Categorization and Representation of Physics Problems by Experts and Novices

Examining organization of semantic information in the domain of Physics for PROBLEM SOLVING for experts versus novices:

1. Use of problem categories (models) to solve problem
2. Types of problem categories used
3. Knowledge associated with problem categories
4. Features of problems that affect how problem represented

Operational definitions:
PROBLEM REPRESENTATION: is a cognitive structure corresponding to the problem, constructed by solver on the basis of domain-knowledge and its organization
PROBLEM SCHEMATA: Category and associated knowledge

HOW IT WORKS:
• Problem solving begins with categorizing the problem in a bottom up manner by analyzing the problem features
  o Experts and novices use the same features but the cues elicit greater knowledge and more abstract representations in experts than novices
    ▪ Novices use surface features in problem
    ▪ Experts transform into 2nd-order features
• Once correct category is chosen, representation completed in a top-down manner with knowledge cued by category label filling in the representation
  o Productions and models
• Experts’ knowledge contains great deal of procedural knowledge (with explicit conditions for when to apply)
• Novices’ knowledge is very content specific with lack of understanding of underlying theoretical principles

STUDY ONE: What knowledge do the problem categories trigger for experts v. novices?
Expert: Physics principles (underlying deep relations between objects)
Novices: Surface features (physical features of objects in problem)

STUDY TWO: Reaffirming novices sort categories by surface features and experts by physics principles but add concept of intermediate expertise levels
Intermediate expertise: use some physics principles and some surface features

STUDY THREE: What are contents of problem schemata?
Node link structural model: Experts use more theoretical knowledge – theory drives representation of the problem
Production Rules model: Experts place physics principle on action side of If – then rules so theory is providing template for action versus novices’ content-specific actions with theory on the condition side of if-then rules

STUDY FOUR: What features cue categories?
Same key words of problems queue categories for experts and novices but experts use a subset of keywords, requiring less cues→therefore it is the mental representation not the cues themselves that predict success at categorizing problem
McDermott & Larkin (1978): Progresses through 4 stages of representations (p134):

1. Literal representation of the problem statement
2. Naïve representation of objects and their spatial relationships
   *Naïve because don't need to know domain to get this type of representation*
3. Scientific representation contains IDEALIZED objects and IDEALIZED relationships
4. Algebraic representation