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Sound Matters: Enhancing Educational Audio Quality for Extension Programs Increases Learning

Abstract

Numerous studies show the efficacy of podcasts in educating diverse audiences. Further, high-quality audio enables greater knowledge retention. Conversely, research shows that subpar audio quality can significantly erode the information's credibility. To maintain Extension's reputation as a trusted source, the quality of audio in podcasts and other areas must match the excellence of our content. We explore cost-effective equipment and production strategies to achieve the best possible audio quality within the constraints of a limited budget. Our aim is to help other Extension educators who desire to use podcasts and audio recordings in their programming. We discuss budget-friendly recording equipment, audio editing, and techniques to achieve top-notch recordings as educational resources.

Abbreviations: Digital Audio Workstation (DAW), Microphone (mic), TRS (Tip, Ring, Sleeve), TRRS (Tip, Ring, Ring, Sleeve)

Keywords: educational technology, educational podcasting, microphones, audio editing software, recreational learning, distance learning

Introduction

Widespread availability and affordability of smartphones, microphones, recording apps, and audio editing software have revolutionized educational podcasting (Strickland et al., 2019). Podcasts are recorded spoken content accessible for on-demand listening. They offer flexibility as single-topic or episodic series, are accessible on various devices, and can be consumed during various tasks. In 2019, 26% of US citizens listened to podcasts at least monthly (Perks et al., 2019). By 2022, the number increased to 50% of Americans ages 12-34 and 48% of Americans over 55 (Götting, 2022). Research by Strickland et al. (2019), showed a public interest in recreational learning and stated that 74% of respondents who listened to podcasts listened to learn something new.

Podcasts are also used as a formal educational supplement in fields including medicine (Kharb, 2013; Malecki et al., 2019; Sandars, 2009) and language (Rosyidah et al., 2021). Studies show that they can be more effective than traditional lecture-based instruction (Guy 2016; Kennedy, 2016; Popova, 2014). Some students prefer subject-appropriate podcasts over in-person lectures, with no negative impact on test scores (Chester, 2001). This preference extends to non-traditional, full-time working Extension clientele, who are often independent learners with limited time. In a Washington study, Extension educational participants preferred passive learning opportunities such as podcasts (Zobrist and Rozance, 2015).

Digital education can also be advantageous for Extension volunteers. Vines, et al. (2016), found that Master Gardener volunteers and coordinators considered time to be the biggest restriction in being able to participate in training programs, and that they favored using web-based education to make learning more convenient. Wilson (2023), found that after moving Master Gardeners education online, participants still "reported a significant increase in knowledge and abilities to answer client's questions."

When educators use podcasts, poor audio is undesirable. Tsagkias and others (2009), reviewed podcasts on several common distribution networks. They found that unpopular podcasts on these platforms exhibited "low audio quality." Newman and Schwartz (2018), emphasized using best practices presenting research-based information to

others stating, "poor audio and video quality on prerecorded videos delivering scientific content reduces the credibility of the presenter and of the content presented." Additionally, one author observed firsthand that poor sound quality caused participants' attention to lapse. Cox stated, "the videos with a lot of wind noise or where the voice was faint caused attendees to tune out in boredom and frustration. Bild et al. (2021), also found that audio quality influences the believability of witness recordings in court settings, with good audio quality enhancing credibility.

Producing Successful Podcasts

Extension requires creativity in delivering impactful programming that can sometimes be a challenge to those in the twilight of their careers. Educators later in their careers especially may be hesitant to communicate with clientele this way, where they prefer face-to-face communications (Kluchinski et al., 2011). We have found, though, that audio recordings such as podcasts are an effective way to educate younger audiences.

An example of this includes one author cohosting an award-winning gardening question and answer radio show with over 50,000 listeners. Part of its success with younger audiences includes embracing social media and making recordings of the show available via podcasts. The author regularly self-records segments for the show. Other authors also host award winning podcasts and self-record, edit, and master their own content.

As authors, we have learned to record, edit, and master our own recordings. We have found the following useful:

- Determine the desired audience for the show. From this, decide the general topic area and level of depth you want to provide.

- Decide on a recording format: whether recordings will be solo, with a cohost, or a host interviewing guests.

- Decide on equipment that fits your needs, including a recording device such as a computer and what kind of mics to use.

- Noisy environments are usually not advised for recording unless the background noise contributes to the credibility of the recording such as tractor noise on a field crops podcast recorded outdoors. One must be careful to make sure the background noise does not overpower the voice.

