comedy is scripted ahead of time, while interviews are, by nature, unscripted. Several shows, including *Science @ NASA Features* and *NASA Astrobiology Magazine*, are scripted from press releases and Web stories. Most shows have multiple hosts (averages of 2.2 and 3.7), and the interplay between hosts is part of the shows' format.

3.2 The Audience

This diversity of podcasts in general and in astronomy podcasts in particular allows for attracting a diverse (and growing!) audience. At the time of this writing, hard numbers on the overall podcast listening audience could not be found.

The often-cited 2004 Pew Internet and Family Study (Rainie & Maden 2005) stated that in 2004, 29% of all Americans had listened to podcasts. However, this number is projected from the responses of just 208 adults who owned some form of MP3 player. In addition to the small sample size, they also phrased their question in a way that might lead people who hadn't listened to a podcast to say Yes. Specifically, the study asked, "Have you ever downloaded a podcast or Internet radio program so you could listen to it on your digital audio player at a later time?" A sample this small and the vagueness of the question calls into question the accuracy of the 29% figure (MacMillan 2005; Morphy 2005).

Instead of relying on their projection, we present projections based on *Slacker Astronomy*'s listenership. In May 2005, *Slacker Astronomy* was in the top 10 of the Podcast Alley ranking system. At that time, we had approximately 4,000 hits per week from unique IP addresses. In January 2006, *Slacker Astronomy* had 14,000 hits per week from unique IP addresses (a 350% increase), but it was not in the top 100 podcasts in the iTunes Music Store or Podcast Alley. We believe that this increase in our listenership could reflect a lower boundary on the increase in the overall podcast listenership, but we stress that this is a back-of-the-envelope approximation and only implies with certainty an increase in the overall podcast-listening audience—something the alert reader can also guess from the increase in the number of people wearing iPods in public.

Although many think that podcasts are something for the young and affluent, our listener surveys show that listeners come in all ages and incomes. Comparison between the distributions of people in the United States versus those in LS1 and LS2 shows that we are picking up a greater percentage of the overall population ages 25 to 44 than we are for those younger and older than this range (Figure 2). Similar, direct comparison between these salary data and the U.S. Census data is not possible because the U.S. Census measures household income rather than individual income. However, our breaks were set so that our six income groups have roughly the same percentage per bin as in the US Census household income data (from low to high, the U.S. Census shows 16%, 19%, 18%, 14%, 16%, and 17% of households fall in our bins). We found that there is no significant relationship between income and podcast-listening habits (Figure 3), with the overall distribution appearing flat. When the population under the age of 22 is removed, however, a low-income gap does emerge. This gap is a reflection of the overall technology divide that appears when studying Internet and computer use by low-income individuals (Goslee 1998).

