

LESSON: Decibel Dilemma

Summary: Students read the article “Decibel Hell: The Effects of Living in a Noisy World” and keep track of sound exposures over the course of a day. Students graph individual and class data to understand some basic statistical concepts (mean and normal distribution) and make a preliminary judgment about whether or not they are at risk for hearing loss. Students are also asked to analyze potential problems with the methods used in collecting the data.

EHP Article: “Decibel Hell: The Effects of Living in a Noisy World”
EHP Student Edition, April 2005, p. A34–A41
<http://ehp.niehs.nih.gov/members/2005/113-1/focus.html>

Objectives: By the end of this lesson, students should be able to:

1. graph individual and class data
2. describe a normal distribution curve,
3. estimate the mean using the graph and calculate the mean,
4. determine whether they or their classmates may be at risk of hearing loss,
5. describe how to improve data collection methods.

Class Time: 2 hours

Grade Level: 9–12

Subjects Addressed: Biology, Anatomy/Physiology, Environmental Science, Health, Physical Science (if presented within a sound waves unit)

►Prepping the Lesson

INSTRUCTIONS:

1. Obtain a class set of *EHP Student Edition*, April 2005, or download the article at <http://ehp.niehs.nih.gov/members/2005/113-1/focus.html>.
2. Make copies of the student instructions.
3. Make an overhead of the class data sheet.
4. Make sure students have graphing paper and markers.

MATERIALS (per student):

- 1 copy of *EHP Student Edition*, April 2005, or 1 copy of “Decibel Hell: The Effects of Living in a Noisy World.”
- 1 copy of student instructions
- Graph paper
- Markers

VOCABULARY:

decibel (dB)
mean
normal distribution

BACKGROUND INFORMATION:

The article provides sufficient background information about the concerns and issues surrounding excessive noise. Refer to the Resources section for additional information on hearing loss, the anatomy and physiology of hearing, and the physics of sound waves. The Resources section also includes links to information on normal distribution curves.

Below is a table of standards for permissible exposure times for continuous time weighted average noises. These standards are from the National Institute for Occupational Safety and Health (NIOSH), which is part of the Centers for Disease Control and Prevention (CDC). Use this table as part of your data analysis discussion with the students.



Continuous dB	Permissible Exposure Time
85 dB	8 hours
88 dB	4 hours
91 dB	2 hours
94 dB	1 hour
97 dB	30 minutes
100 dB	15 minutes
103 dB	7.5 minutes
106 dB	3.75 min (< 4min)
109 dB	1.875 min (< 2min)
112 dB	.9375 min (~1 min)
115 dB	.46875 min (~30 sec)

RESOURCES:

Environmental Health Perspectives, Environews by Topic page. Choose Environmental Medicine, Hearing, Noise Pollution, Urban Issues, <http://ehp.niehs.nih.gov/topic>

National Institute on Deafness and Other Communication Disorders (NIDCD) <http://www.nidcd.nih.gov/health/education/index.asp>

Noise and Hearing Loss Prevention, NIOSH, <http://www.cdc.gov/niosh/topics/noise/>

Normal distribution, Math World, <http://mathworld.wolfram.com/NormalDistribution.html>

Normal distributions, <http://www.geocities.com/thesciencefiles/normal/distribution.html>

Sound Waves, The Physics Classroom, <http://www.physicsclassroom.com/Class/sound/soundtoc.html>

Sound Waves and the Eardrum, The Physics Classroom, <http://www.physicsclassroom.com/mmedia/waves/edl.html>

Types of hearing loss, Dangerous Decibels, <http://www.dangerousdecibels.org/hearingloss.cfm>

What's hearing loss, Kids Health, http://kidshealth.org/kid/health_problems/sight/hearing_impairment.html

Implementing the Lesson**INSTRUCTIONS:**

1. Hand out copies of *EHP Student Edition*, April 2005, and refer your students to the article "Decibel Hell: The Effects of Living in a Noisy World" (p. A34)
2. Discuss any issues of interest within the article.
3. Hand out copies of the student instructions and review their data collection tasks.
4. Inform the students that they will place a tick mark for each SOUND EVENT that occurs each hour between 7 a.m. and 9 p.m. This means that typing in front of the computer for two hours (8 a.m.–10 a.m.) with no talking or interruptions would be 1 tick mark in the 35–50 dBA box from 8 a.m. to 9 a.m. and one tick mark in the 35–50 dBA box from 9 a.m. to 10 a.m. If a lawn mower begins at 9:30 a.m. outside the window then a tick mark would be placed in the 80–90 dBA box for 9:00 a.m. to 10:00 a.m.
5. After the students have collected their data, have them graph their individual results. Depending on the students' proficiency with graphing, you may want to review the dependent variable (frequency of events) and independent variable (decibel range) and how they are labeled on the graph (x-axis is the independent variable).
6. Next, have the students write their totals for each decibel category on the class data sheet and then graph the class data on the same graph with the individual data (using a different color).
7. Discuss normal distribution and finding the mean on a normal distribution curve with students to help them answer questions (b) and (c) on Step 6.