- Recording and listening to yourself is beneficial. Listen carefully to look for ways to improve, without being overly critical. It improves quality and shortens production time in the long term.

- Coach inexperienced guests on proper mic technique before starting a recording.

Podcasting Equipment Choices

Listed below is equipment that we have experience with. We discuss the attributes of each. We do not discuss pricing due to it shifting frequently. We also avoid discussing specific models due to newer equipment continuously being introduced.

Audio recording devices

Computers: Computers are common for recording and post-production tasks. Models with a minimum of 8 GB of RAM (16 GB is better), quad/multicore processing speed exceeding 2.6GHz, and multiple USB ports are ideal. Resource-intensive editing software benefits from higher CPU and RAM specifications to prevent crashes and throttling.

Portable digital recorders: Digital recorders are compact and ideal for field recording or conferences. Entry-level models often support external microphones for better quality. To edit or publish, transfer recordings to a computer using SD/MicroSD cards or USB cables. Common brands include Zoom and Tascam.

Smart phones and tablets: When using these devices alone to record, it is easy to jostle or move the phone towards or away from a subject negatively impacting the recording quality. Hold devices 6 – 12 inches from your mouth for the best results. Various aftermarket mics that improve audio quality are made to connect to these devices. Those being recorded also often use wireless earbuds such as Air Pods to record.

Recording quality varies but is usually lower than a dedicated microphone manufactured for that purpose. Additionally, editing and mastering audio on a phone or tablet is more difficult than on a computer.

Audio recording software

Audio editing programs, known as digital audio workstations (DAW), record and offer extensive post-production capabilities. They can edit, delete, copy, paste, and adjust audio elements, including reducing background noise and enhancing vocals. Interestingly, the choice of a DAW has minimal impact on recording quality, and so free DAWs are a great option (Leonard, 2012).

Most DAWs offer YouTube tutorials and online support forums. Audacity (https://www.audacityteam.org/) is a popular free DAW. It is limited to stereo recordings, and some find its interface less user-friendly. However, it boasts a large user community and numerous user-made add-ons.

Other examples of DAWs include:

- Cakewalk (free) Windows Only
- GarageBand (free) Mac OSX only
- Logic Pro IOS (paid) Mac OSX only
- Adobe Audition (subscription-based)
- Reaper (free to try and inexpensive to purchase)
- Hindenburg Journalist (paid) designed primarily for interviews and spoken word

Additionally, many online recording sites also offer editing software with their paid plans. Editing is the most time-consuming step in production. For every minute recorded you should expect 2-6 minutes of editing. If you do not wish to do your own editing and mastering, many independent podcast/audio editors are available for hire. For basic editing and mastering, individuals can be found on websites such as Fiverr. However, it would be difficult to find an outside company that would be able to edit scientific content

for clarity. More thorough content editing and mastering is expensive and may cost too much for a limited budget in our experience.

Microphone options

Start with an affordable microphone. There are options fitting almost any budget. Expensive, professional-grade mics, costing hundreds to thousands of dollars, do not offer significant benefits unless you have a dedicated studio, high-end equipment, and specialized vocal training. Brands like Samson, MXL, Shure, Behringer, Electro-Voice, Rode, Logitech, and Audio Technica are some that offer budget-friendly options.

The mic you choose will moderately influence the qualities of how your recorded voice sounds. Familiarizing yourself with your recorded voice and its unique traits makes choosing a microphone easier. When just getting started, an inexpensive mic is great. Clientele usually listens to podcasts using inexpensive equipment or using a car stereo that negates the need to use a high-end mic.

Dynamic microphones: Dynamic mics excel in noisy environments, offering reduced sensitivity to distant sounds. Staying close to the mic is essential to maintain audio quality, a phenomenon known as "off mic." Ideally, position your mouth 3 - 6 inches from the mic, although this distance may vary. For podcasters lacking a dedicated studio or a quiet space, dynamic mics are recommended.

Condenser microphones: Condenser microphones are more sensitive to voice subtleties, but they also capture unwanted ambient noise. They are ideal for dedicated studios and quiet environments.

Broadcast headsets: Broadcast headsets combine headphones and a dynamic boom mic positioned close to the mouth. They are ideal for noisy environments or situations where it's challenging to keep someone consistently on mic. Be cautious of wires causing unintended noise if bumped or dragged during recording.

