

A Preliminary Study to Enhance Communication on Construction Field Trips

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Construction job sites are noisy places. Students who visit construction sites as part of a class field trip often struggle to hear and understand the group leader as they are led around the site. Education research indicates that a student's ability to hear is a primary driver for understanding of key concepts and interest in the topic discussed. Few, if any, construction programs have explored the use of assistive listening devices on construction visits to improve the student's ability to hear. Primary barriers to such an approach have been the cost of such systems and the added complication of implementing a portable transmitter/receiver system that can be moved easily from job to job. This preliminary study explores the use of a simple assisted listening device utilizing a single transmitter for the group leader and individual receivers with headsets for the students. Results indicate that the perception of student hearing during field trips improved with the assisted listening device. Students indicated that a system that allowed both the instructor and the field professional to speak through the assisted listening device would improve the system. In addition, minimizing the bulky nature of the device would also improve the overall experience and ease of use.

Key Words: FM Systems, Hearing, Field Trips, Tours, Assistive Listening Devices

Introduction

Any instructor who has taken a group of students to a construction job site or manufacturing facility knows how much of an issue the students' ability to hear at the job site can be. Noise from construction equipment, workers, machinery, and even adjacent properties all impede the ability to communicate with a group of students on the site. This issue is also complicated because the distance from the speaker to the students often cannot be controlled because of job site parameters. Students often trail behind the group leader in essentially a single file line for much of the trip yielding a large distance from the leader to the last student.

Communication between group leaders and students on the job site is key to their ability to learn and comprehend what is happening around them. Without clear communication, students often lose focus and are distracted by minor, insignificant issues occurring around them on the site. Instructors are often required to repeat instructions and key issues multiple times putting strain on the instructor and requiring additional time for all involved in the trip. On many occasions, groups are led by construction site personnel who are not accustomed to speaking to large groups making it even harder for the students to understand – they tend to speak to the few students who are in close proximity.

Few, if any, schools employ any type of assistive listening devices (ALDs) for students on construction job sites. No data was found in the literature on the subject of ALDs used for construction field trips. However, FM radio systems are used in similar applications for "lectures, tours, and noisy restaurants" (Ross, 2004). Many of these systems are expensive with system costs exceeding $10,000. Such cost parameters would make ALDs for construction field trips almost impractical for students and faculty alike.

Can a simple FM system be used, selected specifically for class field trips, to improve the ability to communicate with the group? This study utilizes a simple FM transmitter and receiver to explore whether such a system would improve hearing for students on a field trip. Students responded positively to the system tested noting a perception

of improved hearing on construction field trips. Problems with the system selected are detailed including the bulky nature of the equipment and the need to hear multiple people on the site.

Literature Review

An ALD is essentially any type of device that allows one to improve their ability to function better in communication situations (American Speech-Language-Hearing Association). Such a device may be used in conjunction with other hearing aid devices a person may be using.

FM systems are particularly appropriate for ALDs. They are "flexible, mobile, and sturdy" (American Speech-Language-Hearing Association). "An FM system provides a favorable signal-to-noise ratio even in the most difficult listening situations" (Kordas, 2008). Such a system allows one to hear at an appropriate and constant intensity level. The person wearing the microphone is more prominently heard than background noise.

The technology is rather straightforward. FM systems consist of a transmitter and receiver. A microphone connected to the transmitter converts voice to FM waveform. This waveform is then broadcast by the transmitter over the airwaves. The FM receiver accepts this signal and converts it back to an audible signal. A power supply is required by both the transmitter and receiver (Nelson, 2002).

As with other technology, FM systems have advanced greatly in the past few decades (Nelson, 2002). Small transmitters and micro receivers are available on the market. Special features like "multiple bands, wide dynamic range compression, automatic feedback suppression system and directional microphones" have evolved within the market (Ross, 2009). Such advancements in technology allow for essentially a wireless FM system. Many of these are "personal frequency modulation systems" (American Speech-Language-Hearing Association). Essentially, they act like miniature radio stations with special frequencies assigned by the Federal Communications Commission (American Speech-Language-Hearing Association). "In noisy environments and when the speaker is not near the listener, a personal FM system is unmatched in improving poor listening situations" (Nelson, 2002).