8. Step 6 question (d) on the student instructions asks the students to calculate both the individual and class mean decibel exposure. Review calculating the mean as needed, and remind students that 5 tick marks in a given decibel range represents 5 exposures to sound of a certain level. A single decibel level has been selected for each decibel range in order for the students to calculate the mean. Also, using this approach, we are not accounting for length of exposure time. Each exposure is counted as a single event. Therefore, 3 tick marks in a given decibel range represents 3 exposures to sound of a certain level. As an example, 3 tick marks in the 50–60 dBA category means 55 dBA, 55 dBA, 55 dBA, and 2 tick marks in the 80–90 dBA category means 85 dBA, 85 dBA. The mean of these numbers would be $(55+55+55+85+85)/5 = 67$ dBA.
- 25–35 dBA = 30 dBA
 - 35–50 dBA = 42 dBA
 - 50–60 dBA = 55 dBA
 - 60–70 dBA = 65 dBA
 - 70–80 dBA = 75 dBA
 - 80–90 dBA = 85 dBA
 - 90–100 dBA = 95 dBA
 - 100–120 dBA = 110 dBA
 - 120–140 dBA = 130 dBA

Students can enter their data on the overhead titled “Class Data: ‘Your Own Decibel Dilemma?’” The overhead master is at the end of the lesson.

9. After the class data are averaged and the students have had the opportunity to answer the rest of the questions on the student instructions, discuss the results. Be sure to highlight any noises over 85 dBA, which is when hearing damage is thought to begin. You may want to refer to the NIOSH table of standards for permissible exposure times for continuous time-weighted average noises provided in the Background section.

NOTES & HELPFUL HINTS:

- This lesson would complement a Physics unit on sound waves or Biology/Anatomy/Physiology unit on hearing.
- Extending the lesson to include how the ear works would meet the additional National Science Content Standards for Unifying Concepts and Processes Standard: Form and function, and from Life Science: Matter, energy, and organization in living systems
- Extending this lesson to include sound waves would meet the additional National Science Content Standard for Physical Science: Interactions of energy and matter.

▶Aligning with Standards

SKILLS USED OR DEVELOPED:

Communication (written—including summarization), Comprehension (listening and reading), Computation, Critical thinking and response, Experimentation (conducting, data analysis, design), Graphing, Graph reading, Observation

SPECIFIC CONTENT ADDRESSED:

Noise, hearing, data collection and analysis

NATIONAL SCIENCE EDUCATION STANDARDS MET:

Unifying Concepts and Processes

- Systems, order, and organization
- Evidence, models, and explanation

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Science in Personal and Social Perspectives

- Personal and community health
- Natural and human-induced hazards
- Science and technology in local, national and global challenges



History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge

▶Assessing the Lesson

The students should be assessed on the following:

Graphs:

- The graph should have a succinct, descriptive title.
- The x- and y-axes should be properly labeled (correct titles, appropriate distribution of numbers).
- Individual and class data should be correctly placed on the same graph in different colors.
- The mean line for decibel exposure should be drawn and labeled for each graph (individual and class).

Calculating the Mean:

- Students should clearly show how they calculated the mean. Make sure they entered each tick mark as a decibel exposure and divided by the correct number of samples (e.g., 1 tick mark in the 25–35 dBA range would be one entry of 30 dBA and 2 tick marks in the 50–60 dBA range would be entered as 55 dBA each. The average of these entries would be $[30 + 55 + 55]/3 = 47$).

Answering the Questions:

- Students need to provide thorough answers to Step 6 questions (b), (c), (f), (g), and (h), and Step 7 questions (i), (j), and (k). Answers may vary, however the data should represent a normal distribution curve and students should be able to identify this characteristic. Examples of how data collection can be improved to increase accuracy include using an actual sound meter instead of estimating from a list, accounting for the length of exposure time, increasing the number of students who collect data, more accurate tracking of sounds (no missed entries), etc.
- As stated in the article, the NIOSH definition of 'hazardous noise is sound that exceeds the time-weighted average of 85 dBA, meaning the average noise exposure measured over a typical eight-hour work day.'
- When answering questions (j) and (k) students should address both the average noise exposure for themselves individually and the class average over the period of a day, as well as short-term high-decibel exposures (such as jamming in the car with the stereo cranked on the way to school).

▶Authors and Reviewers

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Investigation

Have you ever really paid attention to the type and amount of noise you are exposed to every day? In order to function, most of us have learned to “tune it out” or ignore the noise. This investigation asks you to carefully pay attention to and track the noises you hear from 7 a.m. to 9 p.m. over the course of one day.

