APPENDIX F: ORAL PRESENTATIONS & POSTERS

Invited


Abstract: This poster set proposes a framework to characterize the processes of student reasoning during an interview, and discusses implications of the framework. The interviews on which this framework is based were conducted by five researchers, with different research goals. The research participants are enrolled in various introductory physics courses at KSU.

From our interview transcripts we have constructed a framework involving four aspects: [1] External Inputs (e.g. questions asked, verbal, graphic and other cues) from the interviewer and interview environment; [2] Tools (e.g. memorized and familiar formulae, laws and definitions, prior experiences) that the student brings to the interview; [3] Workbench encompassing mental processes (e.g. induction, accommodation) that incorporate the aforementioned inputs and tools; and [4] Answer given by the student.

We have used a coding scheme to map out reasoning paths through the four aspects of our framework. Our analysis finds remarkable commonality between students’ reasoning paths in different contexts as well as interesting patterns depending upon the question type, topical area etc. Based on these observed patterns we discuss the implications of our framework to elucidate the dynamics of student reasoning and its potential to inform the construction of interview protocols.

Supported in part by National Science Foundation grants REC-0087788 and REC-0133621.


Abstract: There is a critical need for high quality science (physics, physical science) teachers in the United States. We have developed an online course to help in-service teachers update their pedagogical and content knowledge about contemporary physics. Contemporary Physics Online adapts an existing on-campus course for Internet delivery. The course utilizes computer programs and hands-on activities to focus on 20th Century physics. Experiment kits are mailed to the teachers. These teachers also participate in a summer workshop after completion of the online component. We provide follow-up support to facilitate the development and transfer of new teaching materials into their classrooms.

Supported in part by National Science Foundation grant ESI-9452782.


Abstract: Many areas of the United States face shortage of teachers who have studied a significant amount of physics at the university. To provide secondary school students with a course in physics many states allow teachers of other sciences and mathematics to become physics teachers. These teachers must complete some minimal number of physics courses at the university. To help these teachers understand contemporary physics we have designed a course which future secondary science teachers complete. The course relies on computer visualization
and hands-on activities rather than mathematics to convey the concepts of quantum mechanics
and other related topics.
Supported in part by National Science Foundation grant ESI-9452782 & Eisenhower Profession
Development Grant.

4. “Physics education research as a guide to application-based curriculum development,” N.
Sanjay Rebello, Invited Talk, Fall Section Meeting, American Association of Physics Teachers,
Western Pennsylvania Section, Latrobe, PA, October 24, 2003.
Abstract: Students often use several everyday devices without thinking about the underlying
physical principles of these devices. Advances in educational research and cognitive psychology
have enabled us to gain better insights into how students think and learn (or don’t!). Based on
this research, we are able to design curriculum that enables students to build their reasoning and
construct mental models that explain the physics underlying their everyday experiences.

We will share with you some of the ongoing research and associated curriculum development
at Kansas State that is aimed specifically at enabling students to learn the physics of everyday
objects. We discuss our research methodology to explore students understanding and an
analytical framework to understand the various cognitive tools and processes that students’ use.
Finally, we will describe examples of curricular materials that we have developed based on our
research.
Supported in part by National Science Foundation grants REC-0087788 and REC-0133621.

Contributed
1. “Mental models in energy — Mechanics contexts,” Salomon F. Itza-Ortiz, Benjamin
Lawrence, N. Sanjay Rebello & Dean A. Zollman, Contributed Talk, 126th AAPT National
Meeting, January 11-15, 2003, Austin, TX.
Abstract: Energy is a central concept in science. In an introductory physics course this concept is
often introduced in mechanics contexts such as kinetic and potential energy. What are students’
mental models of energy and how do these models change with context? We are investigating
students’ mental models of energy in these various contexts in mechanics. Our research
participants include students in a first-semester calculus-based physics course as well as students
in a conceptual physics course. We contrast our results from these two groups of students. We
will present details of our research method and preliminary results.
Supported in part by National Science Foundation grant REC-0087788.

Rebello, Contributed Poster, 126th AAPT National Meeting, Austin, January 11-15, 2003, TX.
Abstract: As evidence begins to accumulate about how question order can affect the results of
diagnostic instruments, one can ask the same question regarding interview results. Does the order
in which we ask students questions during an interview affect the information that we receive?
Results from two closely related studies will be presented. The first study examines how the order
in which questions are presented (easy to hard, hard to easy, grouped by concept) affects the
results that are obtained on a multiple-choice diagnostic instrument: DIRECT (Determining and
Interpreting Resistive Electric Circuits Concepts Test). The second study focuses on students’
mental models of real-world applications. We investigate the effect of introducing various real-
world applications in different orders during interviews. Results from interviews on simple
electric circuit elements; batteries: light bulbs, switches, and sockets, will be discussed.
Supported in part by National Science Foundation grant REC-0133621.