The literature on ALDs indicates that these devices have been used extensively in the classroom setting (Listen Technologies). In this setting, the quality of oral instruction is enhanced with all students receiving a clear audible signal through the classroom regardless of interfering noise. Teachers using such an FM system have reported "improved student attention, fewer distractions, and less need to repeat instructions" (Listen Technologies). Students have reported that they pay attention better, understand directions easier, and block out distracting noises (Listen Technologies).

If the technology is available and the student's experience at the site is improved, why are these FM systems not being used? One key issue is the cost/benefit ratio perceived by the user of the system. "Even when there is proven subjective and objective benefit, adults who have tried personal FM systems have elected not to use them when it entailed purchasing them" (Ross, 2009). Ross (2009) reported two separate studies where FM systems were tested on two groups. For both groups, the quality and clarity of the audio was improved. One group, who obtained the FM system for free, opted to keep the system. The other group, who had to pay for the FM system, had only a small number of people purchase the system.

One of the key factors in implementing ALDs in a noisy environment is using an appropriate microphone. "Nothing is more effective in increasing the loudness of speech relative to the noise than a close-talking microphone" (Ross, 2009). The loudness of speech or signal to noise ratio is one of the most important factors in speech perception. If a signal cannot be heard over surrounding noise, it will not be understood. Directional microphones are especially good at improving the signal to noise ratio (Ross, 2009). Another feature found in some modern microphone designs is noise cancelling capability which effectively screens out surrounding background noise thus enhancing the clarity of the speaker's voice.

Research Question

The introduction of the ALDs for construction field trips posed the following question for students participating in field trips:

Could the overall field trip experience from the student's perspective be improved with a simple, FM system?

This research study attempted to answer that question.

Methodology

2009 Pilot Study Motivated This Research Approach

A pilot study was conducted in the fall of 2009 to evaluate the need for ALDs that would work for student field trips to construction sites. A small sample group was used to limit confusion, insure safety for students and faculty, and minimize costs. As part of a "structures" class, nine individuals used an FM system during a field trip to a large steel fabricator's facility. The fabricator's shop provided an excellent environment for testing with the inherent noise of the manufacturing facility and the relatively "tight" confines of the plant building. Since only nine subjects were employed in the test and no control group (without ALDs) was evaluated, the pilot study was viewed as qualitative and directional only.

The pilot study of 2009 utilized a commercially available FM transmitter manufactured by Mobil Black Box, model V6000 (approximately $100), which transmits in the frequency range of commercial radio stations. This was thought to be an advantage since system costs could be minimized by utilizing standard FM radio receivers which most students would already have. The transmitter equipment used in the pilot study is shown in Figure 1. Students provided their own receivers which varied in design. The headset used for the group leader utilized a noise cancelling microphone but it was part of a headset with earphones that were not necessary for the speaker.

Students were asked to answer a questionnaire on their experience with the FM system. There were 15 questions designed to obtain a general overview of the student's perception of their ability to hear on the jobsite and their opinion of the system. Questions were developed by the researchers and included the following:

- Was hearing on field trips in general a problem? Was hearing on construction field trips problematic?
- Does the use of the FM transmitter improve the ability to hear the leader, safety, and the student's learning experience?
- Based on your experience, do you prefer to use the FM Transmitter over traditional (no assisted hearing) means?
- What was the brand name and model of the FM receiver you used during the field visit?
- Rate your experience on the parameters of the ability to control volume and amount of static (1-5).
- What do you like best about the FM transmitter approach?
- What do you like least about the FM transmitter approach?
- What suggestions for improvement do you have for the FM transmitter approach?

Despite the limited sample size, the pilot study revealed that students do have problems hearing on field trips. Construction field trips appeared especially problematic. Students appreciated the ALDs with almost all realizing better hearing on the site and a perception of an improved learning environment. One of main problems found with the pilot study was excessive radio noise. This was attributed to the use of the standard FM radio band where strong signals from commercial stations could interfere with the local transmission. Based on the excessive noise in the pilot study, the authors concluded that the initial, cost effective system tested in the pilot study was clearly unusable. Research dollars were then secured, better equipment was acquired, and more extensive field tests were conducted in the Fall of 2011.