The data you collect will be combined with other students' data to create a picture of the average amount of noise in a high school student's life. Please try to be accurate in your data collection, because every “error” you make is compounded by the errors from the other students. Fewer errors means more reliable and more meaningful results.

Step 1: Using the data collection sheet, place a tick mark next to the appropriate noise and time of day for each sound event that occurs in each hour, regardless of the length of exposure (e.g., 1 minute or 1 hour). If you hear a sound that is not listed on the sheet, estimate the number of decibels of that sound.

EXAMPLE: A 15-minute conversation between 8 and 9 a.m. is one tick mark in the 8–9 a.m. 50–60 dBA box. If a school announcement comes on over the loud speaker at 8:30 place a tick mark in the 8–9 a.m. 70–80 dBA box.

Step 2: Add the tick marks for each decibel category and place in the appropriate square in the “Total” column.

Step 3: Share your data with your teacher, who is collecting a class total.

Step 4: On a piece of graph paper, plot your data on a bar graph.

Step 5: On the same graph that contains your individual data, plot the class total data in a different color.

Step 6: Answer the following questions about the graphs.

a) Write the x- and y-axis labels below.

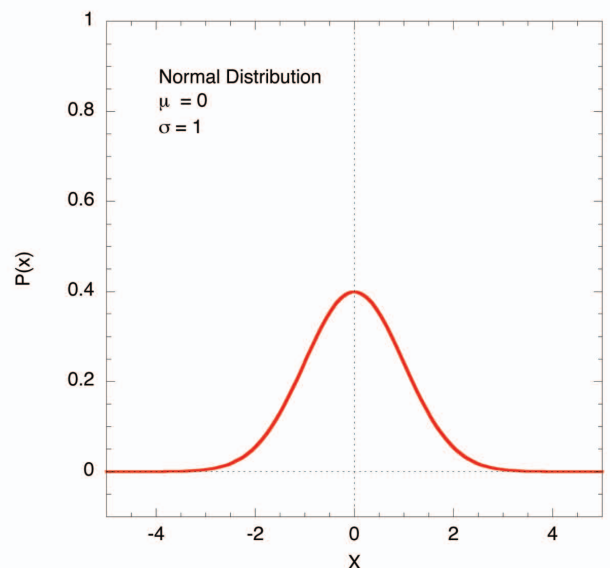
x-axis label (independent variable):

y-axis label (dependent variable):

b) Are the shapes of the two graphs (your individual data compared to the class data) similar or dissimilar? Describe.

c) Refer to the image of a normal distribution curve (also called “bell” curve) below. Does either of your two graphs look like a normal distribution curve? Explain why or why not.

d) If the graphs have a normal distribution, estimate the mean decibel exposure level per day for you and the class. Draw the mean line on the graphs.



e) Now calculate the mean decibel exposure level for you and the class using the following numbers to represent each range.

HINT: Remember that if you had 5 tick marks for the 50–60 dBA category, each tick mark represents an average exposure. So, using the guide below, 5 tick marks really represents (55 dBA, 55 dBA, 55 dBA, 55 dBA, 55 dBA). To calculate the mean dBA for all of your exposures over the day, you need to add all of the individual decibel exposures and divide by the total number of exposures. For example, 3 tick marks in the 50–60 dBA category means 55 dBA, 55 dBA, 55 dBA, and 2 tick marks in the 80–90 dBA category means 85 dBA, 85 dBA, for a total of 5 exposures. The mean of these numbers would be $(55+55+55+85+85)/5 = 67$ dBA.

- 25–35 dBA = 30 dBA
- 35–50 dBA = 42 dBA
- 50–60 dBA = 55 dBA
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- 100–120 dBA = 110 dBA
- 120–140 dBA = 130 dBA

f) How closely did the mean line you drew on the graphs match the mean you calculated?

g) Looking at the way the data were collected and how the mean was calculated, what could account for any differences between the mean you estimated by the line on the graph and the mean you calculated?

h) Describe how you could modify the data collection method to make it more accurate. Be specific and include at least three improvements.

Step 7: Refer to the article “Decibel Hell: Effects of Living in a Noisy World” and your data to answer the following questions.

i) How does the National Institute for Occupational Safety and Health (NIOSH) define **hazardous noise**?

Consider the following:

- Music on earphones is a noise exposure of 100 dB on average. This can cause permanent damage after just 15 minutes per day!
- Immediate hearing damage can be caused by a nearby clap of thunder (120 dB) or a gunshot (140–190 dB). (from <http://www.dangerousdecibels.org/hearingloss.cfm>)

j) Based on average noise level exposure on one day, the NIOSH definition for hazardous noise, and the points listed above, describe whether you and/or your classmates are at risk for hearing loss. Why or why not?

k) What are some actions you can take today and in the future to prevent hearing loss?