Abstract: Homework problems covering the same conceptual areas can appear quite different to students due to different situations, variables, and unknowns. To study the effects of problem context, students in a calculus-based introductory physics course (including physics majors and engineering majors from several areas) were interviewed up to four times during the first semester and twice during the second semester of the course. In these interviews, each student was asked conceptual questions related to their homework problems. From this information, students’ applications of Newton’s Second Law and the dependence of those applications on the context of the problems were assessed. This presentation will focus on the second semester topics of electric and magnetic fields. The methodology and preliminary results will be presented. Supported in part by National Science Foundation grant REC-0087788.


Abstract: Recent research has often focused on students’ mental models of physics concepts as they are encountered in the typical introductory physics course. But how do students apply these mental models to situations outside the physics classroom, for example, to a bicycle? We interviewed students in a conceptual physics course on the mechanics of the motion of a bicycle. We will discuss the methodology and the results of our study. Supported in part by National Science Foundation grant REC-0087788.


Abstract: Educators and researchers often assume that the order of questions on a test or survey is unimportant. Is this assumption valid? This study follows up on our previous investigation1 of how the order of related questions or inclusion of unrelated questions affect students’ responses on a multiple-choice survey. We used a think-aloud protocol to interview students as they worked through two sets of related questions. Students were also asked to describe the similarities and differences between questions, and their thoughts on how the questions related to each other. Interviews were conducted both before and after instruction. We will present the methodology and results of our study. Supported in part by National Science Foundation grant REC-0087788.


Abstract: The everyday meaning and usage of several words can differ significantly from their meaning and usage in physics. Examining these differences, and how students respond to them, may shed some light on students’ physics learning difficulties. We surveyed (N=154) students in a conceptual physics course on their use of some words, “force”, “momentum” and “impulse.” We also interviewed some (N=14) of these students to probe their understanding of these terms and to triangulate data collected from the surveys. We found that students who were able to
clearly discern the similarities and dissimilarities between the physics and everyday usage scored higher on a class exam that tested these concepts. In the interviews, students who were able to explain the distinction between the physics and everyday meanings often described the words in terms of the physical parameters associated with them.

Supported in part by National Science Foundation grant REC-0087788.


Abstract: We investigated students’ mental models of Newton’s second law in various contexts encountered in mechanics, and for the first time, in electricity and magnetism. We interviewed a cohort group of 16 students enrolled in a two-semester calculus-based sequence of physics courses. We find that there are two predominant mental models: the “F = ma” or Newtonian model and the alternative “F = mv”, often called the Aristotelian model. Our results indicate that although the contexts may change, no new mental models emerge over two-semesters of physics instruction. However, we do find that some students, who may have adopted a Newtonian model after instruction in Newton’s laws during the early part of the first semester, may revert back to using an Aristotelian model when they encounter unfamiliar contexts. Our research also provides some insight into how students transfer their understanding of Newton’s second law from contexts in mechanics, where the law is first introduced, to contexts in electricity and magnetism where Newton’s laws are typically not explicitly addressed.

Supported in part by National Science Foundation grant REC-0087788.


Abstract: After in-depth probing of students’ mental models of sound propagation through a set of semi-structured interviews, we constructed a multiple choice assessment to elicit the identified models. The assessment can be delivered over a classroom response system to identify those mental models in a classroom setting in the real time.

Through our interviews we have found that students hold two models of sound propagation that are fundamentally different. One fundamental model is scientifically accepted wave model. Another is the entity model, which the most common initial alternative model. According to this model, sound is a self-standing entity different from the medium through which it propagates. All others identified models can be described as hybrid models that share some of the features of each of fundamental models, but which are at the same time also distinct from both, the entity and the wave model. We will discuss the general characteristics of hybrid models as well as their implications for construction of the assessment that we developed.

Finally, we will show results that we obtained using this assessment during spring 2003 in several educational institutions in US and Croatia. The test was administered to students at different levels and at different points of time during instruction. Possible implications of the assessment for instruction will be discussed.

Supported in part by National Science Foundation grant REC-0087788.

Abstract: Students' difficulties with battery, light bulb and wire circuits have been well documented. Prior research has blamed these difficulties on students' misunderstanding of complete circuits. This talk will present a different reason for these mistakes and a new curriculum that addresses these difficulties. Based on interviews we have found that students' difficulties are not with the concept of complete circuits, but with their understanding of the internal wiring of a light bulb. Students do have a functional, albeit partial, definition of complete circuits. This curriculum includes a series of hands-on, discovery-based activities that are intended to lead students to an understanding of the internal wiring of a light bulb and a more comprehensive definition of complete circuits.

Supported in part by National Science Foundation grant REC-0133621.


