Distillate of

Minutes of the Advisory Committee
For the Model Analysis Grant

Context

- Must make the meaning of context much clearer in project.
- Must show that any new context is isomorphic to others that we are comparing it to.
- Investigate relationship between concept and context: Does a student think of certain concept within the context presented? Can a student apply a concept in a particular context?
- Consider the ways in which students interpret the contexts that we have presented[1].
- Consider how "memories" affect students' interpretations of contexts presented to them.
- Consider what we leave out in a scenario and what students may put into it.
- Utilize different modes of representation (words, equation, graph etc.) of physical principles.

Students' Mental Models

- Investigate "Modality"[2, 3, 4]
- Consider how context of a problem affects the intellectual resources that are activated[5]
- Ask whether students' ideas concerning a certain situation and physical principle can in fact be classified into a few models [6]. Perhaps they just make something up on the spur of the moment to answer a question.
- When we are unsure of whether individual students do in fact have mental models, what can we learn by combining models from the entire class?
- Consider the dimensionality of the context of a problem, not just the dimensionality of the students' state of understanding i.e. each context has a different model space.
- Do multiple choice questions have inherent limitation that they may trigger mental models which are not represented in multiple choices – so we must use interviews to extract these models.
- Look at theories of conceptual change and how they interact with model analysis.
- Case Study of few students: Engage students in questions about features and concepts: develop a story line on how students' reasoning processes develop over the course of a semester[9]

Online HW System used in Math:

- How do student scores on a particular trial relate to those on the previous trial?
- Ask students to think aloud their reasoning when they convert information in a representation that cannot be input into the computer to one that can be input into the computer[7]
- Consider whether online system should provide feedback on worked out problems so students can use that reasoning in future problems.
- Compare student performance using a variety of input mechanisms on online system[8]
- Observe students completing online exercises and classify behaviors.
- Refer to data collected by students using web-based homework at University of Illinois.

Dissemination

- Limit it to pilot study i.e. how faculty respond to these types of issues and results.
- "Sell" faculty innovations that analyze responses from large classes.

Other General Comments

- Project focuses on analyzing group learning, rather than individual learning.
- Exploit extensive research on FCI but not be limited by it as a research tool.
- Do not spend time on..
    - Developing a user-friendly form of Model Analysis
    - Investigating Transfer between Mathematics & Physics courses.
    - Investigating too many concepts. Limit it to one concept per institution, and develop many questions in each.
- Criteria for choosing concepts:
    - What have largest research base to build on.
    - What are most frequently encountered in physics.
- Possible concepts:
    - Force (Newtons 2nd Law)[10]
    - Circular Motion (centripetal & centrifugal forces in larger context of Newton's 2nd Law.)
    - Buoyancy.

Recommended Readings:

[1]Alfred Schutz (1930s)
Pat Heller's paper on proportional reasoning with changing objects.
"Modes or Representation" research.
Judah Schwartz re. Extensive vs. Intensive variables.
Jerry Golden re. Context of mathematics problems.
Pat Heller's paper on problem solving re. 21 characteristics that make problems difficult.
Tom Koch, Jose Mestre re. Students' cue on different physical situations.
[2] Susan Golden-Meadows re. Students' gesturing while solving problems.
[3] McCloskey re. Dynamic vs. Static images.
[4] Ricardo Nemirovsky re. Representations in studying calculus.
[5] Steinberg & Sabella re. Students' comparative performance on FCI and Exam problems.
[6] Recent paper in *Intl. Jour. Of Science Education* on models of sun and moon.
[7] Judah Schwartz re. Students solving math problems with a broken calculator.
[8] John Seely Brown re. Different kinds of errors by students on subtraction problems could be explained by a small number of bugs.
Search literature on Computer-aided instruction for feedback and representations.
[9] Hans Niederrer's case study on two students in Quantum Mechanics published in *Intl. Jour. Of Science Education*.
[10] Univ. of Minnesota's data on how students apply Newton's 2nd Law to study context.