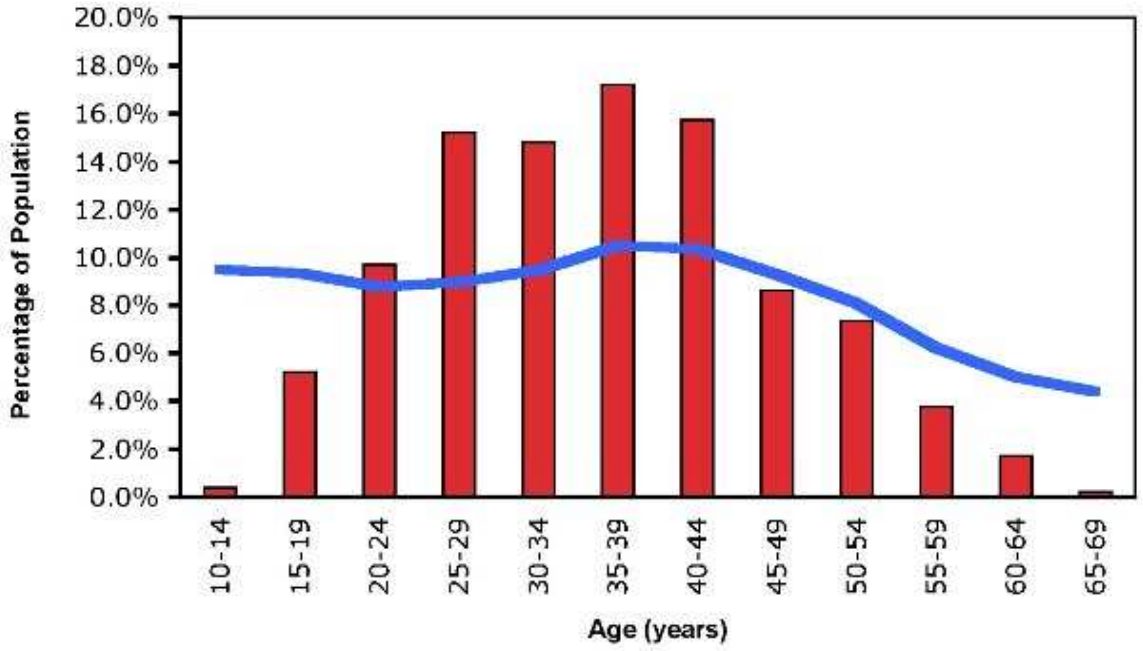

Figure 2. Distribution of Listener Ages. This figure shows a histogram of the percentage of respondents having a given age averaged between LS1 and LS2 (red). The populations in these two surveys are statistically drawn from the same population (paired two-tailed t-test P value of P = 1, Pearson Correlation = 0.85). For comparison, the distribution of the U.S. population between 10 and 69 years is shown in blue (U.S. Census 1990).

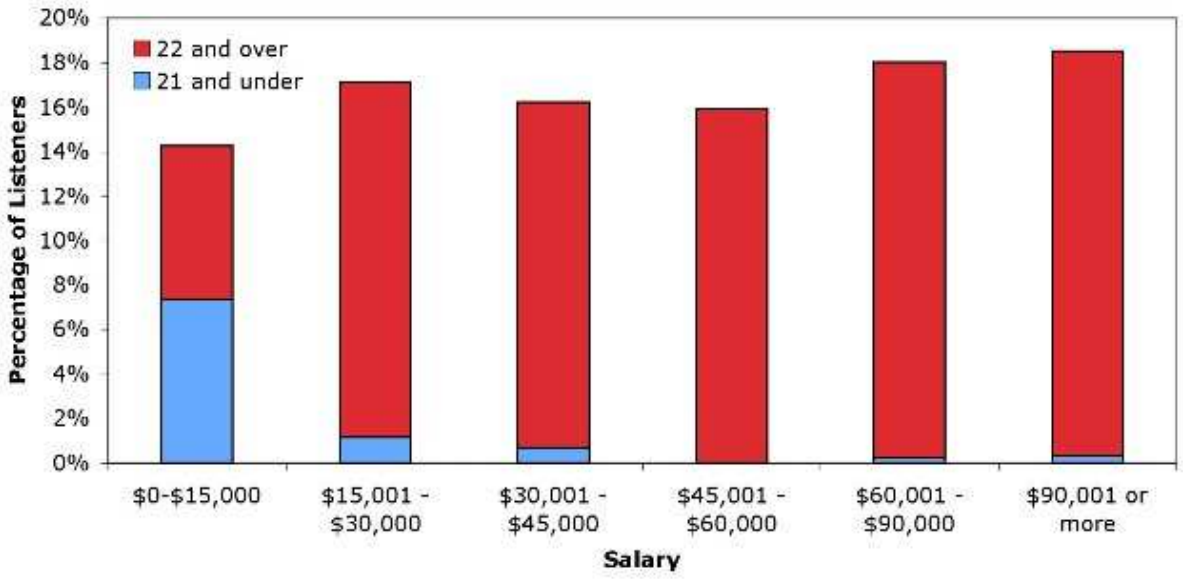

Figure 3. Distribution of Listener Incomes. Shown is a histogram of salary versus percentage of listeners, breaking out ages 21 and under versus ages 22 and over.

