# Towards a Spanning Architecture for Analogical Problem Solving

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## Introduction

Prior work has claimed that analogy can be a detriment to problem solving. (VanLehn & Jones, 1993) VanLehn & Jones claimed that poorer problem solvers used analogy more frequently and with less effectiveness. However, analogy can be used in problem solving in a variety of ways, and we claim that some methods can have significant benefits. We are exploring the possible ways that analogy can be used in problem solving. In particular, we intend to explain some aspects of the performance of individuals in terms of the differences in their use of analogy.

## Theory

Analogy can be used in many ways in problem solving. For example, analogy can be used to lay out an initial overall plan when first attempting a problem. This indexical use of analogy can quickly retrieve relevant knowledge. It can also enable a problem solver to get to a solution faster by using more optimal control knowledge. Alternatively, this can be bad for a problem solver if the control knowledge in the example is less optimal.

This may also occur when analogy is used as a "recipe", where a surface level match which lacks deeper relational correspondences is chosen. In this case, we would expect to see errors in the problem solver's performance, because where the past example may have used a particular technique, the problem solver would blindly use that technique without considering the conditions of applicability.

Analogy can also be used to resolve impasses. This technique allows a problem solver to solve problems that it would not have otherwise been able to solve. This way a problem solver can also achieve a means of graceful degradation. Instead of failing, a problem solver can proceed with a probable solution path.

Analogy can also provide a means to introduce learning into problem solving. Since analogy involves a comparison, an analogy can be used to discover differences between a base and a target. These differences can be used to learn other rules. For example, if in one case a technique was used, and in another case a different technique was used, then perhaps the analogy will highlight the difference between the two situations that caused that decision to be made. Likewise, analogy can be used to discover commonalities between a base and a target. These areas of overlap could provide the basis for constructing a schema.

## Architectural Plans

We are studying physics problem solving because there have already been studies of human problem solving in that domain. Unfortunately, previous simulation efforts have been limited to small number of examples, which precludes simulation of substantial learning.

We are constructing a *spanning architecture*, which we define as a model that is able to cover the space of individual performances. This architecture will cover the ways that people can use analogy in problem solving. Underlying this architecture is the MAC/FAC system, which is a two-stage model of analogical retrieval. (Forbus, Gentner, & Law, 1995) This model includes SME, which will be used to generate analogical inferences. (Falkenhainer, Forbus, & Gentner, 1989)

The architecture will be implemented as a suggestion module in TPS. (Pisan, 1997) TPS is a suggestion-based architecture that solves a wide variety and large number of problems in thermodynamics.

Our architecture retrieves relevant past examples using MAC/FAC. Since each example may be mapped to the current problem in different ways, there may be multiple mappings per example. All examples are considered independently. Some of these mappings are selected. If TPS chooses to use one of the remaining mappings, then our architecture chooses inferences from the analogical inferences that mapping supports and makes them into the TPS database, where they contribute to the problem solving process.

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