Abstract: The Modeling Cycle has been effectively used in several high school and introductory college courses. Here we discuss the adaptation of this hands-on, guided discovery-based learning approach in an upper-level physics course covering analog electronic devices and circuits. We applied the Modeling Cycle paradigm most specifically in the learning of diodes and transistors. Through hands-on experiments and computer simulations students explored the electrical properties (e.g. current vs. voltage graphs) of these devices. Based on these experiments, associated computer simulations, and thought provoking questions students constructed equivalent circuit models of these devices. They then deployed these models to predict the behavior of these devices in several different circuits. They also applied the model to design of power-supplies and amplifiers circuits to satisfy given specifications. We will discuss the successes as well as the pitfalls of using this approach, and lessons learned for future implementations.

11. “Retention and transfer of physics knowledge to engineering courses,” N. Sanjay Rebello, Paula V. Engelhardt & Salomon F. Itza-Ortiz, Contributed Talk, 127th AAPT National Meeting, August 2-6, 2003, Madison, WI.

Abstract: Do engineering majors retain what they have learned in physics courses when they begin their engineering courses? Do they see a connection between engineering courses and previously taken physics courses? We created a survey that tested physics concepts which engineering faculty expect that students entering their courses should know. Engineering students were surveyed on the first day of their statics & dynamics and electromagnetics courses to assess their retention of the relevant physics knowledge. We interviewed a subset of these students several times through the semester to investigate the extent to which they could connect topics that they covered in their engineering course to previous physics courses. We also interviewed physics faculty to compare theirs and students' expectations about connections between physics and engineering courses. We will present the results of our study and their implications for the teaching of engineering majors in introductory physics courses.

Supported in part by National Science Foundation grant DUE-0206943.
12. “Student understanding and perceptions of the content of a lecture,” Zdeslav Hrepic, Dean A. Zollman & N. Sanjay Rebello. Contributed Talk, 127th AAPT National Meeting, August 2-6, 2003, Madison, WI.

Abstract: In spite of advances in physics pedagogy, the lecture is by far the most widely used format of instruction. We investigated students' understanding and perceptions of the content delivered during a physics lecture. Participants viewed a segment of a videotaped lecture on sound propagation by a well-known teacher. All of the participants were enrolled in a conceptual physics course and had previously covered the topic in class. Before viewing the lecture, the participants responded to a series of conceptual questions on sound. The participants then looked for answers to these questions in the videotaped lecture. On a written questionnaire, they indicated instances, if any, in which these questions were answered during the lecture. In addition to the students, a group of content experts (physics instructors) also participated in our study. We will discuss students' and experts' responses to the questionnaire.
Supported in part by National Science Foundation grant REC-0087788.


Abstract: How do students apply the information they have developed from their everyday experiences to explain the working of real-world devices, such as the bicycle, simple electric circuits and musical instruments? Previous talks discussed the bicycle and simple circuits. This talk will focus on preliminary results from individual interviews conducted with students enrolled in an introductory conceptual physics course and how these students apply their everyday knowledge to explain how various musical instruments produce sound.
Supported in part by National Science Foundation grant REC-0133621.


Abstract: Energy is a central concept in science. We have extended our previous research of students' models of energy from mechanics contexts to electromagnetism contexts. We conducted interviews and administered a written survey, which was designed based on students' responses in the interview. Our research subjects were students enrolled in a two-semester, calculus-based physics course. We found that students seemed to use a model of energy with four different components: energy due to position, motion, substance and conservation. We will present the research results from our interviews and surveys.
Supported in part by National Science Foundation grant REC-0087788.

15. “Student goals and expectations in a large-enrollment physical science class,” N. Sanjay Rebello. Contributed Poster, Physics Education Research Conference, August 6-7, 2003, Madison, WI.

Abstract: What are the goals of non-science students taking a lecture-based physical science course as they begin the class? Do students' goals and expectations change as they progress through the class? To answer these questions we surveyed students on the first day of class about their goals for the course (in addition to getting a good grade), and the barriers they perceived in achieving these goals. Students were also asked what they, their instructor, and their classmates could do to help them achieve these goals. At the end of the course we again surveyed students.
and asked them whether they were able to achieve their goals and the factors that helped or hindered them in the process. We will describe student responses on both the pre- and post-course surveys and the insights these responses give regarding students' perspective about the role of the instructor and peers in the learning process.


Abstract: Much of the research to investigate how students' reason or what knowledge structures they possess and utilize have typically been done using the clinical interview format. The clinical interviews are often semi-structured and may or may not involve demonstration equipment. In the early 1980's, mathematics researchers began experimenting with a new style of interviewing which they termed the "teaching experiment." These two methods will be compared and contrasted within the context of sound. Students from a conceptually-based introductory physics course were interviewed using both formats in an effort to understand how they view the production of sound from musical instruments.
Supported in part by National Science Foundation grant REC-0133621.