11/16: Problem Solving

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5*, 121-152.

Research goal: differences between experts and novices in solving physics problems.

Background (Literature):

General Difference: experts engage in qualitative analysis of the problem prior to working with the appropriate equations. This is an initial categorization to narrow down the search to a small set of possible operations (similar to chess expert).

- early phase of problem solving (qualitative analysis) involves the activation and confirmation of an appropriate schema (principle-oriented knowledge structure)
- The initial activation of this schema can occur as a data-driven response to some fragmentary cue in the problem
- once activated, the schema itself specifies further (schema- driven) tests for its appropriateness (Bobrow & Norman, 1975).
- when the schema is confirmed, the knowledge contained in the schema provides the general form that specific equations to be used for solution will take.
- the solver then needs only to specify these terms for the problem at hand.
- the equations used depend more on the way the problem is represented than on the "unknown."
- the status of the unknown in the expert solution method appears secondary to that of deciding which physics principles have their conditions of applicability met in the problem.

The authors suggest that problem solving in a rich knowledge domain begins with a brief analysis of the problem statement to categorize the problem. They undertake four studies

1. the existence of problem categories as a basis for representation;
2. differences in the categories used by experts and novices;
3. differences in the knowledge associated with the categories; and
4. features in the problems that contribute to problem categorization and representation.

They reported the following outcomes:

- experts categorize problems into types that are defined by the major physics principles that will be used in solution,
- novices categorize them into types as defined by the entities contained in the problem statement.
- authors view: the categories of problems represent internal schemata, with the category names as accessing labels for the appropriate schemata.
- the categories constructed by the novices may not correspond to existing internal schemata, but rather represent only problem discriminations that are created on the spot during the sorting tasks

- the persistence of the appearance of similar category labels across a variety of tasks gives some credibility to the reality of the novices' categories even if they are strictly entities related.
- conception of problem solving begins with the typing of the problem (or activating the appropriate schema) in a bottom-up manner by analyzing the problem features, Study Four attempted to capture these features.

Findings:

- both skill groups use the same basic set of features in the problem statement
- the cues themselves and their interactions engage greater tacit knowledge for the experts than the novices.
- once the correct schema is activated, knowledge---both procedural and declarative---contained in the schema is used to further process the problem in a more or less top-down manner.
- the declarative knowledge contained in the schema generates potential problem configurations and conditions of applicability for procedures which are then tested with what is presented in the problem statement.
- the procedural knowledge in the schema generates potential solution methods that can be used on the problem.

Experts:

- base their selection of the appropriate principle on the resulting second-order, derived cues.
- experts' schemata contain a great deal of procedural knowledge, with explicit conditions for applicability.

Novices:

- use the features explicitly stated in the problem.
- novices' schemata contain sufficiently elaborate declarative knowledge about the physical configurations of a potential problem, but lack abstracted solution methods.