# Research-Based Design Features of Web-based Simulations

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# Introduction

Through extensive interviews with students, we have developed guidelines for creating simulations which are easy to use, inviting, encourage exploration by the student and promote development of student understanding of physics.

The Physics Education Technology (PhET) Project[1] focuses on the development of elaborate Java- and Flash-based animated simulations that help students develop visual and conceptual models of physical phenomena. We have researched and characterized elements of effective simulation layouts, representational models, user help and guiding questions. We incorporate these elements into the design for future PhET simulations and they should prove useful for developing simulations in general. This poster will present these design principles and the research base of clinical interviews used to derive them.

# Research Methodology

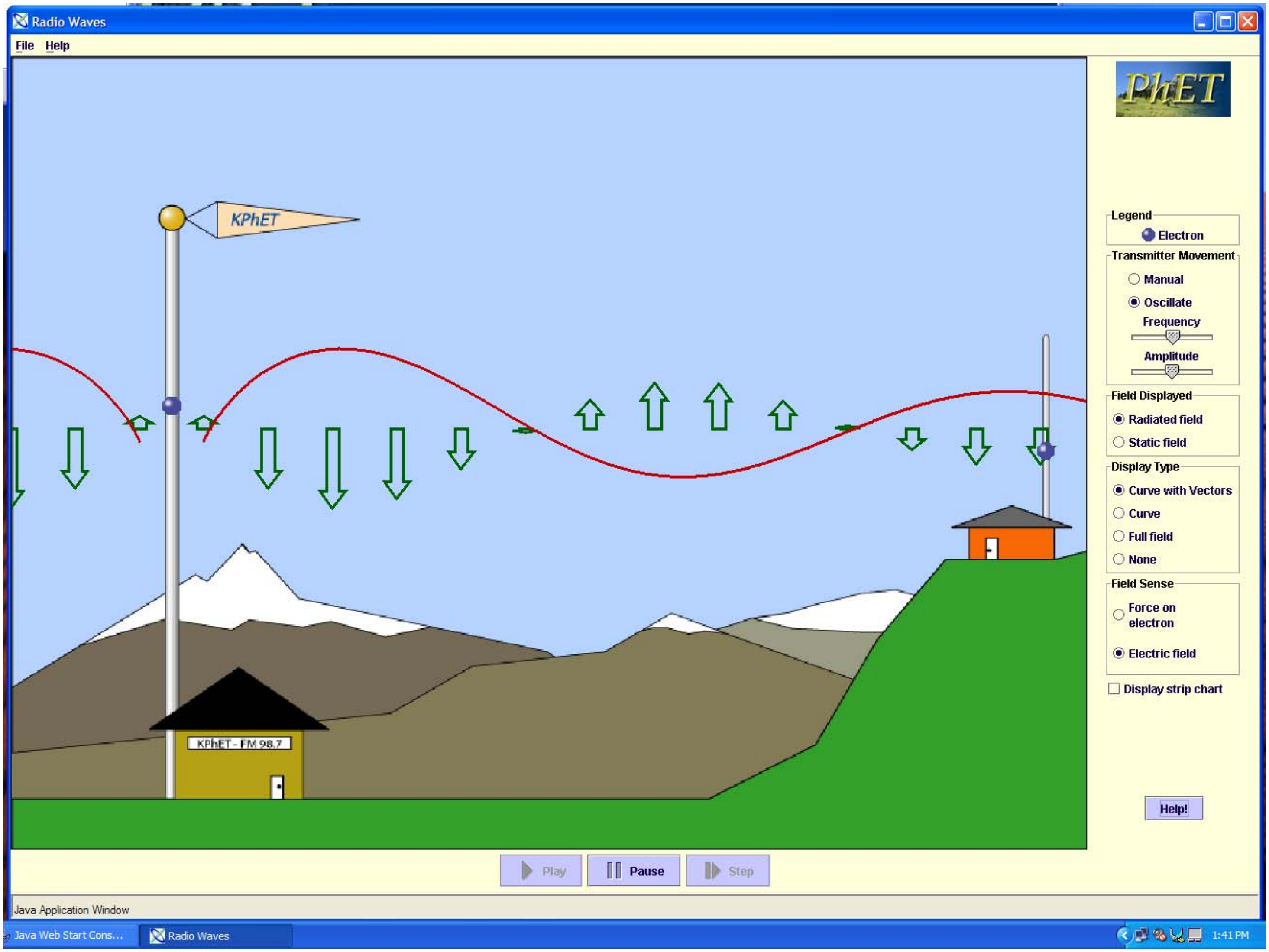
- Interviews
  - Think-aloud style
  - Either no guidance or limited to one or two conceptual questions.
  - 30 to 60 minutes per simulation
  - 4-6 interviews per version of simulation
- Homework
- Pre-Class Assignments
  - Simulation use vs. Reading
  - Helps identify level of simulation sophistication.
- Lecture Demonstrations
  - Clicker Questions

