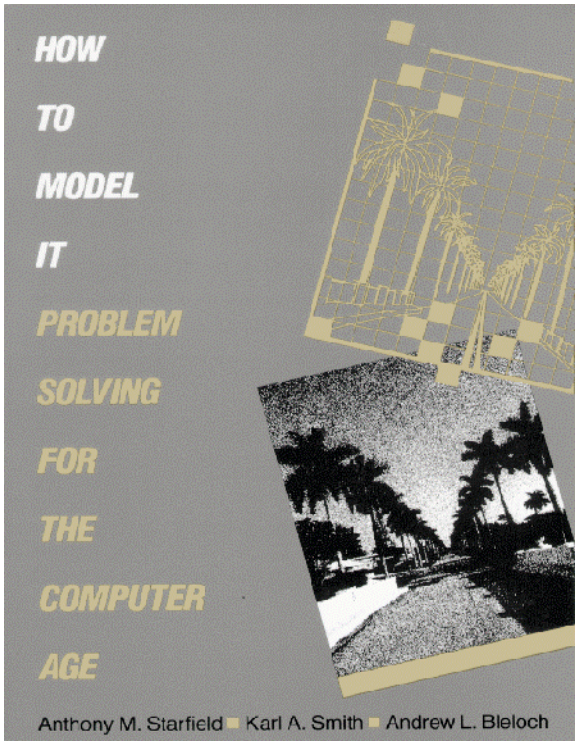
Problem-Based Cooperative Learning

Karl A. Smith
Engineering Education – Purdue University
Civil Engineering - University of Minnesota
ksmith@umn.edu
http://www.ce.umn.edu/~smith

Estimation Problem

First Course Design Experience
UMN – Institute of Technology

- Thinking Like an Engineer
- Problem Identification
- Problem Formulation
- Problem Representation
- Problem Solving



Problem-Based Learning

Problem Based Cooperative Learning Format

TASK: Solve the problem(s) or Complete the project.

INDIVIDUAL: Estimate answer. Note strategy.

COOPERATIVE: One set of answers from the group, strive for agreement, make sure everyone is able to explain the strategies used to solve each problem.

EXPECTED CRITERIA FOR SUCCESS: Everyone must be able to explain the strategies used to solve each problem.

EVALUATION: Best answer within available resources or constraints.

INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) the answer and (b) how to solve each problem.

EXPECTED BEHAVIORS: Active participating, checking, encouraging, and elaborating by all members.

INTERGROUP COOPERATION: Whenever it is helpful, check procedures, answers, and strategies with another group.

Team Member Roles

- Observer/ Process Recorder
- Task Recorder
- Skeptic/Prober

Technical Estimation Exercise

TASK:

INDIVIDUAL: Quick Estimate (10 seconds). Note strategy.

COOPERATIVE: Improved Estimate (15 minutes). One set of answers from the group, strive for agreement, make sure everyone is able to explain the strategies used to arrive at the improved estimate.

EXPECTED CRITERIA FOR SUCCESS: Everyone must be able to explain the strategies used to arrive at your improved estimate.

EVALUATION: Best answer within available resources or constraints.

