WHAT IS BAYESIAN KNOWLEDGE TRACING?

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LEARNING ANALYTICS SYSTEMS USE BKT TO PREDICT WHAT SKILLS STUDENTS MASTERED

http://www.cs.williams.edu/~iris/res/bkt/

WHY BAYESIAN KNOWLEDGE TRACING?

- Maintains an estimate of the probability that students have learned a particular set of skills in Technologically Enhanced Learning Environments
- Used in the Open Learning Initiative, Open Analytics Research Service, etc. within Learning Analytics systems
- Instructors rely on BKT to assist in making decisions in the classroom
  - Concepts to review • Students to follow up with • Exam question identification

$$P(L_1) = P(L_0) \tag{1}$$

$$P(L_{n-1}|obs_n = corr) = \frac{P(L_{n-1}) * (1 - P(S))}{P(L_{n-1}) * (1 - P(S)) + (1 - P(L_{n-1})) * P(G)} \tag{2}$$

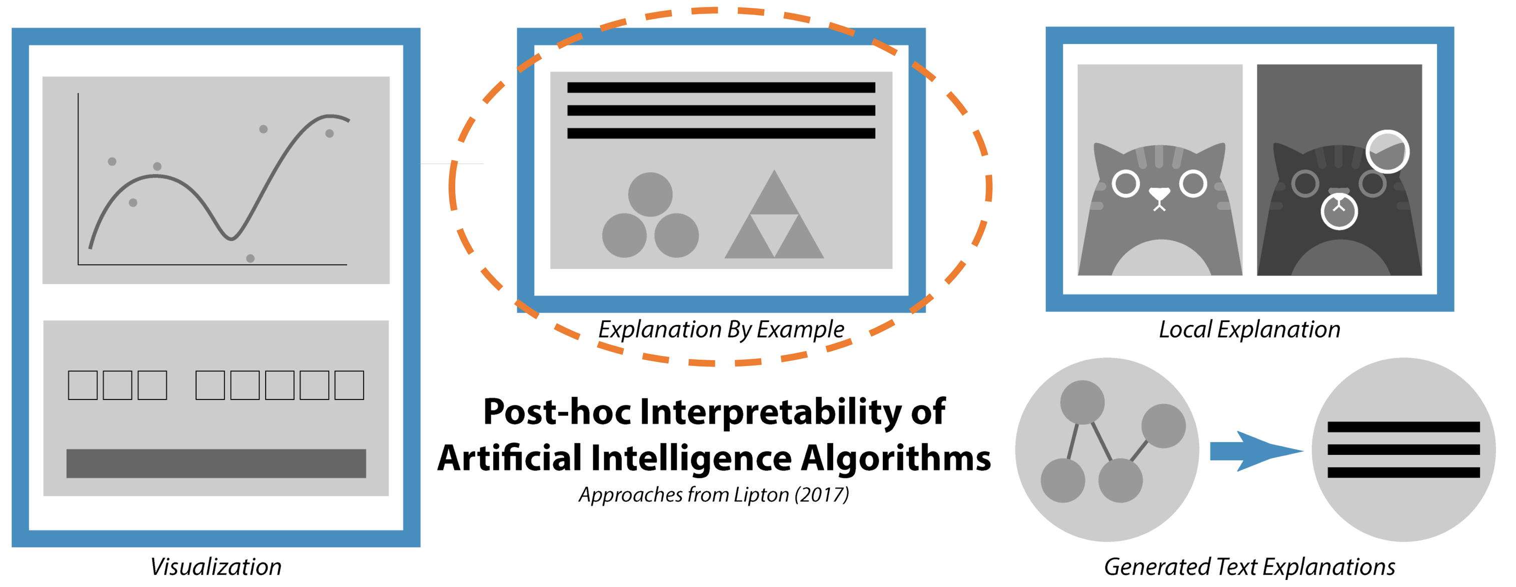
$$P(L_{n-1}|obs_n = incorr) = \frac{P(L_{n-1}) * P(S)}{P(L_{n-1}) * P(S) + (1 - P(L_{n-1})) * (1 - P(G))} \tag{3}$$

$$P(L_n|obs_n) = P(L_{n-1}|obs_n) + ((1 - P(L_{n-1}|obs_n)) * P(T)) \tag{4}$$

A 2-node dynamic Bayesian network

$P(L_0)$: Probability student already knew the skill
$P(T)$: Probability student learned after learning opportunity
$P(G)$: Probability student guessed correctly
$P(S)$: Probability student made a mistake on known skill
If *$P(L_n)$* > 0.95 → Skill is mastered