# Design Philosophy

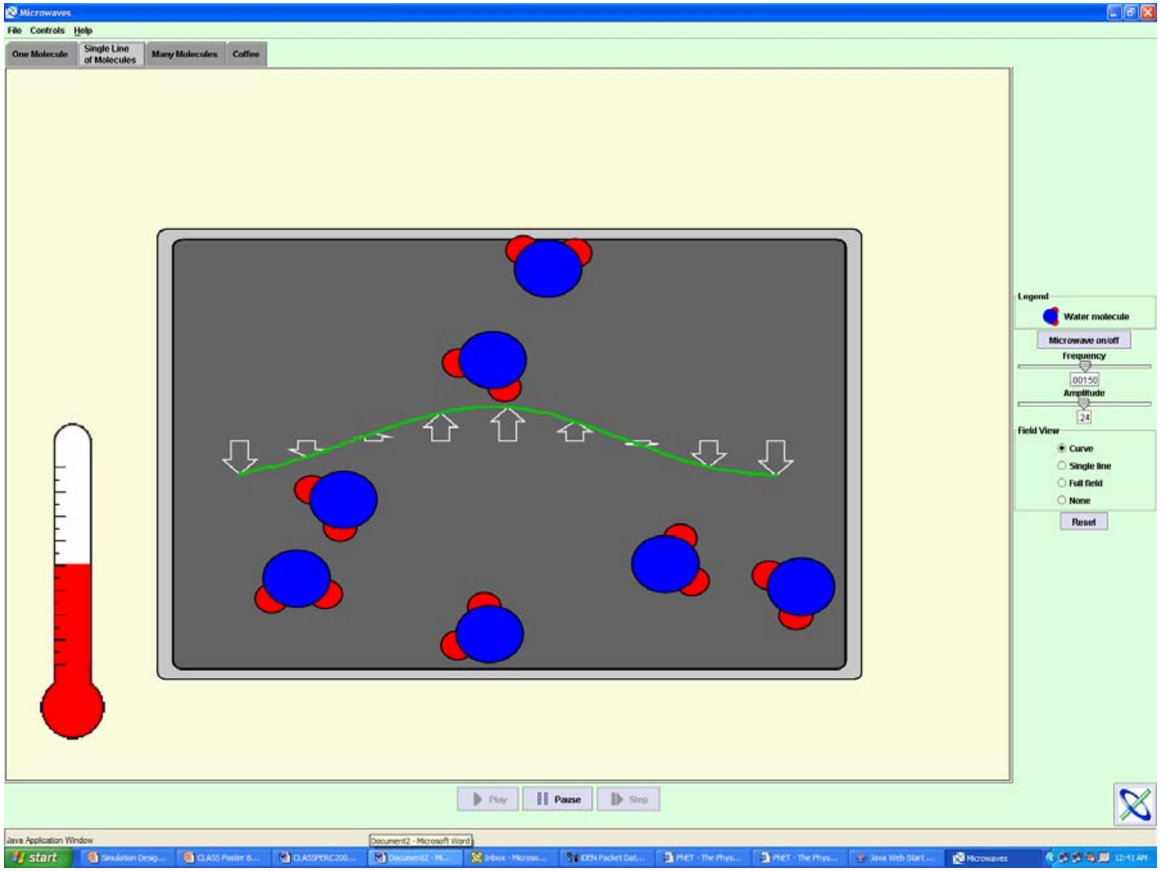
- Fun Bridge to Real World
- Research-Based
- Interactive
- Animated
- Engaging
- Promote Student Learning

