Resources and Recommendations for K-12 AI Education

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Overview

- Resources for AI Assignments and Projects
- A different description of “Artificial Intelligence”
- How that description encourages an integrative approach across disciplines
- Leveraging what you enjoy in order to promote AI

Educational Advances in Artificial Intelligence

- The Educational Advances in Artificial Intelligence (EAAI) Symposium was established in 2010 as a **primary venue focused on AI Education**.
  - Whereas there have been many venues with a focus on CS education or the application of AI to education, the primary focus of EAAI is on **advancing the education of AI**.
  - It is **collocated with AAAI**, the largest general AI conference in the western hemisphere.
  - Although EAAI has been open to AI educational topics at all levels, there was a **surge in K-12 interest** starting with panels at EAAI-2019 and EAAI-2020 and with a special track at EAAI-2021 "Demos, Tools, and Activities for Teaching AI in K-12".

AI4K12.org (The AI for K-12 Initiative)

- Much of the EAAI content for K-12 (kindergarten through the end of high school, 12th grade) has come from faculty contributing to the efforts of AI4K12.org.
- Jointly sponsored by AAAI and CSTA
- David Touretzky is one of the Steering Committee members for AI4K12, so be sure to see his AIDE talk.

Model AI Assignments

- The Model AI Assignments session of EAAI seeks to gather and disseminate the best assignment designs of the Artificial Intelligence (AI) Education community.
- The largest peer-reviewed archive of open AI assignments.
- While we have invited K-12 materials for over a decade, there has been an increase in K-12 materials in recent years, e.g.
  - "Unplugged" Semantic Networks and Knowledge Representations
  - Using Markov Chain Text Generators To Facilitate Found Poetry Creation

Mentored Undergraduate Research Challenges

- EAAI track for mentored undergraduate research challenge presentations
- Although these research challenges have been run for undergraduates, the software and published resources may serve advanced high-school students as well.
  - Poker Squares
  - Birds of a Feather
  - Gin Rummy
- Teams often consist of students who haven't taken a college-level introductory AI course. They learn AI topics as needed.

What is Artificial Intelligence (AI)?

- Well-defined: “Artificial” = “human-made”
- Ill-defined: “Intelligence” = ???
  - Learning, Knowing, Reasoning, …
  - Effectively: performs well on a difficult task
- What do you call control engineering where stability proofs, etc., are impossible (e.g. autonomous driving, piloting, vacuuming)?
  - ???
- What do you call database research with expressivity and computational complexity beyond that of relational databases?
  - ???

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  - **Robotics, a subfield of AI**
- What do you call database research with expressivity and computational complexity beyond that of relational databases?
  - **Knowledge Representation and Reasoning, a subfield of AI**

A New Perspective on AI

- AI as a Computer Science field welcomes work on *any difficult problem (requiring intelligence) that doesn't fit other categorizations.*
- Thus: **Artificial Intelligence is the really interesting miscellaneous pile of Computer Science.**
- As such, AI shouldn't be taught in K-12 as a separate topic. Rather, it should most naturally integrate with and extend other topics.
- (Similarly, Computer Science programming skills should be integrated with many mathematical topics.)

Example: The Game of Pig

- Materials: A single 6-sided die
- Object: The first player to reach 100 points wins.
- On a turn, a player rolls a die repeatedly until:
  - the player holds, scoring the sum of the rolls ("turn total"), or
  - a 1 ("pig") is rolled, and there is no score change.
- Example turns:
  - roll 4, roll 5, roll 2, hold → add 4 + 5 + 2 = 11 to score
  - roll 3, roll 6, roll 6, roll 1 → score remains the same

A Progression of Probabilistic Pig Problems

- There is a continuum of Pig-related problems spanning from basic probability and introductory programming to reinforcement learning.
- Probability exercises:
  - What is the probability of rolling a Pig (1)?
  - What is the average turn total gain if one doesn't roll a Pig (1)?
  - At which turn total is one indifferent to rolling or holding for expected turn total gain? (expectimax reasoning)
  - The game of Hog is like Pig except that one can only roll once per turn with as many dice as one chooses, i.e. Pig where you predetermine your number of rolls for a turn. How many dice should one roll to maximize ones expected score gain? (2 correct answers!)

A Progression of Probabilistic Pig Problems (cont.)

- Introductory (CS1) Programming Exercises:
  - Monte-Carlo Simulation:
    - Estimate the probability of different hold-at-20 turn outcomes.
    - Estimate the number of turns in a game where 2 players hold at a turn total of ≥20 or that achieves the goal score (hold at 20 or goal).
    - Estimate the first-player win advantage in a 2-player hold at 20 or goal game.
  - Dynamic Programming:
    - What are the actual probabilities for different hold-at-20 turn outcomes?

