NOISE LEVELS AND HEARING PROTECTION DEVICES: EFFECT ON STUDENT WELDING PERFORMANCE

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The level of noise in the agricultural mechanics laboratory has been established as an area for concern. Several researchers (Bear, 1969; Madou-Bangurah, 1978; Shell, 1979) documented the concern for level of noise found in agricultural mechanics laboratories. Weston and Stewart (1980) reported a concern for the level of noise found in Missouri vocational agriculture shops.

Recent researchers have shown that high levels of background noise have a detrimental effect on students' abilities to perform learning tasks. Daniels (1985), Jewell (1977, 1978), and Hambrick-Dixon found that high noise levels produced a detrimental effect on students' abilities to perform cognitive or psychomotor skills. Jewell (1977, 1978) also discovered that students exposed to higher levels of sound required more time to complete assigned tasks.

Another area of concern is the effect of impact or impulse noise. Research has shown that sudden impact noise (such as welding metal dropped on a concrete floor) or impulse noise (a grinding wheel intermittently coming in contact with steel) can cause actual damage to parts of the inner ear (Bohne, 1976; Luz & Hodge, 1971). Depending on the decibel level, impact or impulse noise levels can cause temporary loss of hearing activity or even result in damage that is permanent.

The use of hearing protective devices (HPD's) has been established as a sound practice to reduce the negative effect of loud noise on students' performance levels (Feldman and Grimes, 1985; Hartley, 1974; Miller, 1986). Experimental research (Miller, 1986) has shown that HPD's are effective in maintaining higher levels of student performance when completing learning activities under noisy conditions.

Standard maximum levels of noise exposure have been established by the Occupational Safety and Health Administration (OSHA, 1981). The maximum exposure levels and time periods during a working day without hearing protection are shown in Table 1. More recent federal regulations (OSHA, 1981) are imposing a maximum eight hour exposure limit of 85 decibels as the point where employers are required to monitor noise levels, notify employees, and recommend use of HPD's. At noise levels of 90 decibels and above, employees are required to use HPD's.

Table 1
Permissible Exposure Time by Intensity of Sound Pressure Level in Decibels (dBA)

Exposure in Hours	Sound Pressure Level (in dB)
8.00	90
4.00	95
2.00	100
1.00	105
0.50	110
0.25 or less	115
Maximum available exposure	140

Note. Adapted from OSHA, Federal Register, Vol. 46, No. 162, 42635.

Miller identified near maximum levels during arc welding operations in the agricultural mechanics facility (1988). Although excess levels were not reached, he recommended further research to determine the effect of noise on student performance.

Purpose

The purpose was to determine whether students wearing HPD's would be more efficient in improving their welding skills than would students without HPD's. The objectives of the study were to:

Journal of Agricultural Education
Volume 31, Number 2, pp.23-28
DOI: 10.5032/jae.1990.02023

1. Determine the long term noise levels found in a welding laboratory environment.

2. Determine whether students using HPD's would show improved gains in welding performance compared with students who did not use HPD's.

Procedure

A beginning welding class (N = 14) of students pursuing an Associate Science degree at Eastern Wyoming Community College in the Fall, 1988 semester was selected as the sample group. Although the class size was smaller than expected, it was not considered desirable to include another class with a different instructor in the sample. A pretest-posttest randomized experimental design was selected. Each of the seven randomly selected subjects in the experimental group were asked to agree to wear the foam-type HPD's during the semester. All agreed to participate. The explanation given to the class including the seven students in the control group was that research was being conducted to determine the noise level of a welding shop and to determine whether HPD's work. It was determined that a placebo HPD for the control group was not necessary since long term skill development was being measured. No comments were made to the class suggesting that HPD's would have any effect on skill performance. Informal observations indicated that some effort was required to overcome resistance to the use of HPD's. Later in the semester, one student in the control group dropped out of school.

The welding class laboratory was conducted five days a week from 8:00 AM to 12:00 noon. A lecture period was scheduled for one hour each day. The instructional procedure was best described as conventional for a welding class. The instructor presented group demonstrations and provided individual assistance to all members of the class during the laboratory period.

The welding laboratory is one of the more modern and spacious facilities in the state of Wyoming. Excellent ventilation, adequate lighting, and efficient layout for traffic patterns provided an ideal environment for learning. The facility was rated for a larger capacity than the thirteen students who were enrolled in the class.

