In-video Tutors: Revisited and Beyond

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Background

- ❑ Demand for online education, specifically in the domain of AI, has exponentially increased over the past decade with instructional videos being the primary method for delivery[1].
- ❑ During the onset of COVID-19, this directly impacted two sets of learners:
  - 19.7 million students enrolling in online post-baccalaureate and post-secondary programs[2].
  - Approx. 100 million adult workers will require upskilling and reskilling[3,4].

Primary Benefit & Challenge of Online Learning Compared to In-Person Instruction

✓ **Scalability:** empower students with increased access to education across domains and disciplines and enable instructors to focus on teaching by leveraging AI and automation to avoid routine tasks.

✗ **Unattainability:** online learning via MOOCs have lower completion ratios and lower student satisfaction than equivalent in-person instruction largely due to passive learning.

Research Questions[1,5,6]

RQ1: How may AI help make online education videos foster active learning and learning by doing?

RQ2: How do we design an effective, repeatable, and scalable online course in the domain of AI?

A Successful Experiment for Teaching Cognitive Systems Online[1,5,6]

- ❑ The CS 7637: Knowledge-Based Artificial Intelligence (KBAI) course taught as part of the Online Master's in Computer Science degree (OMSCS) at Georgia Tech successfully addressed RQ1 and RQ2.
- ❑ Key characteristics of the KBAI course includes:
  - Content based on design-based research and principles of cognitive and learning sciences like *learning by doing*, *learning by example*, *learning by reflection* etc.
  - "Using AI to teach AI" approach such as 100 intelligent tutors embedded in online videos ("in-video tutors") to provide adaptive feedback.

Deep Dive into In-video Tutor Concepts[1,5,6]

- ❑ **Context:** Guide students' understanding of one narrowly defined concept or skill using interactive exercises with in-video tutors
  - E.g.: Completing a semantic network representation problem (see Figure 1 & 2)
- ❑ **Development tools:** Using the Udacity infrastructure and custom Python code to evaluate multiple user input types.
- ❑ **Methodology:** At each step, the tutor contextualizes feedback in terms of the concept demonstrated
  - **Step 1:** Assess the readability of learner's input.
  - **Step 2:** Checks if input matches the rules of the problem.
  - **Step 3:** Assesses if the final state matches the goal state.
- ❑ **Evaluation:** Across two modalities and time periods
  - Class assessment outcomes (Fall 2014): Comparing OMSCS students' (n=200) and in-person students' (m=75) performance, OMSCS students **on average outperformed** in-person students across 14 written assessments and exams.
  - End-of-course student surveys (Fall 2014 to Spring 2017)
    - **> 80%** students (x=1,242) agreed that the interactive exercises were engaging, and the feedback received enhanced course content understanding.

