

# Characterizing Learning Progress of Problem-Solvers Using Puzzle-Solving Log Data

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## ABSTRACT

The goal of this paper is to gain insight into the problem-solving practices and learning progressions by analyzing the log data of how middle school and college players navigate various levels of *Baba Is You*, a puzzle-based game. In this paper, we first examine features that can capture the problem-solving practices of human players in early levels. We then examine how these features can predict players' learning progressions and their performance in future levels. Based on the results of the current quantitative analyses and grounded in our previous in-depth qualitative studies, we propose a novel metric to measure the problem-solving capability of students using log data. In addition, we train artificial intelligence (AI) agents, particularly those utilizing Reinforcement Learning (RL), to solve *Baba Is You* levels, contrast human and AI learning progressions, and discuss ways to bridge the gap between them.

## Keywords

Baba Is you, Human Learning, Reinforcement learning, Problem-solving, Learning progression

## 1. INTRODUCTION

### 1.1 Problem-solving & Log Data

There is ubiquitous agreement that problem-solving is an important goal of STEM education [8, 4, 3]. However, there is little agreement as to what features compose effective problem-solving or how to teach and measure these features [14]. Advancements in AI and human behavior analysis introduce the possibility of identifying these features, capturing problem-solving performance in rich detail, and consequently providing problem-solvers with just-in-time feedback and scaffolding [16]. Several works have tried to accomplish this using *log data* generated from interaction with

a digital environment. For example, Wang et al. [17] have examined how to engineer features from log data to capture the efficacy of problem-solvers' data collection when solving electric circuit problems. Bumbacher et al. [2] and Perez et al. [13] have used log data to determine how deliberately a person engages in problem-solving related to physics. Here we continue this line of work by using log data of problem-solvers interacting with the puzzle-based game *Baba Is You*. We also compare the problem-solving processes of human problem-solvers with a standard reinforcement learning agent and discuss the potential underlying causes of these differences.

### 1.2 Reinforcement Learning & Human Comparisons

It has long been noted human learning behaviors in game environments differ significantly from those of standard Reinforcement Learning (RL) algorithms, with much attention paid to the sample inefficiency of the latter [11]. Tsividis et al. [15] study human learning behaviors in the Arcade Learning Environment (commonly referred to as Atari [1]), and hypothesize a range of mechanisms for their differences with RL algorithms. Human and reinforcement learning behavior and attention [9] as well as neural activity [5] have been also compared within the Arcade Learning Environment. Works have investigated the inclusion of object representations [6] and linguistic grounding [10] so as to close the gap between human and RL behaviors. Dubey et al. [7] compare human and RL algorithm behavior in environments specifically designed to limit the usefulness of human visual priors. Our work, while preliminary, eventually seeks to characterize the sorts of representations and motivations RL systems need in order to engage in human-like problem-solving behaviors in challenging problem-solving environments.

## 2. METHODS

### 2.1 Baba Is You

*Baba Is You* is a puzzle game where players can change the rules by which they play. In *Baba Is You*, players move *Baba*, a small sheep-like creature, by pressing keys or buttons/joysticks on a controller to make *Baba* move up, down, left, or right; players can also reverse their actions in a level or restart the level completely. At every level, the rules themselves are present as text blocks that players can inter-

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