A skill taken from the American Welding Society (AWS) Welding Qualification tests was used as the pretest-posttest skill. The students were given two, one-half inch thick steel plates, eight inches long, and asked to perform a tee weld in the horizontal position using their choice of E6013 electrode size and amperage setting. The students were asked to stop once, and restart the arc. The pretest was administered by the instructor just prior to the introduction of arc welding in the course. Neither the experimental nor the control group used HPD's during the pretest. The posttest was given during the last week of the semester. The pretests-posttests were included as part of the instructor's course outline and were not introduced by the researcher.

The instructor was asked to conduct the class in a normal manner. The only disruption to routine practice was to ask the instructor to verify that all members of the experimental group wore a pair of HPD's during each laboratory period. Foam-type HPD's that fit inside the ear canal were selected as the noise attenuation device. A Quest Model 27 noise logging dosimeter was used to monitor the noise levels in the laboratory. This model dosimeter contains a microprocessor which records, accumulates, and prints out peak noise levels, the OSHA required L-average (L-ave), total weighted average, percent dose plus time interval histograms. A built-in clock function prints out the time of day that the monitoring occurred. When plugged into a dot matrix printer, a complete printout of the data and statistics were obtained. The instrument was small enough to be inserted in a shirt pocket or clipped on a belt with the microphone clipped to the shirt collar of the wearer. Each of the students included in the study plus the instructor volunteered to wear the monitor during one full laboratory period. In addition, the monitor was placed on a tripod in the center of the laboratory during one session.

To obtain a realistic measure of the noise level in the work environment, the instrument was turned on just as the class began and stopped at the end of each class period. This method of monitoring provided an accurate measurement of exposure to noise typical of one-half working day. Each day the dosimeter was used, it was calibrated to check for accuracy.

Scores on the pretest and posttest coupons were determined by visual appraisal. A committee of three experts including the welding class instructor, and two staff members at the university determined all of the pretest and posttest scores. The scores were then averaged to determine a final score for each student for their pretest and posttest. The pretest coupons were scored and recorded prior to the scoring of the posttest coupons. The following criteria were used to score both the pretest and posttest welds:

Completion of test (2 pieces welded)	=	60 points
Undercutting, overlap, fusion to root	=	10 points
Appearance (bead, ripples, uniformity)	=	10 points
Stop and start	=	10 points
Size of weld	=	10 points
TOTAL		100 points

The pretest-posttest data were analyzed using the analysis of covariance. This approach was used to improve design efficiency and to reduce error variance (Kennedy and Bush, 1985) as opposed to using the net gain (posttest-pretest) approach.

Results

Data were collected and analyzed to accomplish two objectives of the study. First, the noise level data were analyzed to determine sound levels in the welding shop. Second, the experimental group (with HPD's) was compared with the control group (no HPD's) as to whether hearing protection would improve performance. Only the second objective was tested as a hypothesis.

Noise exposure data collected during the experiment are presented for three events; 1) stationary monitoring with instrument on a tripod, 2) highest dose of noise when worn by a student, and 3) lowest dose of noise when worn by a student. The data were reported at the 90 decibel criterion or threshold level with an exchange rate of five decibels. This rate of exchange means that each time the noise level doubles in intensity (or drops in one-half), the instrument records an increase (or decrease) of five decibels.

The results of the noise monitoring of the three events is presented in Table 2. The highest dose, converted to an eight hour day basis, was 19.67%. The lowest dose was 0.79%, obtained when the dosimeter was placed in a stationary position. The TWA calculation, an average dB exposure for an eight hour day, was a high of 71.9 dB and a low of 49.2 dB.

Of special concern were the peak levels obtained during each monitoring period. Peak levels of 136.1, 130.5, and 129.7 dB were recorded. Peak levels for those days when other students wore the instrument followed a similar pattern to the levels shown in Table 2.