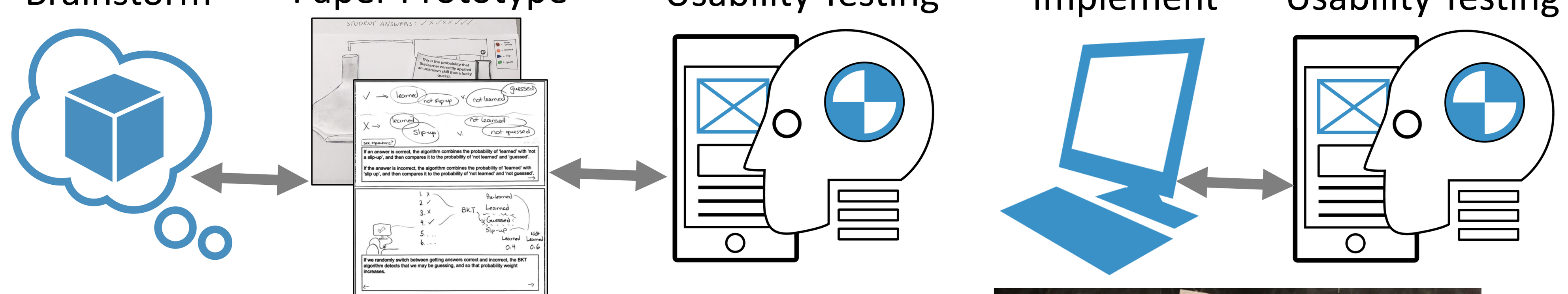
EXPLAINABLES



Post-hoc Interpretability of Artificial Intelligence Algorithms
Approaches from Lipton (2017)

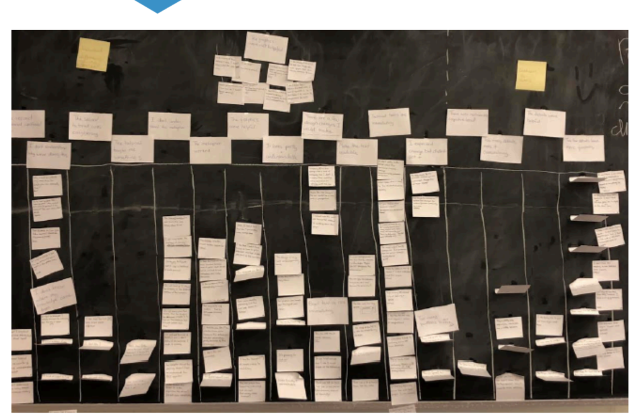
DESIGN PROCESS

Brainstorm · Paper Prototype · Usability Testing · Implement · Usability Testing



Themes: Consider individual differences, Refine the level of detail, Usability design principles

- "Am I supposed to be remembering all these [parameters]? Because that ain't gonna happen."
- "I was able to understand it more because it was more in depth."
- Yeah, now I think I'd believe that [BKT works]."



Affinity Diagram of User Comments

FUTURE WORK

- Interactivity of Explainables → Understanding the Algorithm
- Understanding the Algorithm → Trust, Fairness, Model Interrogation, Decision-making, …