- Intuitive Controls
  - Click and Drag Interface
  - Grabbable objects
- Representations
  - Start up Settings (manual/not moving, simplest version!)
  - Subtle visual cues important (electron spacing, E-field, nothing without conceptual value)
- Tool Use
  - Limit on useful number of tools (play buttons overlooked)
  - Tabs (placement is crucial)
- Encourage Exploration
  - Legends (some tool labels encourage use, label electrons, photons, molecules etc., but avoid “information overload”.)
  - Little Puzzles (don’t tell the student everything)

# Interface Design- Research Conclusions

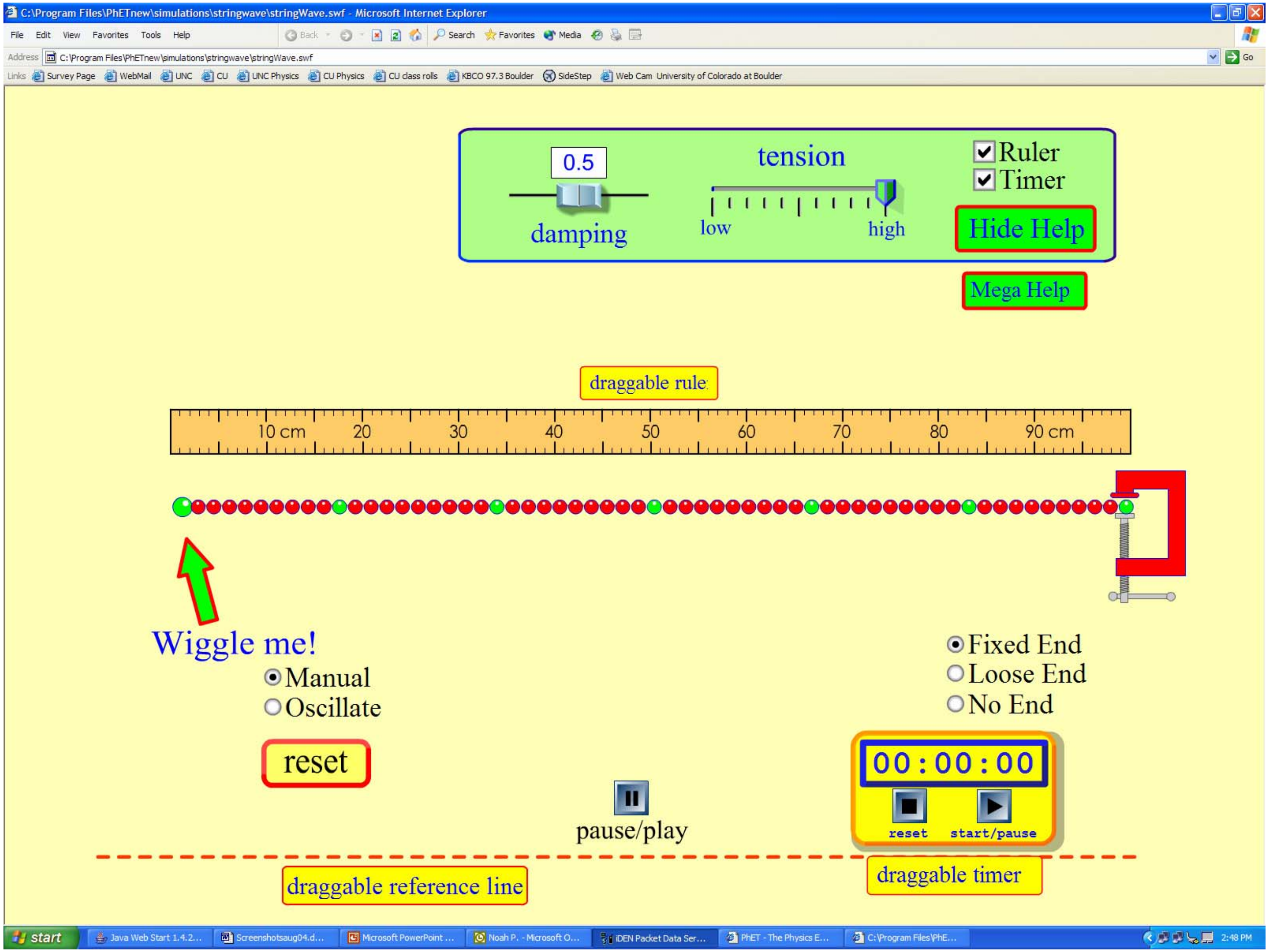


# Microwave oven simulation: design principles work!




- Design features from previous interviews integrated into Microwaves
  - Start up Settings
  - Tab Placement
  - Intuitive control
  - Legend