Table 2
Noise Levels in the Eastern Wyoming College Welding Shop During Laboratory Practice

Location of Dosimeter	L-ave (in dB)	Dose (in %)	TWA (in dB)	Peak Level (in dB)
Stationary	55.1	.79	49.2	130.5
Worn by student, highest noise level	78.2	19.67	71.9	129.7
Worn by student, lowest noise level	64.0	2.72	56.4	136.1

Based upon the standards as mandated by OSHA, no more than a TWA of 90 decibels for an eight hour working day, the noise exposure to students in this study was well below the critical level. It was of concern, however, that occasional impulses of high noise levels approaching the maximum OSHA allowable level of 140 dB were present.

To facilitate understanding of the noise exposure data, a sample histogram printout from the M-27, collected when the dosimeter was worn by the student, is shown in Table 3. A threshold level of 90 dB, 5 dB exchange rate at one minute intervals was selected. Only the first hour of the data is shown in the table.

Table 3
<u>Histogram of Noise Exposure Monitoring 90 dB Threshold, One Minute Averages, 5 dB Exchange Rate</u>

Time	One Minute Interval Readings (in dB)					Decibel L-ave (each * represents 2 dB) 50 60 70 80 90 +****+****+****+****+
8:13	00	00	90	100	95dB	+****+****+****+****+* 93dB
8:18	84	88	69	00	72dB	+****+****+** 74dB
8:23	81	82	72	82	82dB	+****+****+****+ 81dB
8:28	81	69	79	00	75dB	+****+****+**75dB
8:33	72	00	71	67	56dB	+****+*** 67 dB
8:38	00	79	00	00	76dB	+****+****+ 71 dB
8:43	00	00	72	77	57dB	+****+**** 69 dB
8:48	00	00	71	00	67dB	+****+* 63 dB
8:53	77	00	00	00	00dB	+****+** 65 dB
8:58	00	62	59	69	00dB	+****+ 61 dB
9:03	70	00	00	00	00dB	+**** 59 dB
9:08	00	00	71	74	00dB	+****+*** 66 dB
9:13	00	65	00	00	00dB	+* 53 dB

The highest L-ave obtained during this particular time period was 93 dB, above the level at which OSHA requires the use of HPD's. This level, however, only occurred for a five minute time during the four hour laboratory period. The double zeros indicate a one minute period when the noise level was below the 90 dB threshold limit, below which the instrument does not store any data.

The second analysis was conducted on the pretest-posttest welding skill scores of the experimental (students with HPD's) and control groups (students with no HPD's). The mean scores obtained for the two groups are presented in Table 4.

Table 4
<u>Mean Pretest and Posttest Welding Skill Score for Experimental and Control Groups</u>

Group	Mean Scores (maximum score = 100) Pretest	 Posttest
Experimental (HPD's) (<u>n</u> = 7)	72.42	84.00
Control (no HPD's) (<u>n</u> = 6)	71.80	78.60
Overall Mean	72.15	81.54

To test the hypothesis to determine whether differences existed between the experimental and control groups, an analysis of covariance model was designed. Posttest scores were established as the dependent variable compared by group with pretest scores as the covariate. The results of the analysis are presented in Table 5.

When using pretest scores as a covariate, no significant difference was obtained between the experimental and control group on their posttest welding skill scores.

Table 5
Analysis of Covariance Summary of Posttest Welding Scores by Group with Pretest Welding Scores as the Covariate

Source of Variation	df	SS	MS	F	Significance of F
Pretest Scores (Covariate)	1	312.694	312.694	2.871	.121
Group	1	81.531	81.531	.749	.407
Main Effects					
Explained	2	394.225	197.113	1.810	.213
Residual	10	1089.005	108.901		
Total	12	1483.231	123.603		

Summary, Conclusions and Recommendations

The results indicate that the welding laboratory was well within the maximum limits established by OSHA. According to OSHA standards, the use of HPD's is not necessary in this environment. Concern is expressed, however, that very high peak levels of noise approaching the maximum level set by OSHA were recorded which suggest that the use of HPD's may have some benefit in increasing the comfort of students working in the laboratory. Recommending the use of HPD's in an environment of loud noise bursts would also reduce the temporary or possible permanent physical damage incurred from such exposure.

The hypothesis that there was no significant difference in the welding performance of students wearing HPD's compared with those who did not was not rejected. Even though the mean scores showed greater gains for the group wearing HPD's, the analysis did not produce significant differences. It is recommended that further research, replicating the procedure followed in this study, be conducted with larger groups of students.

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