A similar gap also appears in the education backgrounds of our listeners. Listeners have a variety of educational backgrounds, but college-educated listeners dominate (see Figure 4). This reflects the higher rates of Internet use among the college educated; 61% of high school graduates go online, compared with 89% of college graduates (Fox 2005). Although our listeners predominantly have computer- and Internet-related jobs (40% in LS1 and 33% in LS2), significant numbers also work in K–12 and university education (10% in both surveys), health/medical/veterinary (4% in LS1 and 5% in LS2) fields, and research and development (5% in LS1 and 4% in LS2). Between LS1 and LS2, we had responses from all 50 states and 33 countries, including 43 listener responses from the United Kingdom, 26 from Canada, 20 from Australia, and 8 from New Zealand. All other countries had fewer than five responders.

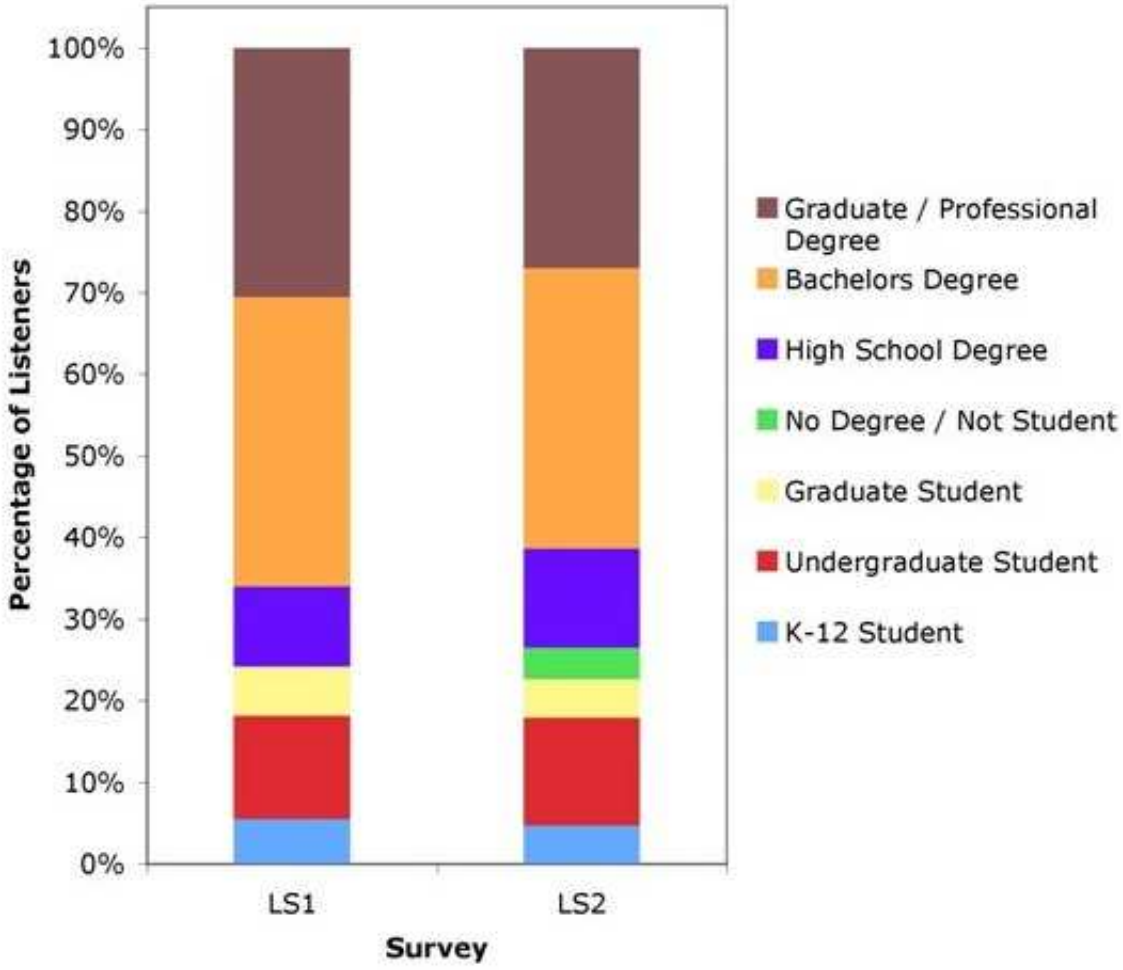

Figure 4. Distribution of Listener Education Level. Note that the option "No high school degree / Not a student" was introduced in LS2. The graph shows stacked histogram of listener education level by percentage.