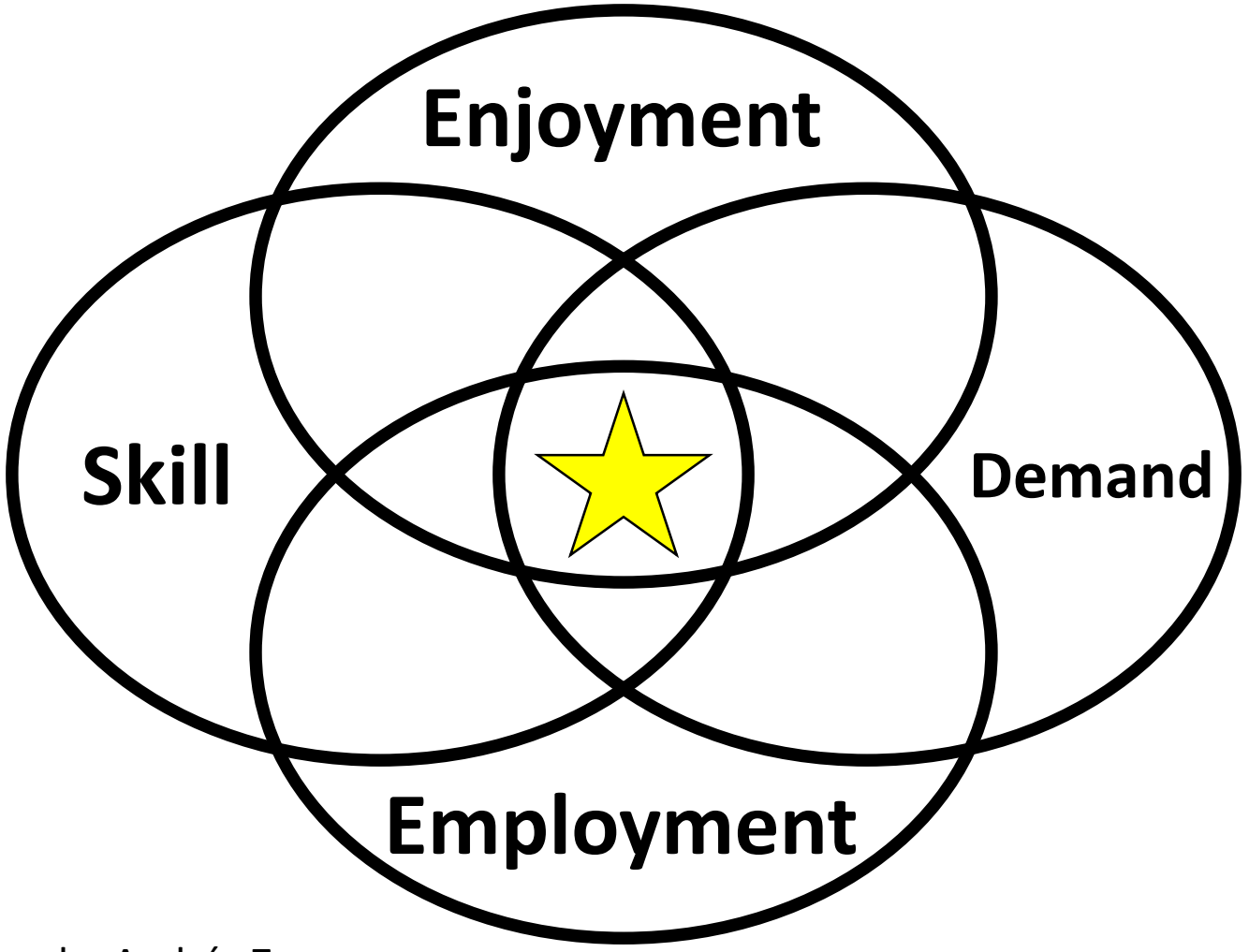
A Progression of Probabilistic Pig Problems (cont.)

- Introductory AI Reinforcement Learning Exercises
  - Dynamic Programming:
    - What is optimal play for Pig Solitaire, where a single player seeks to score *g* points within *n* turns?
    - What is optimal play for Progressive Pig, where a player scores a minimum of 1 point each turn?
  - Value Iteration:
    - What is optimal play for Pig?
    - What is optimal play for Hog?