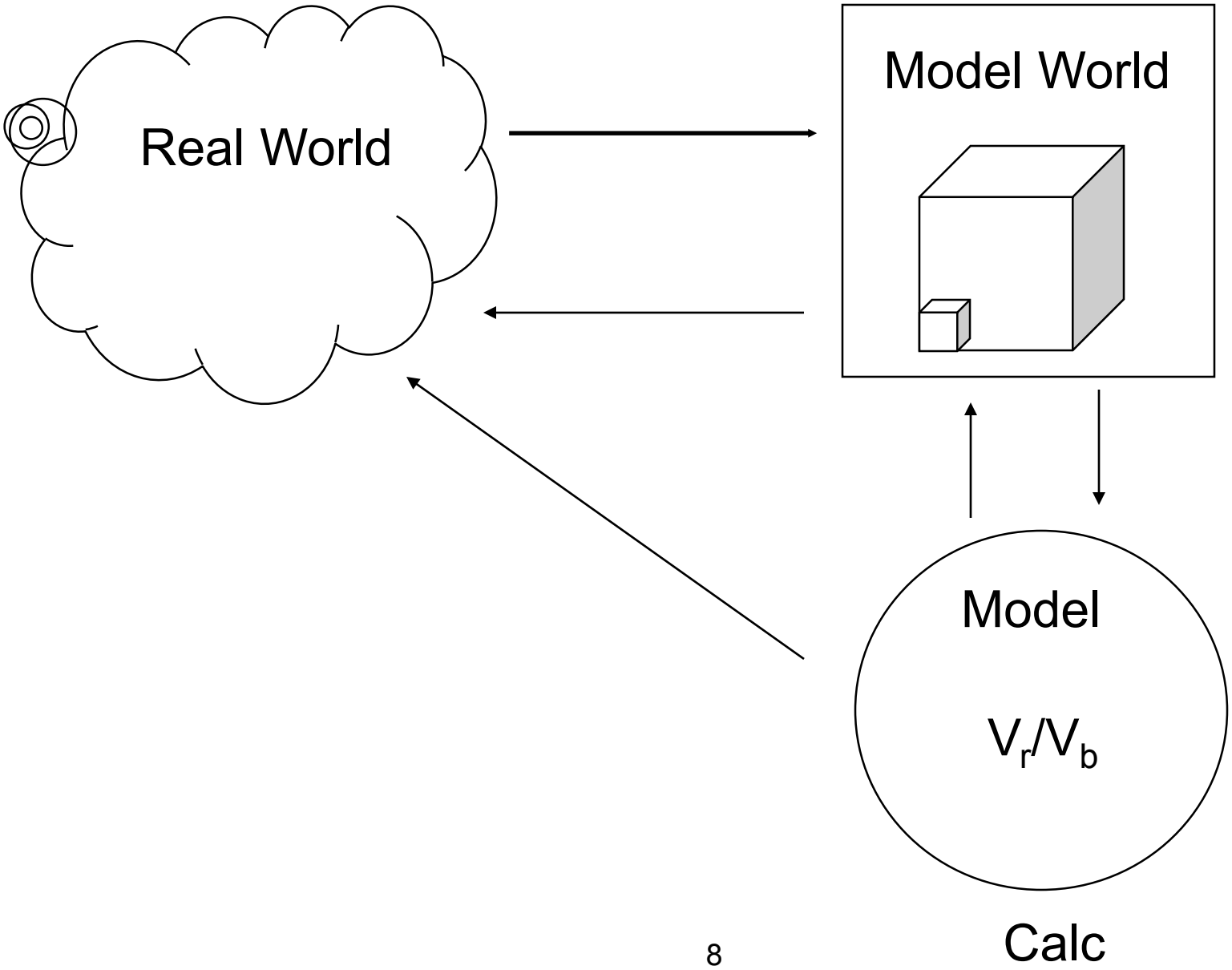
INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) your estimate and (b) how you arrived at it.

EXPECTED BEHAVIORS: Active participating, checking, encouraging, and elaborating by all members.

INTERGROUP COOPERATION: Whenever it is helpful, check procedures, answers, and strategies with another group.

Group Reports

- Estimate
  - Group 1
  - Group 2
  - . . .
- Strategy used to arrive at estimate – assumptions, model, method, etc.


Real World
Model World
Model
V_r/V_b
Calc

HOW TO MODEL IT

PROBLEM SOLVING FOR THE COMPUTER AGE

Anthony M. Starfield ■ Karl A. Smith ■ Andrew L. Bleloch

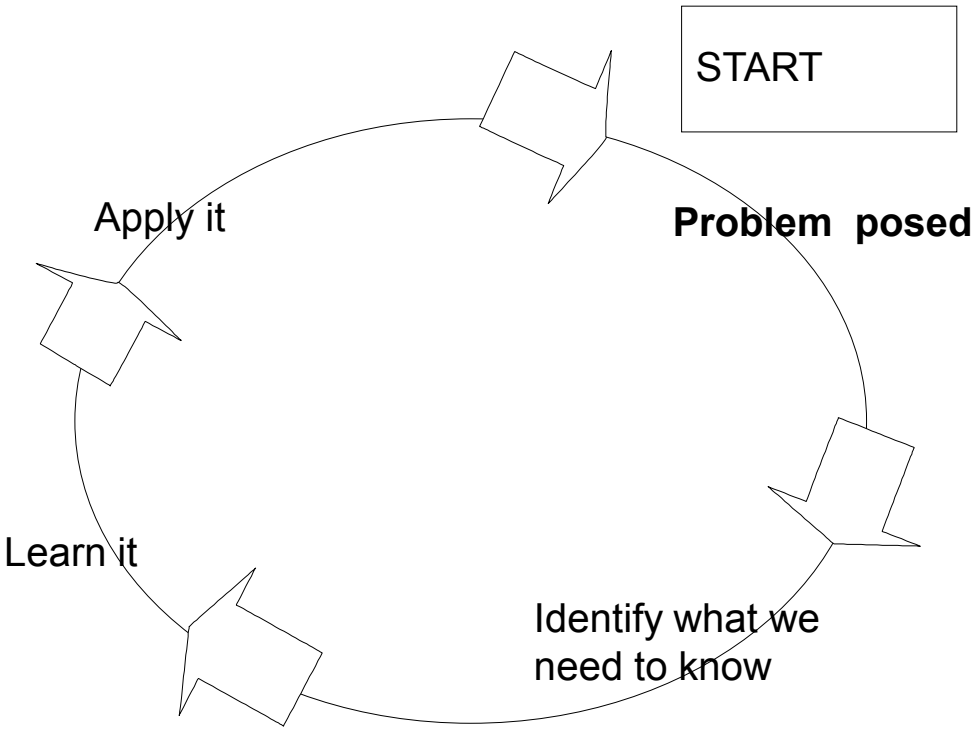
" 'How to Model It' . . . it is a serious attempt to teach modeling. . . . it's the best I've seen on the subject."
Jerry Pournelle, BYTE Magazine, March 1991 © McGraw-Hill, Inc.