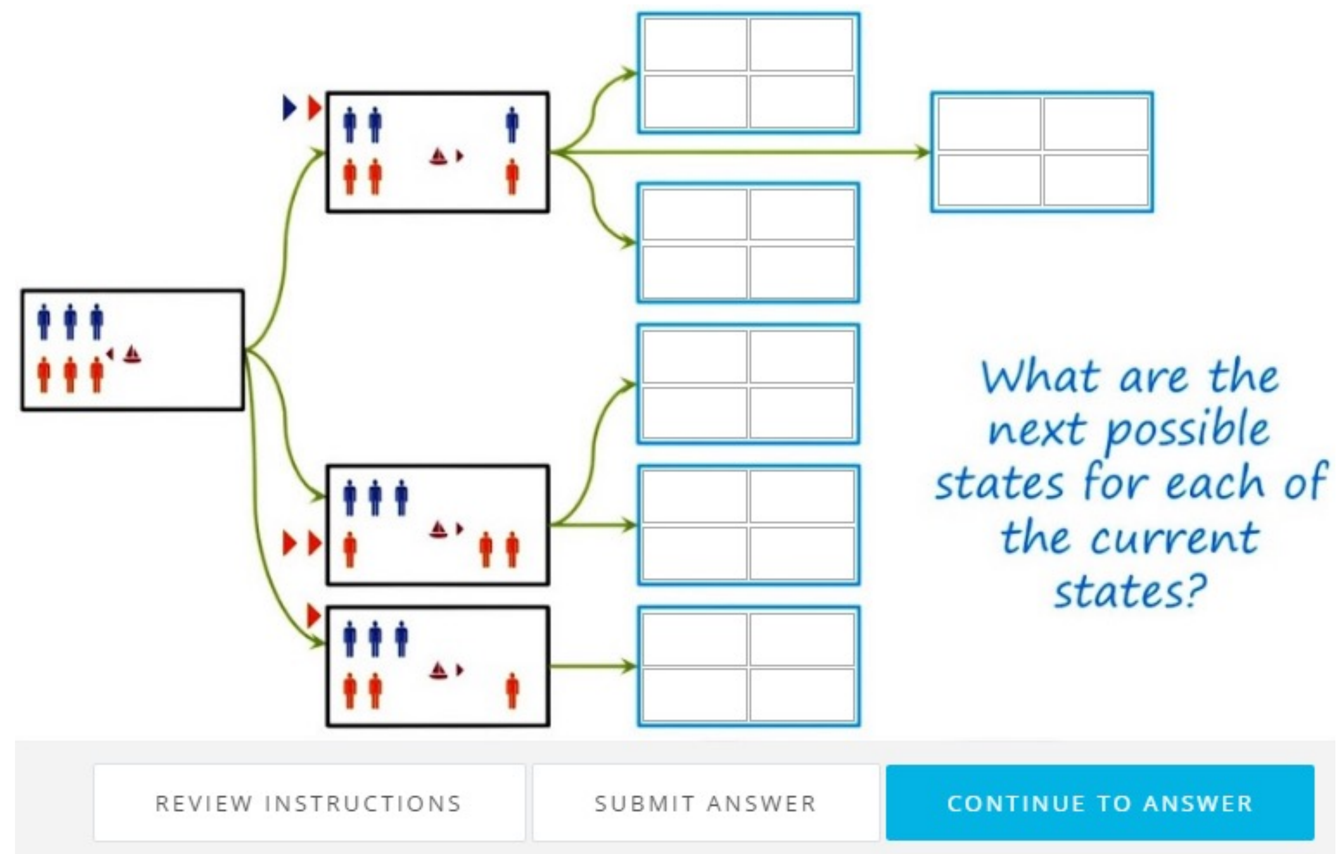

Figure 1: Example exercise from the KBAI course in Fall 2014. Here, students are asked to fill in 24 boxes to represent the possible next states of a problem in means-ends analysis in accordance with rules provided[1,5]