Microphone connection options

USB: These are popular among do-it-yourself creators because of their convenience. They offer excellent audio quality while keeping equipment costs low. Connecting multiple USB mics to a computer can be impractical due to compatibility issues when using more than one, especially with Windows machines.

3.5 mm: These are budget-friendly and used for connecting microphones to tablets, smartphones, and computers. They are better than built-in device mics, but they are not superior to USB and XLR mics. There are two variations on 3.5 mm plugs and jacks. They include TRRS used for headphone and mic combinations, and TRS exclusively for stereo headphones. It is valuable to distinguish between these to avoid recording errors. In Figure 1, you can see a computer's 3.5 mm ports with a headphone symbol (TRS) and a stereo headphone and a mic (TRRS). The jacks for TRS and TRRS (center) are also depicted. Many newer computers and laptops exclusively have a TRRS port or may only have a few USB-C ports, with the expectation you purchase adapters (Figure 1, right).

Figure 1. An example of a TRS, TRRS plugs and jacks, and a TRRS to USB-C adapter.

XLR: Figure 2 (left) shows an XLR cable. They are an industry standard, have the widest selection of mics to choose from, and offer the best audio quality. They can only be used for computer recording with an adapter, as seen in Figure 2 (right), and center. USB adapters are widely available, but a limitation is that only one mic can be connected to a computer using a USB adapter. Other options allow more than one mic to be connected as discussed in the Audio interfaces and Mixing boards sections.

Figure 2. A microphone cable with XLR male and female connections along with two types of XLR to USB adapters.

Wireless: Wireless microphones connect to phones, computers, cameras, or other devices via Bluetooth or a small, attached base. Rhode and Saramonic make popular models that clip to a shirt lapel that are convenient.

Audio interfaces: These devices enable XLR microphones to connect to a computer via USB. Models with at least two XLR inputs are valuable for recording office or studio interviews. Audio interfaces offer mic gain adjustments and include a headphone jack for monitoring and post-production. They typically do not record directly to internal memory cards; instead, they transfer audio to a computer via a DAW and save it on the computer's hard drive. Models exist offering from 1 to 8 or more XLR inputs that can be recorded on separate tracks. Manufacturers include Mackie, Behringer, Motu, Focusrite, M-Audio, PreSonus, Rode, Tascam, and Zoom. Even inexpensive models are sufficient.

Music mixing boards: Newer models typically include a USB connection. They offer detailed control over audio elements like bass and treble. However, most only support stereo, where only two mics can be recorded separately on a left and a right track. Even though they often have more than two XLR jacks, recording more than two people places more than one person per track, complicating post-production editing, especially when guests talk over each other, cough, etc.

Podcast mixing boards: These typically feature between two and four XLR inputs, each recorded to separate tracks. They come with presets that can modify the recording's characteristics, offering options like a "warmer, darker tone" or a "crisp and bright" tone. They often incorporate built-in noise reduction, adjust for mic proximity (if someone is

too close or far away from the mic), and include sound pads for playing pre-recorded audio like applause or jingles. They connect to cell phones, tablets, or computers, allowing interviews to be recorded during phone calls or via apps like Zoom or Teams.

Podcast mixing boards usually record to an external memory card, a computer, or both simultaneously, creating a backup. Those with memory cards do not require a computer for recording. Most also can be battery-powered, making them convenient for recording away from the studio or office. They tend to be pricier, though. They are useful but only when specific needs arise. Zoom, Rode, Mackie, and Tascam produce models.

Remote podcast recording platforms: Numerous online recording services provide near studio-quality multitrack audio and video recording for remote collaboration with cohosts and guests. They work similarly to the online meeting apps Zoom or Teams but recording quality is much better. They also include the option to record simultaneously locally and to the cloud. A stable, high-speed, preferably hardwired internet connection is essential. Occasionally, users may encounter track synchronization issues (drift), which can be resolved with editing but can be time-consuming. Riverside.fm, Zencaster, Squadcast, Cleanfeed, and Ringr are a few popular options.

When using these services, everyone being recorded should have an external mic on a stand to speak into during the recording. Using the stock mic on a computer or another device such as a phone often gives poor results. The use of wired earbuds with a mic on the earbuds is highly discouraged. As guests turn their heads and move their bodies, the sound of the wires rubbing on clothing and desktops cannot be heard during recording and is often not noticed until post-production. These sounds are difficult to edit out. Additionally, when remote guests do not have an external mic available, we have heard of podcast hosts mailing inexpensive USB mics to the guest to use for the interview with a postage-paid, padded return envelope to mail the mic back.

