Science, Music, and Math Lesson Plan
West Virginia Symphony Orchestra Young People's Concert Series

Grade Level(s): Third, Fourth, and Fifth
Lesson Title: Sound Production

Focus: Physics, Sound Production, Wind Instruments, Air Columns

Objectives: See end of lesson for objectives and standards achieved.

Background Information:
Students will be able to explain the physics of sound production as it applies to wind instruments (vibrating air columns). This lesson correlates with Lesson 8 – Conditions Affecting Timbre of Sound.

Activities (Procedures):

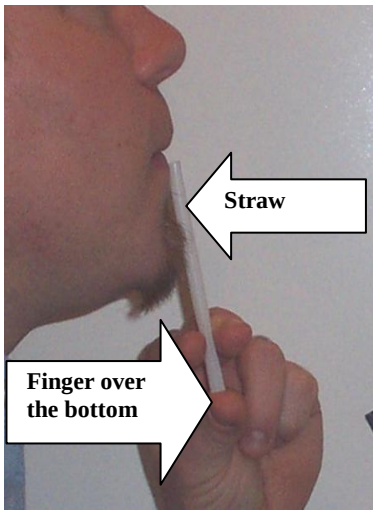
1. Exploratory: Ask the students if they have ever made a musical sound by blowing across the top of a soft drink or water bottle. Have students form groups of three or four and provide each student with a clean water bottle, preferably all of the same size. Have the students in each group put varying amounts of water in the bottles (one bottle could remain empty). Have students take turns playing their bottles. **Note**: Students will be able to do this most successfully by not blowing too hard and by focusing the air stream on the far edge of the bottle's opening. Changing the angle of the bottle may help as well. Have each group write an explanation (a white board works well) of how they think the sound was produced and why the sounds (pitches) changed with varying amounts of water in the bottles.

2. Guided Discovery: Show students a recorder (a wind instrument). Applying what they learned from the previous exploratory activity with bottles, have each group predict and record their conclusions as to whether (a) there will be a high or low pitched tone when all the holes are covered, and (b) there will be a high or low pitched tone when none of the holes are covered. Now demonstrate that when covering all the holes on the recorder, a lower pitched sound is produced. When covering no holes, a higher pitched sound is made. Show the effect when holes are covered in order from top to bottom. Have the class relate the pitches they hear to the effective length of the recorder. Explain that the more holes that are covered, the longer the recorder's effective length. (The "effective

length" is the length of the vibrating air column for any given pitch. When all holes are covered, the entire air column of the instrument is vibrating; when only some of the holes are covered, the effective length is from the air vibration source [mouthpiece] to the first open hole.) **Note:** This activity works best when the thumb hole on the back is always covered. For best musical results, use proper fingerings by consulting a standard fingering chart for the recorder. The left hand covers the thumb whole and the top three holes; the right hand covers the bottom four holes.

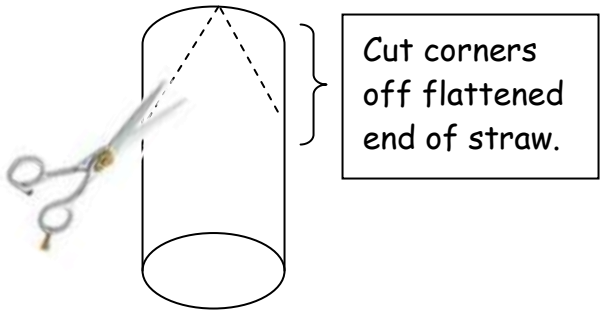
3. Discussion: This can be done with the class as a whole or facilitated with the groups.
   - Ask: What is pitch? (Pitch is the characteristic of sound that we hear as higher and lower. The more vibrations per second produced by something (usually a string, solid object, or column of air), the higher the sound, or pitch. The fewer vibrations per second produced by something, the lower the sound, or pitch.
   - Ask: What was vibrating in the bottles to produce the different pitches? (When you blow across the top of each bottle, it makes the air inside vibrate. Small air spaces vibrate more rapidly than large air spaces. When there is little air in the bottle, you produce a high pitched note. When there is more air, the pitch is lower.)
4. Challenge the class to use their knowledge to stand in pitch order based on the amount of water in their bottles, first within their groups, and then in the whole class. If bottles have been filled (tuned) carefully, students may try playing a simple tune such as *Mary Had a Little Lamb* (four pitches: do, re, mi, sol) or *Twinkle, Twinkle, Little Star* (six pitches: do, re, mi, fa, sol, la). **Note**: bottle instruments may be saved for follow-up lessons by capping and marking the bottles.
5. Have students go to the Woodwind Family and Brass Family instruments in the Structure of the Orchestra under The Performers in The Great Hall in the WVSO *Rumpelstiltzkin* CD ROM and listen to each of the wind instruments.

Extension Activities: 1) Older and more advanced students could try an experiment by blowing across the tops of drinking straws (large diameter straws work best). Demonstrate that by holding a finger over the bottom and blowing across the top of the straw, a sound can be made. After successfully producing a sound, have students cut their straws to a variety of lengths. Have each student take turns playing his/her straw. The teacher should facilitate this process and guide students to correlate the length of the straw with the pitch of the sound. Each group should present its conclusions.