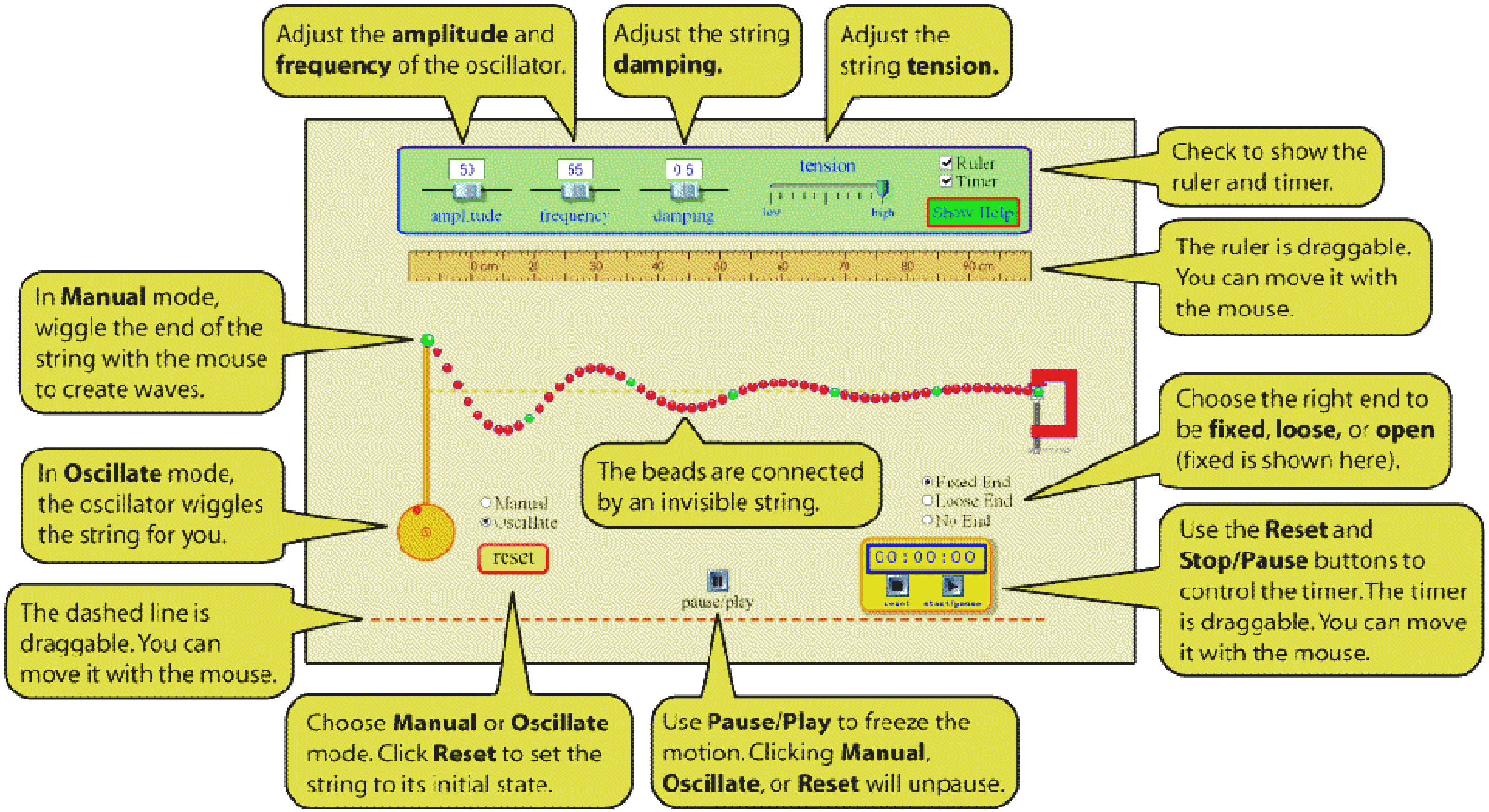
- Help
  - Best if the simulations are designed totally intuitive.
  - Minimal Reading
    - *Student’s rarely read.*
  - Inviting straight forward text
  - Minimal Guidance
    - *Found that help (both from instructor or onscreen), if not done properly, severly limits students’ natural curiosity thus exploration.*
  - Unobtrusive
    - *Place help so that it can be seen; however, all fo the simulation should still be accessible.*




Basic Help (appears only upon request)

Normally all that is needed.