Additional equipment and considerations to improve audio recording quality

Recording environment: Record in a quiet space with minimal background and reflected noise. Such noise is often present in rooms with hard surfaces and sharp edges, easily

picked up by microphones. Common sources of unwanted background noise include HVAC systems, fans, and traffic, which can complicate post-production.

One author experienced increased background and reflected noise when switching to a higher-quality dynamic mic. She noted, "While my voice quality improved, I could hear more room noise and realized I needed soundproofing in my office, like sound treatments or hanging a blanket on the wall during recording." Here are some tips we have found useful to improve sound quality:

- Use a dynamic mic.

- Avoid recording in front of computer screens that reflect sound back into the mic.

- Record a few seconds of 'silence' to establish what is called a noise floor at the beginning and end of the recording to pick up background noises. Many DAWs can be set to recognize the noise floor (the quietest sound you want to keep) to make softer background noises easier to edit out.

- If a loud noise occurs during recording, it is best to re-record that section than to try to edit it out or offer a brief explanation in the recording excusing the sudden noise, if that section cannot be recorded again.

- Pause or mute the recording when moving the mic or making other noises such as shuffling papers. Keystrokes and mouse clicks can be surprisingly loud in playback. Mount acoustic panels, or soft items such as fabric drapes or blankets over windows, walls, and doors to absorb extra soundwaves.

- Silence cell phones and office phones because notification noises, ringers, and vibrations are almost impossible to completely edit out.

When recordings have greater amounts of background noise that must be removed, quality suffers, and the recording may sound muffled or otherwise distorted.

Wind screens and pop filters: Windscreens are foam covers placed directly over the microphone to reduce wind and air movement noise. In windy conditions, fuzzy windscreens, often referred to as "mice" or "dead cats," work best. Pop filters are positioned between the speaker and the microphone to mitigate plosives and sibilance. These accessories can be observed in Figure 3.

Plosives occur during speech, particularly with words starting with 'P,' 'S,' 'T,' and 'K,' and result from sudden air pressure changes. Sibilance is the excessive or pronounced "S" sound. While many digital audio workstations offer post-production plosive and sibilance filters, it is advisable to prevent them during recording due to the tedious editing required to remove or diminish them. Using tools in a DAW to reduce them is also tricky.

Some microphones include a shock mount, which holds the microphone similarly to a regular mount but secures it with elastic strings, as depicted in Figure 3. This design aims to absorb vibrations and isolate the microphone in case the microphone stand is accidentally bumped.

Microphone stands: A microphone stand, whether in a scissor-arm style or freestanding, should offer stability. Scissor-arm stands attach to the edge of a table or desk. For desktop stands, it is essential to have a weighted base and adjustability to position the microphone comfortably. Regardless of the stand type, they should include padding between the stand and the table to minimize noise transfer and prevent table scratches.

Figure 3. Devices to reduce plosives, sibilance, and table/desk noise on a scissor mount.

<u>Monitor headphones</u>: These headphones, sometimes called studio monitor headphones, are tailored for recording, studio work, and post-production. They allow a thorough assessment of recording quality. It is crucial to ensure they fit snugly on your head and fully cover your ears to prevent sound leakage into the microphone, which may lead to an echo effect.

When choosing headphones, costlier options do not always equate to better results. Online reviews can be helpful. However, avoid popular consumer headphone brands designed for recreational music listening, as they often have boosted bass frequencies that can alter your perception of the recording compared to the original.

<u>Practice using your equipment</u>: A way to minimize the amount of time spent in post-production, especially if you are recording yourself, is to practice speaking into a mic to learn proper mic technique. Some suggestions include:

- Positioning your mouth 3 – 6 inches away and slightly diagonal from the mic. This position reduces sibilance and plosives because the airflow from your mouth hits the mic on an angle instead of head-on. You may need to be as far as 6 – 12 inches away from some mics that are extra sensitive to plosives.

- Hydrating and taking small drinks in between recordings to reduce mouth clicks.

- Breathing deeply and quietly instead of taking sudden shallow breaths. Most breaths need not be edited out, but slow, deep, quieter breaths are much less jarring for listeners.

- Avoiding crutch words and sounds like umm, such as, like, you know, etc. For professional quality, these are often edited out. It is tedious to do, and this type of editing is avoided by practice and preparation. Sometimes crutch words may be left in for effect, to convey mood, deep thought, etc.