Figure 1: FM Transmitter/Microphone Used in Pilot Study

2011 Study Methodology

For the current study, a transmitter and ten receivers were purchased from Williams Sound. These units utilize an FM frequency band reserved for personal transmitters, remote controls, and other low power equipment. It was hoped that such a system would eliminate some of the radio noise experienced in the pilot study. The transmitter cost was approximately $200 with each receiver around $110. Both the microphone for the speaker and headsets for the receivers were a style commonly referred to as "behind the ear". The equipment is pictured in Figure 2. The microphone is noise cancelling, and a hard hat can be worn with either the transmitter or receiver headsets.

Figure 2: Equipment Used in Current Study

The first field trip to utilize the new system was conducted at the campus district plant which houses 4 large chillers and 10 boilers. This provided a good mix of environments with a quiet control room, very noisy equipment areas and outside cooling towers which provided moderate noise from equipment and wind. Subsequent trips were conducted at an outdoor construction site for a large facility where footings and foundations were in place or under construction and lower level walls were being formed. This provided a moderate noise level with site equipment, tools, and workers. It also provided the most separation of the group from the speaker. Field trips in this study included a total of approximately 68 students over three separate sites. Ten students were supplied with receivers and the group leader, or speaker, was a representative of the company visited. Thus, three groups of 8-10 separate students used the system on three field trips (26 total ALD users on 3 field trips). The remaining 38 students composed the control group for the study (no ALDs).

A written survey was given to all students on all three field trips noted immediately upon completion of the field visit. The questions asked of the students contained questions appropriate for all students, whether they used a receiver or not, and questions that would be appropriate for students with receivers only. Figure 3 shows the equipment in use.

Figure 3: Equipment in Use-Students looking around while equipment is being discussed

The authors view this 2011 study as the second preliminary phase in a multi-phase design approach to develop an effective ALD for construction field trips. Goals of the study included testing of a simple system and development of additional ideas for the next phase of development and testing.

The authors recognize that students within the control group may have been biased in any responses given regarding hearing on the job site since control group students were not given the ALDs provided to other students. Essentially, the students in the control group could be influenced by the students wearing the ALDs (and vice versa). Despite said bias, the authors do not believe the goals of the study were compromised.

Results and Discussion

Sixty-eight students toured three construction sites with approximately 40% of the students utilizing ALDs. Results indicated that students preferred the ALD over the traditional approach (no assisted listening devices). Primary concerns centered on the cumbersome nature of the device and the need to hear more than one person at a time on the job site. Also mentioned by the students was static or "noise" over the transmitter system.

Section 1: Student Profile

All the students who participated in the study had been on both non-construction and construction field trips during their time in school. Sixty-eight students composed the sample size for the study with approximately equal groups tested during each of three separate field trips. Of the sixty-eight students that participated in the field trip, 26 tested the ALDs. Other students completed surveys detailing previous field trip and work experiences. Of the 68 students, 87% indicated that they had been on two or more construction related field trips during their time in school. This indicated that students had experienced construction sites during field trips and understood what trips without hearing devices were like. Almost all students had work experience with more than 70% having spent seven months or more working on an actual construction site. This indicates at least a minimal level of experience with a "typical" construction sites and established some credibility of the students ability to effectively perceive hearing issues on a job site.

Of particular note was the response of the students in the control group who did not utilize ALDs. Although these students visited the same sites as students who utilized the ALDs, the control group indicated that hearing on those job sites was a problem as suspected and as identified in the pilot study.

Section 2: Opinion of the FM Transmitter

Based on your experience, do you prefer to use the FM system over traditional (no assisted hearing) methods? 85% of the students who utilized "strongly preferred" the FM system over no assisted hearing on the job site. Another

12% preferred the FM system over no assisted hearing on the job site. Only one of the twenty-six students that used the ALD reflected that they preferred not to use the device.

If the group leader was not your class instructor, how helpful would it have been to be able to hear both the group leader and your instructor at the site? 80% indicated that it would be either "helpful" or "very helpful" to hear both the instructor and the field construction leader during the visit. Only one of the students indicated that such an approach would not be worthwhile.