# PhET Waves on a String

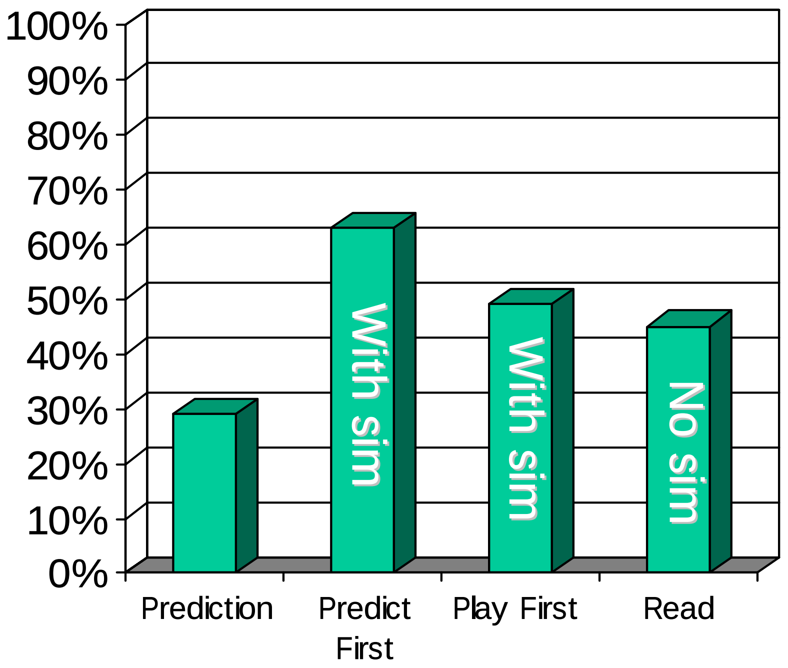



Mega Help (appears if requested after basic help)

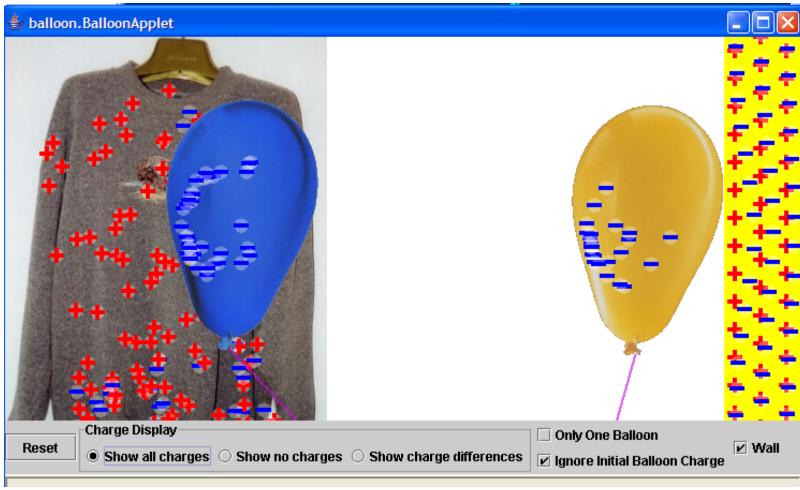
Full manual. Does not explain concepts.

# Guidance – Research Conclusions

- Some simulations are effective with a single question *(Understanding of concepts gained before instruction with only prediction question as guidance.)*




- Others require instruction or more carefully designed guidance. *(Not gain understanding of concepts before instruction. After instruction and written homework, students gain conceptual understanding with simulations.)*



# Conclusion

Computer simulations are quickly becoming accepted as effective educational tools. We also feel that simulations can be highly effective learning tools; however only if carefully designed, researched and implemented. Interface design is crucial. If the students are not engaged, the simulations can not be effective. We are carefully studying our simulations through interviews, use as homework, lecture demonstrations, pre-lecture assignments and replacement for lab equipment[1] to be sure that each simulation is engaging and encourages learning. In this poster we have outlined the design features we have found effective in creating engaging, interactive computer simulations.

1. See Posters EA20 and EA22 PERC Poster CP-IP05