We did find a strong gender bias in our respondents. In LS1, 9% of all respondents were female, and 13% were female in LS2. This gender bias is a complicated problem involving differences in how men and women use the Internet, the gender bias among amateur and professional astronomers, and an initial

gender bias due to hype started by some listeners about the sexiness of the female host's voice. A 2005 Pew/Internet study showed that female computer users were less likely to "pursue and consume information online" and that "men use the internet more than women as a destination for recreation" (Fallows 2005). There are also gender biases regarding who gets involved in physical sciences (American Association of University Women Foundation 2004; Ivie & Ray 2005; National Science Foundation 2000) and in amateur astronomy in particular (A. Henden, personal communication 2005), which is reflected in our audience.

Although our survey is biased by the dominance of *Slacker Astronomy* listeners, we feel safe saying that podcasting brings astronomy to listeners of all ages and incomes, and reaches listeners around the globe. Our listeners also have a diverse set of interests and preferred sources of information. To try and understand the preferred media content of our audience, we asked them about magazine preferences, news sources, and favorite podcasts and TV shows (complete responses are available in Appendix A. The results we obtained were extremely diverse, with no majority set of interests appearing, although our audience tends to prefer science and science fiction and to obtain their news online. Although the amateur astronomy community is dominated by "graying white males" (Henden 2005), the astronomy-podcast-enjoying audience reflects a wider cut through society.

4. DISCUSSION

4.1 Paying the Bills

The equipment necessary to produce a podcast on a pre-existing computer and post it on an existing Web server can cost as little as $100. The real cost of podcasting comes in the form of time and bandwidth fees. Time costs take the form of show preparation and research, script writing, searching for interview candidates, maintaining the Web server, and answering listener e-mail. The *Slacker Astronomy* podcast takes roughly 24 hours per week to produce and maintain. Roughly five hours go to script writing and editing, two hours go to recording, two hours go to production and posting, and the remaining time goes to Web maintenance; administrative and community service tasks like answering e-mail; replying to online comments; preparing and editing audio from public talks; and working on fundraising. These remaining tasks vary in intensity from week to week.

Bandwidth costs can be more significant than time considerations. Often running at roughly 3.75 mb/min. of content, podcasts eat bandwidth, and as a site gains listeners, the bandwidth requirements can become vast. If a site produces just four 15-minute podcasts per month at 64 kbps and has 10,000 listeners, it will require 2 terabytes of monthly bandwidth. This level of traffic is not supported by most home Internet service providers and may cause a university to shut down or regulate traffic to a server if they are not adequately warned of potential traffic first. Traffic may also come in spurts that can easily pull down a Web server not designed for heavy traffic. A phenomenon called *slash dotting* can occur when someone posts a recommendation of a story on SlashDot.com, causing thousands of users to visit the story's site in a very short period (10 to 1,000 hits per minute or more for anywhere from a few minutes to a few hours). Because it is impossible to know when slash dotting may occur, it is important to design a site for robustness before it is needed.

To help cover the costs of both bandwidth and podcaster time, a variety of strategies are employed. At this time, astronomy podcasting is not a money-making enterprise for its participants, and the number of podcasts paid for strictly out of pocket is not too different from the number paid for by corporate, institutional, or grant support (Table 4), and only 5 out of 10 podcasts in PS1 and 7 out of 16 podcasts in PS2 pay their staff for their time spent podcasting. Not all independent podcasts are forced to bankroll their efforts on their own, however. User donations are often sufficient to cover all equipment and bandwidth costs. During the period from August 1, 2005 to December 31, 2005, *Slacker Astronomy* averaged US $151 of donations per month, with an average donation of US $10.78 ± 8.88 (median and mode of $10). This covered the $130-per-month bandwidth and server cost, and various software and hardware purchases. It is also possible to seek advertisers.

Table 4. Source of Financial Support for Podcasting-Related Costs for Respondents Of PS1 and PS2. Respondents were allowed to fractionally select more than one source.

