Use of Structure Maps to Facilitate Problem Solving in Algebra-Based Physics

Fran Mateycik,[1] David Jonassen,[2] and N. Sanjay Rebello[1]

[1]Kansas State University, [2]University of Missouri

This work is supported in part by US National Science Foundation under grant DUE-06185459.

1. BACKGROUND

- Students asked to solve problems sharing similar deep-structure elements.
- Students instructed to use expert-designed structure maps.
- Semester long treatment in algebra-based physics.
- Objectives:
  - Gauge how students react to expert-designed structure maps over the entire semester.
  - Gauge how maps evolved to meet the needs expressed by the students.

2. QUESTIONS

- How do students use expert-designed structure maps to solve problems?
- What difficulties do they experience while using these maps?
- How do the maps evolve in response to students' feedback?

3. THEORY

- Case Based Reasoning (CBR): Using analogies to solve real-world problems.
- Case-Reuse promotes CBR using problem pairs sharing deep similarities.
- Case-Reuse used with *Structure Mapping*:
  - Use a visual representation showing functional connections of quantities. (Fig. 2)
- Strategy used with problem pairs.

REFERENCES

1. L. Hsu, et al., *American Journal of Physics* **72** (9), 1147-1156 (2004).
2. D.H. Jonassen, *Educational Technology and Research and Development* **48** (4), 63-85 (2000).
3. M.T.H. Chi, P.J. Feltovich, and R. Glaser, Cognitive Science **5** (2), 121-152 (1981).
4. J. C. Nesbit and O.O. Adescope, *Review of Educational Research* **76** (3), 413-448 (2006).
5. K.A. Ericsson, R.T. Krampe, and C. Tesch-Romer, Psychological Review **100** (3) 363-406 (1993).
6. J.D. Novak, B.D. Gowin, and G.T. Johansen, Science Education **67** (5), 625-645 (1983)
7. D. Gentner, Cognitive Science **7** (2), 155-170 (1983)

4. METHODOLOGY

Focus Groups:

- Algebra-based physics volunteers (N = 11)
- These 11 participants split into two groups:
  - Group I (6 participants)
  - Group II (5 participants)
- Each group met for 1 hour each week for duration of semester.
- Each week, participants were:
  - given a set of deep-structure similar problems.
  - given an expert-designed structure map.
  - asked to identify quantities on given map as: 'directly/indirectly given,' 'asked for,' or 'must be calculated' for each problem in the set.
  - asked to solve deep-structure similar problems.
  - asked to give feedback about the structure map.

Individual Interviews

- Two 50-minute semi-structured interviews.
- Conducted at the mid- and end-points of semester.
- Students were asked to work on problem solving tasks and provide feedback about focus groups and structure maps.

5. RESULTS

For this poster, we focus on three group interviews:

Week 4: Newton's Laws

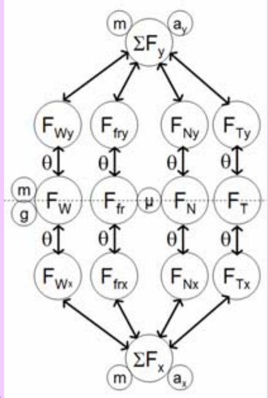

Figure 1: Newton's Law

- 1 of 6 students in Group I stated they found the map useful.
- 1 of 5 students in Group II did not use the map
- 1 of remaining 4 in Group II felt the map was helpful.
- Most students in both groups voiced concern that the map was difficult to follow:

  " I don't know how to mark it on here exactly. Like, I couldn't figure out how to relate like the terms on here to the problem."

6. RESULTS (continued)

Week 6: Work and Energy

- All 11 students favored the work energy map over previous kinematics and force maps.
- 10 of 11 students felt the map was easier to navigate.

  "I feel like this one you're just looking for your potential energy final, like I feel like it's just easier to focus in on that area [of the map] and how you would lead there, other than the other one that's just like you have [a quantity] down here but you feel like you have to go through all bubbles."
- 1 of 11 students declined to use the map stating,

  "I did not need it. Why would I use it?"
- Students would like to see equations and units included in the maps.

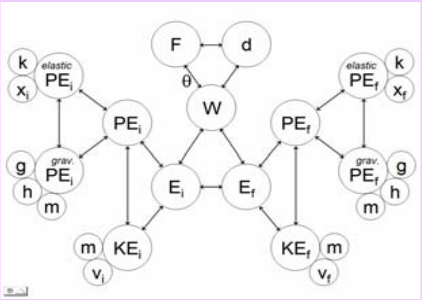

Figure 2: Work and Energy

The Work and Energy map has temporal symmetry, unlike previous maps.

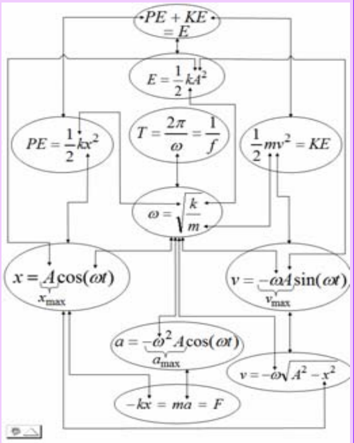

Figure 3: Vibration and Waves

Week 9: Vibration and Waves

- Immediate reaction: The map looked complex and intimidating.
- Given time to work with the map: All students found new map useful.
- Many liked the arrows connecting quantities across equations.

  "[This map is] a lot easier to use. I don't have to like look up a bunch of different equations like, oh I don't have that…you can just see how everything relates and what you have and how it works together."

7. CONCLUSIONS

- Students appear to have trouble using the quantities in a structure map to solve problems if they are not provided explicit equations.
- Students appear to like the Work-Energy map, perhaps due to its temporal symmetry.
- Maps with equations in the nodes facilitate students' recognition of connections between individual quantities inside equations.