CONTENTS

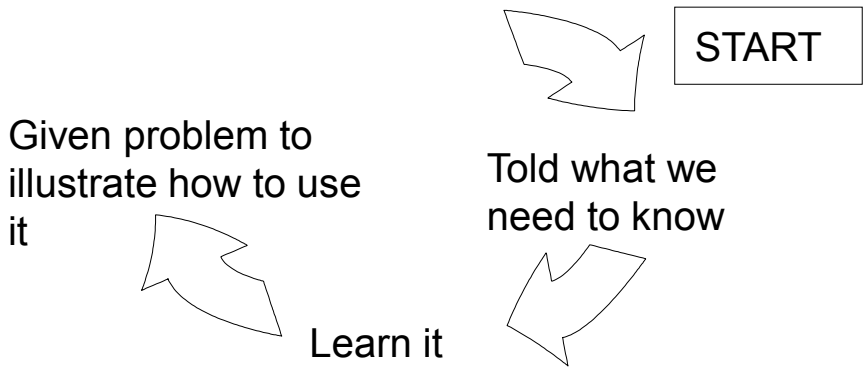
This active learning book has been used by high school students; in both undergraduate and graduate classes; in engineering, business, science and education as well as in professional development workshops.

ISBN 0-8087-7970-2
90000
9 780808 779704

Problem-Based Learning



Subject-Based Learning



Normative Professional Curriculum:

1. Teach the relevant basic science,

2. Teach the relevant applied science, and

3. Allow for a practicum to connect the science to actual practice.

Problem-Based Learning (PBL)

Problem-based learning is the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process – Barrows and Tamlyn, 1980

Core Features of PBL

- Learning is student-centered
- Learning occurs in small student groups
- Teachers are facilitators or guides
- Problems are the organizing focus and stimulus for learning
- Problems are the vehicle for the development of clinical problem-solving skills
- New information is acquired through self-directed learning

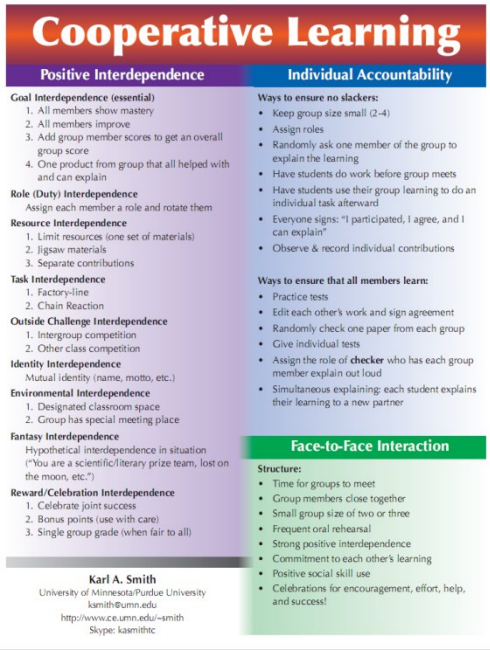
Group Processing
Plus/Delta Format

Plus (+) Things That Group Did Well	Delta (Δ) Things Group Could Improve

Cooperative Learning is instruction that involves people working in teams to accomplish a common goal, under conditions that involve both *positive interdependence* (all members must cooperate to complete the task) and *individual and group accountability* (each member is accountable for the complete final outcome).

Key Concepts

- Positive Interdependence
- Individual and Group Accountability
- Face-to-Face Promotive Interaction
- Teamwork Skills
- Group Processing



Cooperative Learning

Positive Interdependence

Goal Interdependence (essential)
1. All members show mastery
2. All members improve
3. Add group member scores to get an overall group score
4. One product from group that all helped with and can explain

Role (Duty) Interdependence
Assign each member a role and rotate them

Resource Interdependence
1. Limit resources (one set of materials)
2. Jigsaw materials
3. Separate contributions

Task Interdependence
1. Factory-line
2. Chain Reaction

Outside Challenge Interdependence
1. Intergroup competition
2. Other class competition

Identity Interdependence
Mutual identity (name, motto, etc.)