Source of Support	**PS1**	**PS2**
	(# of shows)	
Personal monies	3	6.05
Donations from listeners	3	1.2
Private grants / foundations	0	2
Corporate sponsorship	0	0.5
Government grants	0.5	0.75
Institutional support from your primary employer(s)	3.5	3.5

4.2 Affecting the Listeners

First and foremost, podcasts are a form of entertainment. In judging entertainment, it is important to ask two questions: (1) Do people like it? and (2) Does it affect them? The entertainment industry has long used a show's number of viewers and listeners to track popularity. Based on the prevalence of astronomy, including podcasts in the iTunes top 10 science shows and top 100 overall podcasts, we conclude that people like astronomy-including podcasts

The second criterion—whether a podcast affects listeners—is harder to sample. For LS1 and LS2, we asked our users to self-identify their interest level in astronomy before and after they began listening to podcasts. We found that 24% of respondents who are not professional astronomers had gone from having passive interest or no interest to having an active interest in astronomy, and two amateur astronomers had become professionals (Table 5) after listening to astronomy-including podcasts. In addition, although only 33% of the respondents in LS1 and 40% of the respondents in LS2 had taken astronomy classes in high

school or college, 65% in LS1 and 72% in LS2 would or do attend local astronomy lectures for the public. We evaluate how much they are learning and sharing their learning in Price et al. (2006)

Table 5. Change in Attitude toward Astronomy before and after Listening to Astronomy-Including Podcasts

	LS1					**LS2**				
	Before		**After**		**D%**	**Before**		**After**		**D%**
Could/can spell "astronomy"	6	2%	5	2%	0%	9	2%	4	1%	-1%
It was neat when I was a kid	16	5%	0	0%	-5%	22	4%	0	0%	-4%
Passively pay attention	96	29%	41	12%	-17%	176	31%	71	12%	-19%
Actively pay attention	121	37%	191	57%	21%	239	42%	353	62%	20%
Amateur astronomer / club member	75	23%	80	24%	1%	100	18%	120	21%	3%
Professional / student astronomer	16	5%	16	5%	0%	20	4%	22	4%	0%

5. CONCLUSIONS

With all voluntary participation surveys, it is important to remember that the survey population isn't necessarily an accurate reflection of surveyed population. In our survey, we and other podcasters asked listeners to actively go to a Web site and fill in personal information. Because of the predominance of *Slacker Astronomy* listeners in both surveys (91% in LS1 and LS2), we suspect that having someone else ask listeners to fill out our survey is not effective. We also had a response rate of just 4% of our listeners in both surveys. Determining exactly what biases this may create is something for further study.

Having said that, we feel that we have demonstrated that podcasting is an easy, inexpensive, and effective tool for creating an active interest in astronomy in a diverse audience. If you have a Web server and computer, set-up costs can be as low as the cost of a microphone and preamp for your computer. Software for everything from editing audio to organizing Web sites is available for free. Serious time demands are involved, and this is where the real cost of podcasting comes into play. The *Slacker Astronomy* staff spent roughly 20 hours creating their Web site and continue to average about 24 hours total (8 hours per person per week) producing and supporting the show and Web site.

For the podcast listener, everything is free and easily attained. Thanks to widely available aggregation software and the diversity of MP3/M4B-playing devices, it is possible for anyone with Internet access to subscribe to podcasts in generally five mouse clicks or fewer and have the shows regularly download on their own. Once downloaded, podcasts can be listened to offline at any time. Listeners select shows, listen when it is convenient, and fine-tune their media to their lifestyles and interests.

Astronomy podcast listeners come from all income and education levels and from locations around the globe. There is a bias toward college-educated people above the poverty line, but this trend is a reflection of the economic technology gap found in all areas of digital communications and education. Although males dominate our audience, we understand where this bias originated, and we are working to remedy it. We cannot say if the audiences of other astronomy podcasts have the same bias.

The podcast-listening audience continues to grow, showing a best-guess minimum growth rate of 350% in the past six months based on show growth and ratings changes. We strongly recommend podcasting as a way to disseminate information, and we encourage others to take what we have learned and build on it as we increase the number of people actively interested in astronomy. Grab a microphone and computer, find a friend to cohost or a scientist to be interviewed, and perform your own experiment in informal astronomy education.