Other topic integrations

- Statistics: Linear regression → computing linear regression → logistic regression → computing logistic regression = single-layer neural network backpropagation with a sigmoid activation function → neural networks
- Linear algebra: linear systems of equations → solving linear systems through variable elimination or Gaussian elimination → solving linear systems through iterative improvement → solving nonlinear systems through iterative improvement → Bellman's optimality equation → reinforcement learning (value iteration)

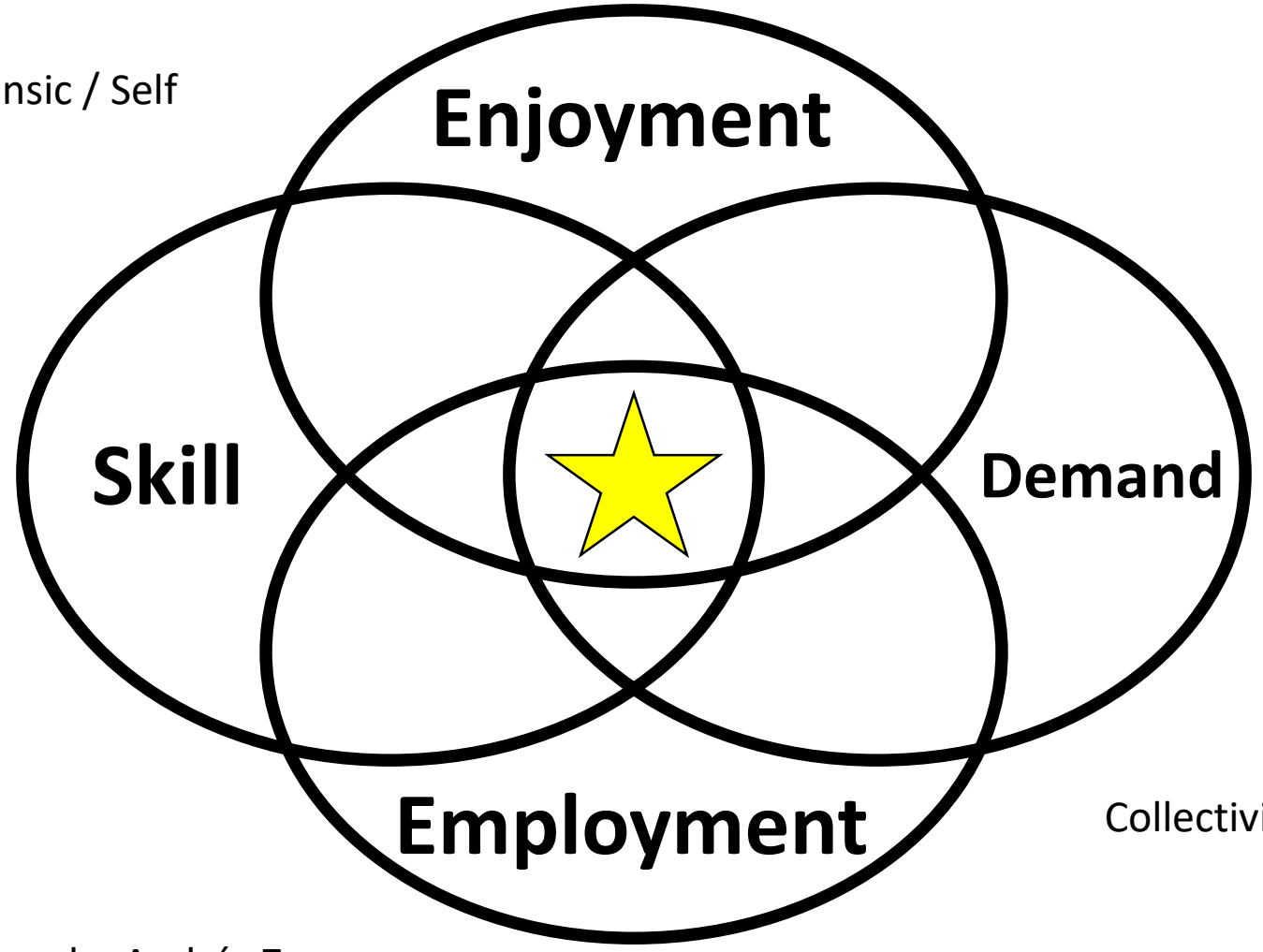
Teach AI to Your Enthusiasms



Adapted from a Venn diagram by Andrés Zuzunaga

Teach AI to Your Enthusiasms

Individualistic / Intrinsic / Self



Collectivistic / Extrinsic / Others

Adapted from a Venn diagram by Andrés Zuzunaga

Integrate AI with Your Topics

- Teaching is more engaging when you genuinely enjoy the topic you teach.
- AI integrates with many topics.
- So integrate the teaching of AI with topics you enjoy.
- Example: Zack Butler, Professor of Computer Science at the Rochester Institute of Technology enjoys orienteering. He created a project for planning human walking routes to illustrate A* search and other concepts.

Conclusion

- It’s difficult to create new AI assignment resources, so see what has already been created: EAAI, AI4K12, MAIA, MURC.
- Artificial Intelligence is the really interesting miscellaneous pile of Computer Science. It defies topical characterization. Therefore, it can and should be taught in integration with other K-12 topics.
- As teachers, I encourage you to find AI applications in topics you enjoy in order to enhance your engaged teaching of AI.