Title

Explaining Success in Discovery Learning. Analyses Leading Towards a Computational Model

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 21(0)

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Publication Date
1999

Peer reviewed

Explaining Success in Discovery Learning. Analyses Leading Towards a Computational Model.

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Abstract

This paper describes the results both of a rational analysis of discovery learning and of an analysis of think aloud data. These data were gathered while subjects learn the effects of different nominal factors in a simulated domain. The reported analyses are conducted to guide the modeling of discovery learning in Act-R.

Introduction

The project reported here is about the construction of an Act-R model (Anderson & Lebiere, 1998) of discovery learning. Learners in our task (see Wilhelm et al.) had to discover what factors determine whether a boy (Peter) comes late at school. Learners construct instances of five given factors with 2x2x3x2x2 levels (e.g., the type of bike used). After constructing an instance, the outcome (in number of minutes too late) for that combination is given. Below we describe the analyses which serve as basis for the modeling.

Rational Discovery Learning

The most economical approach to discovery learning in a domain as sketched above, is to apply a "Vary One Thing At a Time strategy" (VOTAT, Schauble, 1996). A learner systematically using VOTAT in the Peter domain constructs a base instance and six instances in which each time one factor has another level. Given these seven instances, all main effects can be derived by comparing these.

But by using this strategy, a learner does not discover possible higher level effects. If a learner suspects that the domain might contain these effects, there are a three different approaches to test for higher level effects. (1) If something is known about the possible outcomes, the learner can check whether the found outcomes fit the possible outcomes. (2) If (domain related) prior-knowledge does not align with the found effects, this might be an indication of higher level effects. (3) A learner might construct some "random" instances to test by trial whether the found effects are generalizable. Although this last approach might not seem to rational, it is a useful technique because it does not require a lot of effort for a relative high change of discovering higher order effects. These three approaches are identified in the current data.

Protocol Analysis of Discovery Learning

Besides a rational task analysis of discovery learning, we also examined the think aloud protocols of learners working in the Peter-task. As initial framework for the analysis of think aloud protocols, we used the SDDS theory (Scientific Discovery as Dual Space Search, Klahr & Dunbar, 1988). However, although the SDDS theory can be used to classify learners at a higher grained level, it is not specific enough to classify the motives for individual actions.

For example, a lot of subjects try to construct an instance that makes Peter arrive on time. This kind of behavior, often called "engineering", is located in the SDDS Experiment Space. That is, no concrete hypothesis is tested when constructing these instances. Another strategy mainly concerned with actions in the Experiment Space is one in which a learner systematically varies one or more factors, without explicitly mentioning a hypothesis. According to the SDDS theory, both strategies are typical strategies of "Experimenters", learners who derive knowledge from experiments, without using hypotheses. To be able to categorize learners at a more fine-grained level, we used the following categories: (1) **Empiricist**. A learner who systematically changes one or more factors per instance, not necessarily with mentioning a hypothesis, to induce the effect of the varied factors. (2) **Theorist**. A learner who constructs instances to test a theory about the domain, not necessarily using sound experimenting techniques. (3) **Engineer**. A learner who focuses on the outcomes of instances instead of on the underlying effects causing the particular outcomes. The difference between these strategies is the motive of the actions, instead of focussing on the actions themselves as in the SDDS theory. During the discovery process, learners often shift from engineering or theorizing strategies to a more empiricist approach.

Conclusion

Currently, we are expanding the implemented VOTAT strategies to incorporate the different motives learners have for constructing their instances. By incorporating the motives and modeling the shift from one strategy to another, we aim at explaining why some learners perform better than others.

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