Acknowledgments

We would like to offer special thanks to Nancy Griffis for her assistance in understanding our respondents' answers concerning television show preferences, and Thomas Foster for his help with statistics.

References

American Association of University Women Foundation. 2004, *Under the Microscope: A Decade of Gender Equity Projects in the Sciences,* http://www.aauw.org/research/underthemicroscope.pdf.

Apple. 2005, "iTunes Podcast Subscriptions Top One Million in First Two Days." June 30, 2005. http://www.apple.com/pr/library/2005/jun/30podcast.html.

Apple. 2006a, "Apple – iTunes – Podcasts." http://www.apple.com/itunes/podcasts/.

Apple. 2006b, "Apple – iTunes – Podcasts – Technical Specifications." http://www.apple.com/itunes/podcasts/techspecs.html.

Buckner, S., & Gonzalez, J. 2005, "Americans Spend More Than 100 Hours Commuting to Work Each Year, Census Bureau Reports." Press Release. March 30, 2005.http://www.census.gov/Press-Release/www/releases/archives/american_community_survey_acs/004489.html.

Curry, A. 2004, "History." Indiepodder.org. http://www.ipodder.org/history.

Downes, S. 2003, "Ed Radio." http://www.downes.ca/ed_radio.htm.

Fallows, D. 2005, "How Women and Men Use the Internet." Pew Internet & American Life Project. http://www.pewinternet.org/PPF/r/171/report_display.asp.

Fox, S. 2005, "Digital Divisions." Pew Internet & American Life Project. http://www.pewinternet.org/PPF/r/165/report_display.asp.

Goslee, S. 1998, *Losing Ground Bit by Bit: Low-Income Communities in the Information Age*, Washington, DC: Benton Foundation.

Hammersley, B. 2004, "Audible Revolution," *The Guardian*. 12 February 2004. http://technology.guardian.co.uk/online/story/0,,1145689,00.html.

Ivie, R., & Ray, K. N. 2005, "Women in Physics and Astronomy." American Institute of Physics Publication No. R-430.02. http://www.aip.org/statistics/trends/reports/women05.pdf.

MacMillan, R. 2005, "Podcasting in the Dark." *Washington Post*. 6 April 2005. http://www.washingtonpost.com/wp-dyn/articles/A30340-2005Apr6.html.

Morphy, E. 2005, "Six Million Podcasters and Counting." *Newsfactor Magazine Online*. 14 April 2005. http://www.newsfactor.com/story.xhtml?story_id=32251.

National Science Foundation. 2000, "Women, Minorities, and Persons with Disabilities in Science and Engineering: 2000." http://www.nsf.gov/statistics/nsf00327/pdf/document.pdf.

Pike, R. W. 1994, *Creative Training Techniques Handbook*, 2nd ed. Minneapolis: Lakewood Books.

Price, A., Gay, P., & Searle, T. 2005a, "The Slacker Astronomy Podcast," American Astronomical Society Meeting, 206, 05.01.

Price, A., Gay, P., & Searle, T. 2005b, "An Assessment of Slacker Astronomy Outreach Results," American Astronomical Society Meeting 207, 67.16.

Price, A., Gay, P., Searle, T., & Brissenden, G. 2006, "A History and Informal Assessment of the *Slacker Astronomy* Podcast," *Astronomy Education Review*, 5(1).

Rainie, L., & Madden, M. 2005, "Podcasting Catches On." Pew Internet & American Life Project. April 2005. http://www.pewinternet.org/PPF/r/154/report_display.asp.

Voxmedia. 2006, "Podcast Chapter Tool," *VoxmediaWiki*. http://www.voxmedia.org/wiki/PodcastChapterTool.

Winer, D. 2003, "Special RSS Feed for Lydon Interviews,"*Christopher Lydon Interviews*. 23 September 2003. http://blogs.law.harvard.edu/lydon/specialRssFeed.

Appendixes

Click here for Appendixes A, B, and C in PDF format.
ÆR
36 - 52