Table 1 identifies two parameters related to student perceptions of the ALDs used in the field study. Results indicate that factors of "comfort" and "receiver size" were generally considered "effective" by students.

Table 1

How effective was the ALD on the parameters shown?

Parameter	Mean
Comfort of headset	4.0
Size of receiver	4.3

1-Never Effective; 2-Not Effective; 3-Neutral; 4-Effective; 5-Very Effective

Two questions were developed based on the pilot study to evaluate student perceptions of surrounding site noise and safety. The first question centered on noise and static over the system tested: *Did the headset effectively minimize surrounding site noise?* 75% of the students tested thought that the device tested sufficiently masked or minimized surrounding site noise. Despite this apparently high number, several students in one of the three groups noted static and interference at times during the field trip. Further study is needed to determine how such "noise" issues may be handled as the product development continues. The second question sought to determine students' perception of job site safety with the use of headset, cord, and receiver: *Do you feel that the use of the receiver/headset compromised your safety on the job site?* Over 90% of the students perceived that safety was not impacted in any way by their use of the receiver and/or headset.

Students were asked about their opinions of the receiver and headset. First, students were asked *if they would prefer a receiver/headset combination where the receiver is built into the headset (eliminating the connecting wire and separate receiver box)?* Students were divided on this issue with no clear direction offered. Students were then asked *if they would prefer a receiver with a built in speaker (holding it near to your ear to hear) rather than using a headset?* Students responded favorably to this potential with 79% stating that they would prefer such an approach.

What do you like best about the FM transmitter approach? Several students mentioned that the approach provided a way to hear the trip leader in otherwise "un-hearable" environments. Clarity was improved, and students liked not having to be "12 inches from the speaker" to understand what was going on. Students reported "clear sound" with "real time" learning.

What do you like least about the FM transmitter approach? Students complained about the cumbersome and bulky nature of the equipment they used. Several students in one of the field trips reported that the ALD was broadcasting unnecessary noise and static.

Author's Analysis and Conclusions

Hearing during construction field trips is particularly problematic. Noise from equipment, other employees, and outside sources all limit the ability of a leader to communicate key information to students. No ALD system was found by the authors that exist specifically for construction field trips, an none were found that had been tested in such an environment. Most hearing assistance devices currently available on the market are essentially not economical for a construction classroom environment with one or two field trips per semester. All systems found had similar drawbacks including cumbersome equipment, wiring between the receiver and headset, and single speaker operation. This research seeks to assist in the development of a construction specific ALD that can be used

by students who visit a job site. This phase of the research examines the use of reasonably cost-effective receiver/headset system. The authors are essentially in a process of collecting and receiving feedback of anecdotal evidence of ALDS used for students on a site. By presenting and disseminating this research, the authors hope to inspire the identification of traits in an ideal system that would best improve the student educational experience on the job site.

The authors are considering a third generation research effort that collaborates with the school's electrical engineering department to develop a receiver to be used specifically for this purpose. A small receiver that clips around the ear and a speaker that feeds directly to the ear (no cables/cords), similar to a Bluetooth© headset, may be an improvement over the system tested and over other commercially available receivers. The separate receiver pack and wire to the headset appears problematic and has some support from the research conducted. From a "teacher's perspective", the wiring between the headset and pack becomes tangled when you attempt to sort ten headsets from a case. Such experiences may warrant additional studies specific to the people broadcasting on the headset and dealing with the equipment. Ideally, a simpler unit where cost is less than $50/student could be developed so students could purchase and maintain their own unit. Such a system could be acquired by construction management programs and used on multiple site-visits over a period of several years.

A dual channel system where two people can talk or transmit is also planned in the future research. This would give the instructor the opportunity to what is being seen or explained by the construction professional on the site. Such a product is not commercially available in this cost range and would require development.

As equipment is improved, the quality of communications will also improve. Research will continue with better equipment where additional benefits of the wireless transmission system are expected to be seen. More extensive polling of students over a wide variety of job sites will produce a more complete representation of the students' perceptions and benefits of the system.

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