2) Create a reed instrument with your straws!
   a) Flatten one end of a straw. Cut triangular pieces off both sides of the end to form tapered reeds. For best results, cut off the point so it is flat across the top.

b) Carefully place the reed end between your lips. Be careful; it could be sharp! (**Teacher should monitor students carefully**.) Pinch the straw almost flat just below your lips and blow to obtain an oboe type sound. **TIP**: The straw may need to be shifted in or out slightly. The pitch can be adjusted by cutting pieces off the open end.



c) Have the students explain the similarities and differences in the two straw instruments. They are similar because the pitch heard is determined by the length of the vibrating column of air. Shortening the length of the straw raises the pitch in each. They are different in the way in which the column of air is caused to vibrate; in the first straw, air blown across the top sets the column of air into motion; in the second the vibrating "reed" causes the air column to vibrate. Also, one instrument is close-ended and the other is open-ended.

3) Return to the first Extension Activity. Ask students to predict what they think the difference will be if they blow across the straw with the end closed or with it open. Have students blow across the same straw, first with the end closed and then with the end open. How did this difference affect the sound? They should find that the open-ended straw sounds an octave higher than the close-ended straw. **Note**: it requires more air and concentration to play the open-ended straw!

Modifications (Special Needs):

1. Visual and auditory impaired students will need special consideration during this lesson with seating and materials adaptations.
2. Learning disabled students may benefit by abbreviating this lesson's content and length.
3. Varying learning styles will be addressed with the variety of activities in this lesson – tactile, visual and sensory learning styles are utilized.
4. Gifted student needs are provided through the extension activities.

Assessment/Evaluation*:

1. Formative Evaluation Plan: The teacher will observe and facilitate the discussion points to assess understanding of the concepts.
2. Summative Evaluation Plan: The teacher will determine student comprehension by observing if students place themselves in the proper order with their water bottles. The teacher will evaluate understanding of the lesson through completion of the white board activity.

Supplemental Materials and Equipment Needed:
A copy of the WVSO *Rumpelstiltzkin* CD ROM or WVSO Audio CD Companion
Computer able to play audio files on CD-ROM
Clean water bottles
Straws
Scissors
White boards
Dry erase markers
Recorder

Resources:
Moscal, T. (1994). Sound Check: The Basics of Sound and Sound Systems. Hal Leonard Publishing.

More information on the physics of musical instruments can be found on The Physics Classroom website: http://www.physicsclassroom.com/Class/sound/soundtoc.html

References:
Butcher, J.B., & Stephenson, J., & Wayne, T. (2001). *Instrumentally Speaking*. Retrieved December 2, 2004 from http://www.thesolutionsite.com

Nave, R. (n.d.). Vocal Sound Production. Retrieved December 2, 2004 from http://hyperphysics.phy-astr.gsu.edu/hbase/music/voice.html

National Standards:
Music:
Standard 2: Performs on instruments, alone and with others, a varied repertoire of music
Mathematics:
Standard 4: Understands and applies basic and advanced properties of the concepts of measurement
Science:
Standard 9: Understands the sources and properties of energy

WV Content Standard Objectives:
Third Grade
GM.3.1.5 sing or play instruments, following the cues of a conductor.
SC.3.2.4 use scientific instruments and everyday materials to investigate the natural world (e.g., graduated cylinder, hand lens, metric ruler, magnets, weather instruments, thermometer, calculators).

Fourth Grade
GM.4.2.10 evaluate their own musical performances.
GM.4.4.2 identify and discuss tone production for instruments.
SC.4.2.1 demonstrate curiosity, initiative and creativity by developing questions that lead to investigations; designing simple experiments; and trusting observations of discoveries when trying new tasks and

skills.
SC.4.2.4 use scientific instruments and everyday materials to investigate the natural world
SC.4.4.23 explore that sounds are produced by vibrating objects and columns of air and explore the relationship between frequency and pitch of sound.

Fifth Grade
GM.5.1.3 play by ear a phrase of a familiar song on a classroom instrument.
GM.5.2.15 evaluate their own musical performances.
SC.5.2.1 cooperate and collaborate to ask questions, find answers, solve problems, conduct investigations to further an appreciation of scientific discovery.
SC.5.2.2 formulate conclusions through close observations, logical reasoning, objectivity, perseverance and integrity in data collection.
SC.5.2.4 use a variety of materials and scientific instruments to conduct explorations, investigations and experiments of the natural world
SC.5.4.17 compare and contrast the change in length, tension, or thickness of a vibrating object on the frequency of vibration.

Kentucky Program of Studies:
AH-E-1.1.39 Recognize and be able to distinguish families of instruments (brass woodwind, percussion, string, folk) and/or vocal timbres.
AH-E-1.1.38 Identify and discuss simple musical forms
SC-E-1.1.2 Objects are made of one or more materials such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made. Those properties can be used to separate or classify objects or materials.

Ohio Academic Content Standards (Standard and Benchmark)
K-2, Physical Sciences: A. Discover that many objects are made of parts that have different characteristics. Describe these characteristics and recognize ways an object may change.
3-5, Physical Sciences: B. Identify and describe the physical properties of matter in its various states.

*All Assessments are to be at the expected state assessment standard; in West Virginia this is mastery level; in Ohio this is benchmark level; and in Kentucky, this is academic expectations level.

