Students' View of How Sound is Produced by Musical Instruments

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Goal of the CAREER project

- Investigate the ideas that students have developed through interactions with everyday devices and how they apply these ideas in various contexts

- Develop application-oriented curricula for introductory undergraduates

Talk on Wednesday, August 6th at 1:30 p.m. Hall of Ideas J
Kara Gray, "Investigating Students' Understanding of Light Bulbs And Complete Circuits"

Overarching research questions

- What ideas do students use to explain the working of everyday objects?
- How do they develop these ideas?
- Do they transfer these ideas from one context to another? If so, how?

Change of focus

- Comparing two methods
  - Clinical interview
  - Teaching Experiment
- Use students' ideas of how sound is produced in musical instruments as the context

Subject populations

- Semi-structured Interview
  - Spring 2003
  - Introductory conceptual physics course
  - No instruction on sound
  - 5 self-selected volunteers - no incentives
  - All had previously played a musical instrument
- Teaching Experiment
  - Summer 2003
  - Introductory conceptual physics course
  - No instruction on sound
  - 3 volunteers who received extra credit of 3% toward their final course grade
  - All had previously played a musical instrument

Research methodology 1

- Semi-structured Interviews
  - Begin with a general question
  - Specific follow-up based on the response
  - Individual interviews
- Analysis
  - Phenomenological approaches (classify and describe responses)
  - Grounded theory approaches
- Repeat throughout semester to investigate development of ideas

Research methodology 2

- Teaching Experiment
  - Adaptation of interview technique
  - Involves modeling of students' ideas as they develop and change over time
  - Teaching episodes
  - Group of 3 students together
- Analysis
  - Phenomenological approaches (classify and describe responses)
  - Grounded theory approaches
- Takes place over the course of one week or several weeks

Contexts

Specifics of the data presented next

- Clinical Interview
  - 1 session
    - 30 minutes duration
  - Focus only on musical instruments
- Teaching Experiment
  - 3 sessions
    - Each session builds on the previous one
    - 1 hour long
    - Every other day for one week
  - Third day - musical instruments
  - Previous days
    - Definitions of waves
    - Demonstrations
      - Singing wine glasses
      - Coke bottle whistle
      - Singing rods
      - Organ pipes
      - Bugle tubes

Drum

Students were asked to place their hand on top of drum head and then speak

- Semi-structured Interview
  - Surface of the drum vibrates
  - Some found it difficult to feel the vibration
  - Sound from our voices produces a vibration
  - Note tension in face of the drum
- Teaching Experiment
  - Surface of the drum vibrates (wobbles)
  - Key elements that affect the sound produced
    - Tension in drum face
    - Size of the drum face
    - Whether drum is closed or open
    - Length/depth of the drum

Recorder

- Semi-structured Interview
  - 4 out of 5 played in elementary school
  - Relied on personal experience playing recorder
- Teaching Experiment
  - All played in elementary school
  - Connected the recorder to the open and closed organ pipes used earlier

- Number of holes uncovered changed the length
- Few holes covered, high pitch
- More holes covered, lower pitch
- Having uncovered holes allows the air to escape

Xylophone

- Semi-structured Interview
  - Bar vibrates
  - Related bar length to pitch
    - Low pitch, long bar
    - High pitch, short bar
  - The longer the bar the longer it vibrates due to its length
  - Relate length of bar and length of vibration to a loss in pitch or vibration
- Teaching Experiment
  - Same as first 3 bullets
  - Relate length of bar and length of vibration to the lower frequency (pitch) due to traveling slower
  - Connected the length of the sound back to the wine glass demonstration

Cello

- Semi-structured Interview and Teaching Experiment
  - Thicker the wire the lower the pitch
  - Longer wire the lower the pitch
  - Higher the tension in the wire the higher the pitch

Limitations

- Students less confident in Semi-structured Interview
- More scaffolding in Teaching Experiment
- Protocol fine tuned for Teaching Experiment
- Individual vs. Group - group dynamics played a part in answers given

Tentative conclusions

- Semi-structured Interviews - Explanations more detailed with recorder because of students' prior experience with having played
- Teaching experiment - Explanations referred more on the previous demonstrations used
- Teaching experiment can help determine what demonstrations help students understand sound better and what concepts are key
- Teaching experiment is **dynamic** - can see how students are formulating their ideas as they learn new material
- Teaching experiment can help see how students **transfer** information that they have just learned to new contexts
- For our goals, the teaching experiment is a better method.

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For more information

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PERC Contributed Poster on
The Teaching Experiment
Wednesday, August 6
5:30 - 9:30 p.m.
Hall of Ideas G/J