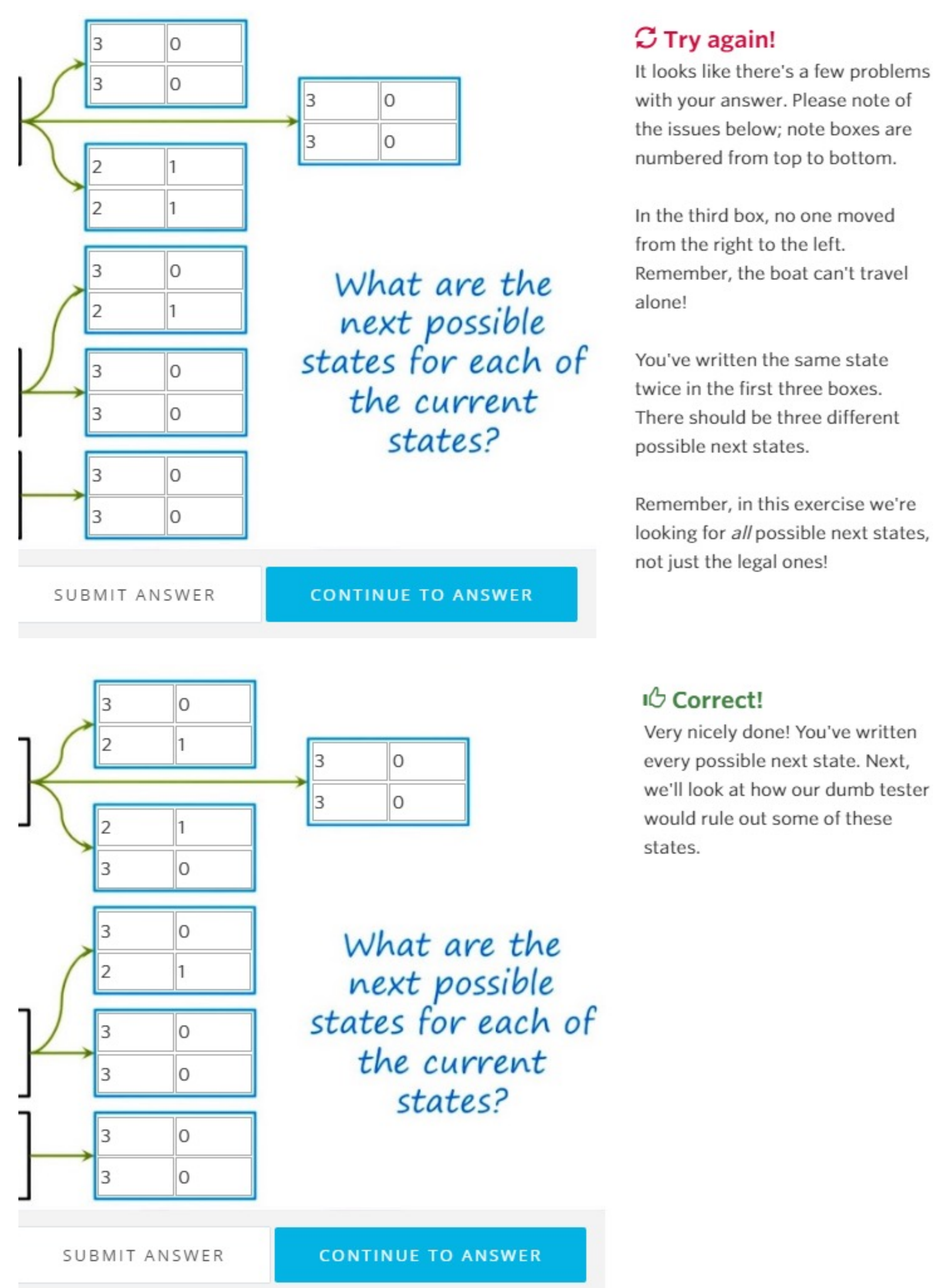

Figure 2: Examples of two pieces of feedback a learner may receive from the in-video tutor based on provided input. The top image represents feedback from the tutor given an incorrect learner response. The bottom image represents feedback from the tutor given a correct learner response[1,5]

Looking Beyond

- ❑ Rethink the ad-hoc process used to develop in-video tutors for the 2014 KBAI course
- ❑ Systematically formalize the methodology, architecture and interface ("tech framework") for in-video tutors that is generalizable and scalable for online courses that have two main characteristics:
  - The primary audience are adult learners.
  - The course content focuses on skill-based learning.

Tech Framework Conceptual Approach

- ❑ **Methodology** (part of content creation, no tutors involved):
  - Step 1: For a given online class where lectures and exercises are in recorded format, list out all the concepts and skills that an educator would like a student to learn
  - Step 2: For each concept *(1..n)*, an educator would list out common student misconceptions *(1..m)*
  - Step 3: For each concept and associated set of misconceptions, an educator would create an exercise to better understand the relationship between incorrect answers (provided by a subset of students) and those misconceptions - this will be handled by the tutor (part of the architecture).
- ❑ **Architecture:** build a tutor for each exercise that can (1) recognize incorrect student responses, (2) correlate an incorrect answer with a misconception, and (3) explain the reasoning
  - For a given exercise, if there are *i* possible solutions where *i-1* solutions are incorrect, and there are *m* possible misconceptions, an in-video tutor would be able to understand student responses and "match" *i-1* incorrect solutions with *m* misconceptions - potentially as a many-to-many relationship
  - For a given (incorrect answer, misconception) pair, the tutor would be able to give an explanation.
  - To what extent will the above "architecture" be accomplished by a low-level architecture is yet to be determined, however, the primary objective of this "architecture" is to not hinder an educator with these (low-level) technical architecture details.
- ❑ **Interface:** Develop an intuitive, high-level interface allowing any educator to build in-video tutors with a course content based on the above-mentioned methodology.

References

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