Learning Physics in the Context of Human Functioning – the Humanized Physics Project

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Abstract

The Humanized Physics Project is a multi-institutional effort to develop human-oriented physics learning activities to motivate student learning for the introductory physics student who is preparing for a career in the life or health sciences. To enhance accessibility and interest each Humanized Physics Project module has a human-context theme. Within each module, the physics concepts are explored through activities with a human functioning focus. The activities loosely follow an inquiry-based learning cycle of exploration, invention, and application. Some of the project activities can be accessed at the project website at www.doane.edu/hpp.

Introduction

The Humanized Physics Project is an effort to develop activity–based curricular materials with physics concepts motivated by human-functioning applications, for the algebra-based introductory college physics sequence. This NSF funded project is a collaboration between the physics departments at the University of Nebraska-Lincoln, Texas Tech University, Mercy College, and Doane College.

We are developing and implementing human-oriented physics activities and associated inquiry-oriented curricula to motivate student learning for a student audience who typically perceive the introductory physics sequence as an irrelevant hurdle in their academic career. They are a different type of student from their physics/engineering major counterparts in the calculus-based course, with different needs, goals, and interests.

The algebra-based student is more likely to be female, to delay taking this course until the junior or senior year, to be preparing for a career in the life or health sciences, and to be intimidated by and/or have little interest in physics and technology. Although often more mature and goal oriented, such a student has often been successful at rote memorization type learning and thus can be resistant to an active learning approach. Student-centered learning can be more effective when the students are interested in the subject matter and believe that what they may be struggling to assimilate is valuable to them. The Humanized Physics project materials guide the students through activities exploring the physics concepts in a context that is meaningful and relevant to their interests and needs.

For most of the algebra-based students, this physics course is their final physics course and for many it is the only physics course they will have – they will have no later opportunity to get to the "interesting stuff". Active student practice making connections between foundational physics and the health or life sciences will help enable these students to see and apply physics principles in their future endeavors

The need for relevance for these students is recognized. Most algebra-based physics textbooks have increasingly added human and life science application examples. Auxiliary texts providing additional biomedical or human body examples and problems are also now available. However, there is a lack of relevant human/biomedical context in active learning curricular materials. The Humanized Physics project has tried to fill this gap by putting a motivating human interest at the initial exposure and exploration of each physics concept.

Human context modules

Each module has a human-context theme, enhancing accessibility and interest in the physics therein. The titles of the modules being developed are:

- Human Senses and Interactions In Nature
- Biomechanics and Modeling Human Motion
- Modeling the Circulatory and Respiratory Systems
- Energy Regulation
- Modeling Human Speech and Hearing
- Bioelectromagnetism
- Modeling Human Vision
- Physics of Imaging the Human Body

Within each module, physics topics are explored through sets of human functioning or human oriented activities. The activities loosely follow an inquiry-based Learning Cycle of Exploration, Invention (Development), and Application, wherein students are guided into constructing their own understanding of physics principles.

Mathematical modeling is integrated into every module. Life systems are inherently complex – so modeling them offers the opportunity for students to become aware of the approximations and simplifications assumed in any model to get at the salient features of the phenomena being investigated.

The types of activities in each module are varying to provide a variety of learning experiences. The students' own bodies are often used for initial exploration of physics concepts, establishing a meaningful foundation from which they can more readily construct a physics understanding. Multimedia materials, such as computer-interfaced data collection, computer graphical analysis, interactive simulations, and video clips are used throughout. As an example, see table 1 for a list of the unit titles in the Speech and Hearing Module and see table 2 for some sample activities of the some of the units, their corresponding physics topics, and the activity modes and materials.

When complete, these materials aim to be available in a selectable form amenable for modification and use in a wide variety of institutional venues. These human-based activities and associated curricula are being implemented in a robust range of project institutional sizes and formats – large universities and small colleges, and standard lecture with separate laboratory format, and integrated Workshop style (a la Priscilla Laws).

Humans are innately interested in learning about themselves. Although the focus of these materials has been the algebra-based physics audience, these activities could be modified for use by other student populations. A similar modular approach, although broader than human functioning, has been done at the early pre-college level, in the series *Active Physics.*

Some of the project activities can be accessed at the project website at www.doane.edu/hpp

Other project members are: Robert Fuller, Vicki Plano Clark, University of Nebraska-Lincoln, Beth Ann Thacker, Texas Tech University, Mark Plano-Clark, Christopher Wentworth, Doane College. Other contributors are Paul Peter Urone, California State Unversity at Sacramento, and Fred Becchetti, University of Michigan.

This project has been funded by NSF – CCLI Grants DUE #00-88780, DUE #00-88712, DUE #97-50638

Table 1. Unit tiltles of Speech and Hearing Module

1. Where are sounds produced?
2. Describing what the larynx does
3. What does the larynx actually produce that we can hear?
4. Periodic Waves
5. How does the larynx produce a pressure wave?
6. What frequencies does the larynx produce?
7. What is the speed of sound?
8. Can you hear me?

Table 2. Sample activities, physics topics, and activity modes from Speech and Hearing module

1. Where are sounds produced?

Which parts of the speech system are responsible for pitch, loudness, and timbre?

1. **Video clip** - Laryngoscopy exam
2. **Own body** – vocal sounds
3. **Video clip** - Larynx in action
4. **Hands on** – Working Larynx model with air supply

2. Describing what the larynx does

Describing Oscillations – Simple harmonic motion, Hooke's law, period, frequency, cycle, amplitude.

1. **Video clip** - initial thinking – vocal folds
2. **Hands on** – conceptual exploration oscillation - of meterstick w/clamp
3. **Hands on** – measurement - Spring/masses for Hooke's law type experiments
4. (3) **Video clips** – measurement - Stick vibration videos:
5. Hands on – measurement - w/ interfaced sensors – oscillation of spring/masses w/Motion detector
6. Revisit thinking – vocal folds

3. What does the larynx actually produce that we can hear?

Describing material waves; sound as a pressure wave

1. **Own body** – initial thinking - clapping
2. **Hands on** – conceptual exploration waves- long Slinky
3. **Hands on** –- conceptual exploration pressure-w/styrofoam cups (~25 per group) and 2'x2' board
4. **Hands on** – measurement - 3 syringes, different cross-sectional areas w/force probe, pressure probe –
5. **Worksheet** - pressure vs. x in syringe
6. (2) **Video clip** – slinky – measurement wave velocity
7. (2) **Video clips** - waves: longitudinal or transverse

4. Periodic Waves

Relationships between wave speed, wavelength, and frequency

1. Own body – clap and humming into sound sensor/microphone
2. Hands on – long coil and long slinky
3. Hands on/own body – hand with marker on paper or whiteboard
4. Worksheet - wave photos
5. Video clips – waves of different frequency