Environmental Interdependence
1. Designated classroom space
2. Group has special meeting place

Fantasy Interdependence
Hypothetical interdependence in situation ("You are a scientific/literary prize team, lost on the moon, etc.")

Reward/Celebration Interdependence
1. Celebrate joint success
2. Bonus points (use with care)
3. Single group grade (when fair to all)

Individual Accountability

Ways to ensure no slackers:
- Keep group size small (2-4)
- Assign roles
- Randomly ask one member of the group to explain the learning
- Have students do work before group meets
- Have students use their group learning to do an individual task afterward
- Everyone signs: "I participated, I agree, and I can explain"
- Observe & record individual contributions

Ways to ensure that all members learn:
- Practice tests
- Edit each other's work and sign agreement
- Randomly check one paper from each group
- Give individual tests
- Assign the role of **checker** who has each group member explain out loud
- Simultaneous explaining: each student explains their learning to a new partner

Face-to-Face Interaction

Structure:
- Time for groups to meet
- Group members close together
- Small group size of two or three
- Frequent oral rehearsal
- Strong positive interdependence
- Commitment to each other's learning
- Positive social skill use
- Celebrations for encouragement, effort, help, and success!

Karl A. Smith
University of Minnesota/Purdue University
ksmith@umn.edu
http://www.ce.umn.edu/~smith
Skype: kasmithtc

Modeling

Modeling in its broadest sense is the cost-effective use of something in place of something else for some cognitive purpose (Rothenberg, 1989). A model represents reality for the given purpose; the model is an abstraction of reality in the sense that it cannot represent all aspects of reality.

Any model is characterized by three essential attributes: (1) *Reference*: It is *of* something (its "*referent*"); (2) *Purpose*: It has an intended cognitive *purpose* with respect to its referent; (3) *Cost-effectiveness:* It is more *cost-effective* to use the model for this purpose than to use the referent itself.

Rothenberg, J. 1989. The nature of modeling. In L.E. Widman, K.A. Laparo & N.R. Nielson, Eds., *Artificial intelligence, simulation and modeling*. New York: Wiley

Modeling Heuristics

Ravindran, Phillips, and Solberg (1987):

1. Do not build a complicated model when a simple one will suffice.
2. Beware of molding the problem to fit the technique.
3. The deduction phase of modeling must be conducted rigorously.
4. Models should be validated prior to implementation.
5. A model should never be taken too literally.
6. A model should neither be pressed to do, nor criticized for failing to do, that for which it was never intended.
7. Beware of overselling a model.
8. Some of the primary benefits of modeling are associated with the process of developing the model.
9. A model cannot be any better than the information that goes into it.
10. Models cannot replace decision makers.

Modeling Resources

- D. Hestenes. 1987. Toward a modeling theory of physics instruction. Am. J. Phys. 55, 440–454.
- Anne-Marie Hoskinson, Brian A. Couch, Benjamin M. Zwickl, Kathleen A. Hinko, and Marcos D. Caballero. 2014. Bridging physics and biology teaching through modeling. *American Journal of Physics 82*, 434.
- Redish, E.F. and Smith K.A. 2008. Looking Beyond Content: Skill Development for Engineers. *Journal of Engineering Education* Special Issue,
- Smith, K.A., & Starfield, A.M. 1993. Building models to solve problems. In J.H. Clarke & A.W. Biddle, (Eds.), *Teaching critical thinking: Reports from across the curriculum*. Englewood Cliffs, NJ: Prentice-Hall, 254-263.
- Smith, K.A. 1993. Designing a first year engineering course. In Mark E. Schlesinger & Donald E. Mikkola (Eds.), *Design Education in Metallurgical and Materials Engineering*, Warrendale, PA: The Minerals, Metals, and Materials Society, 59-73.
- Smith, K.A., Wassyng, A. and Starfield, A.M. 1983. Development of a systematic problem solving course: An alternative to the use of case studies. In L.P. Grayson and J.M. Biedenbach (Eds.), *Proceedings Thirteenth Annual Frontiers in Education Conference*, Worcester, MA, Washington: IEEE/ASEE, 42-46
- Starfield, A.M., Smith, K.A., and Bleloch, A. 1994. *How to model it: Problem solving for the computer age.* Revised Edition - software added. Edina: Interaction Book Company.