- Becoming accustomed to listening to yourself in a recording. You can quickly identify verbal ticks, crutch words, and other sound quality issues.

Budget

A budget depends on available funds, how often you intend to record, how long recordings will be, and if you plan to record long-term. For someone recording occasionally, a smartphone without any additional equipment will likely be sufficient if

you learn to use it correctly. Beyond this, though, a computer or a sufficient tablet is necessary.

The most basic setup includes a USB mic costing $20 - $30 and a set of monitoring headphones for around the same price. A free DAW can be used to record, edit, and master. Many budget-friendly USB mics are available in kits that include a mic stand, a pop filter, and/or a windscreen for $10 - $15 more than just the mic.

Considering mics, though, we do notice significant improvements in the tonal quality of voice recordings, with those costing around $100. Several companies previously mentioned market both USB and XLR mics in this range.

The least expensive audio interfaces with one XLR input start at around $50. Models with two to four XLR inputs cost between $70 and $100. Budget-friendly but more expensive models offer reduced background electronic hiss that cost 30% - 70% more.

Other everyday expenses include mic stands, mic mounts, pop filters, and soundproofing for a recording space. These costs vary widely from $10 - $15 for an inexpensive stand or pop filter to hundreds of dollars. We expect to pay around $25 for a budget-friendly mic stand and $10 - $15 for a pop filter.

Podcast hosting platforms are not our focus, but many, like Spotify, iTunes, and Libsyn, have free publishing options. However, fees can go as high as $150 annually or more. Cost varies based on the number of posts you plan to make, how long they will be, and what kind of statistical feedback you are interested in. Platforms often have add-ons like website hosting and options for subscriptions or monetization (commercials). The hosting site typically takes a percentage of income from subscriptions and commercials. These could be used to help offset the cost of production. Check your state's financial policies to make sure it is allowable. Do not expect to break even or profit with monetization because few podcasts do.

Besides the equipment mentioned in the budget section, we recommend purchasing further equipment only as needed. For more budgetary details, Table 1 gives the approximate equipment pricing for devices mentioned in this article.

Table 1. Price ranges for recording equipment as of November 2023.

Audio Equipment	Approximate Cost ($)	Notes
Computer	800 – 1,200	Refer to the specifications of appropriate computers in the computer section.
Portable Digital Recorder	100 – 200	Models with XLR ports start at approximately $130 - $150.
Smart Phone or Tablet	150 – 1,200	Windows, Apple OS, and Android devices have recording apps and DAWs available. Models above $500 are unlikely to lag or freeze for editing and mastering.
DAW	Free – Several Hundred dollars	Free DAWs are suitable. Paid versions are more feature-rich but may not be needed.
Wired Microphones	25 – 300	Prices include dynamic, condenser, USB, wireless, and broadcast headsets. Many priced at $50 or less are acceptable.
Audio Interface	70 – 300	Single XLR input options start at $70, dual XLR input models at $100, and those with more than two XLR inputs at $200.
Music Mixing Boards	100 – 300	Those with two XLR inputs cost $100 or more.
Podcast Mixing Boards	150 – 800	Basic models start at $150. Most cost between $400 - $700.
Online Podcast Recording Platforms	5 – 50 (monthly)	Lower-priced options limit recording time to a few hours a month. Higher-priced plans offer more recording time and features.
Wind Screen and Pop Filters	5 – 100	Models costing less than $20 are usually sufficient.
Microphone Stands	15 – 300	Higher-priced models eliminate the use of springs and produce less noise when repositioned. When not jostled, lower-priced models work well.
Monitor Headphones	25 – 300	Lower-priced options are acceptable for editing and mastering.
Hosting Platform	0 - 150	Costs vary depending on your needs.

Conclusion

For those considering podcasting, recording, editing, and mastering takes the most time. In our experience, producing a polished, 30-minute podcast can take anywhere from 2 to 6 hours. The more solutions implemented during the recording phase, the less time you will need for editing. However, as audiences increasingly shift toward digital content consumption, outreach organizations must continue to evolve beyond traditional fact sheets and printed materials. While planning, acquiring the right equipment, and setting up your recording space are crucial for a strong start, thorough editing remains a necessary step for achieving quality productions. Just as we emphasize readability for informational fact sheets, to best maintain our credibility in the public eye, Extension organizations should emphasize listenability, in audio-based educational content.

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