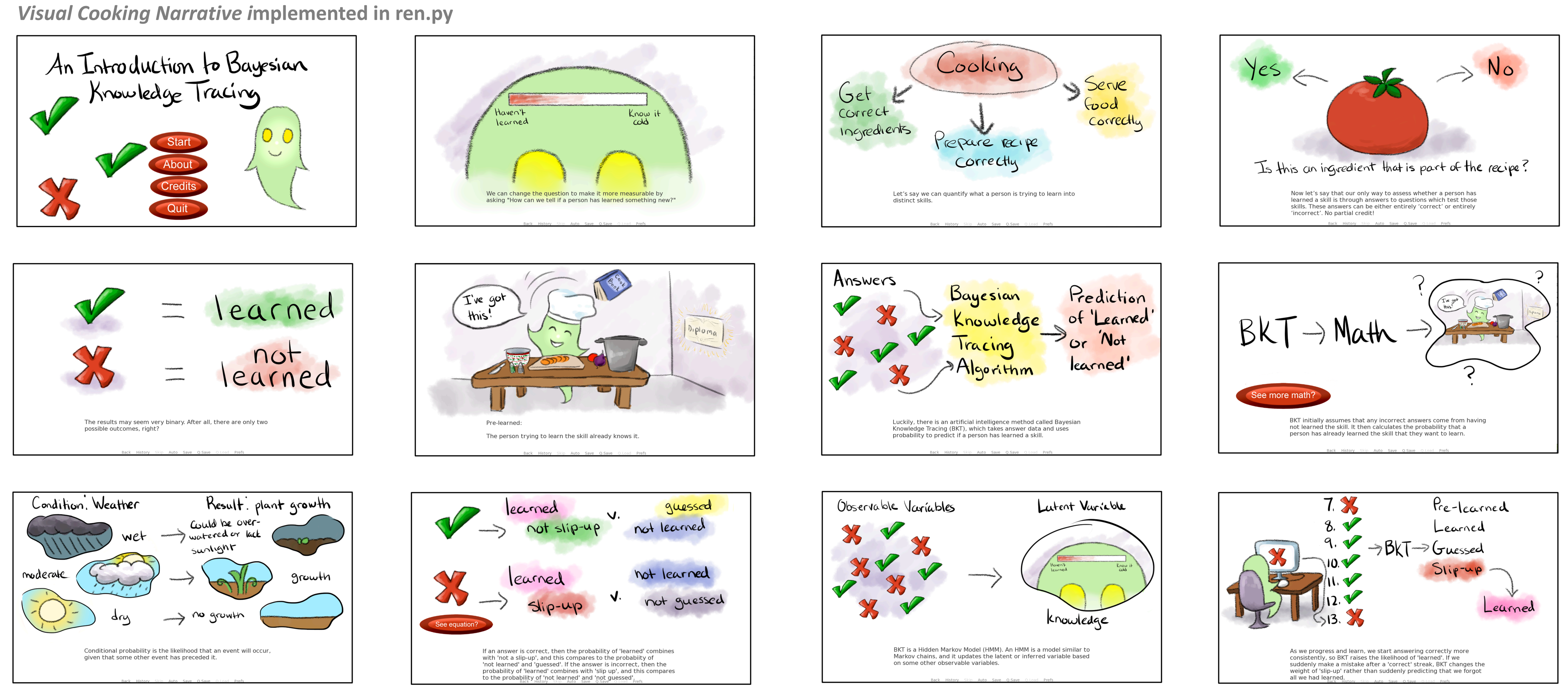
DESIGN PRINCIPLES FROM THE LEARNING SCIENCES

- *Learning by doing*: Learning increases with interactive activities vs. watching videos
- *Backward Design*: Identify learning goals first, then assessments *then* learning activities
- *Cognitive Task Analysis*: Systematically identify hierarchical skills & concepts to learn
- *Zone of Proximal Development*: 'Goldilocks' of learning challenging concepts

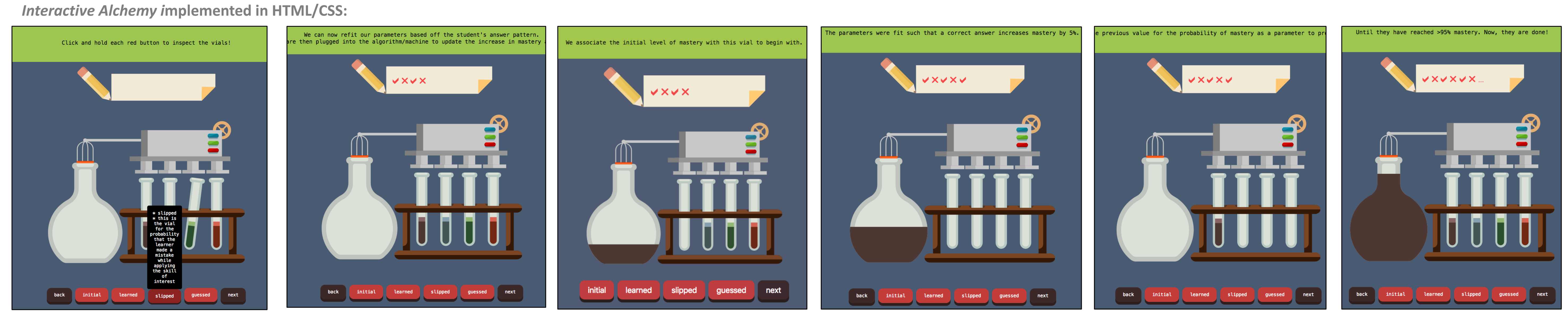
DOES UNDERSTANDING THE ALGORITHM MATTER, IF THE USER CAN'T CHANGE THE SYSTEM?

SAMPLE SCREENSHOTS

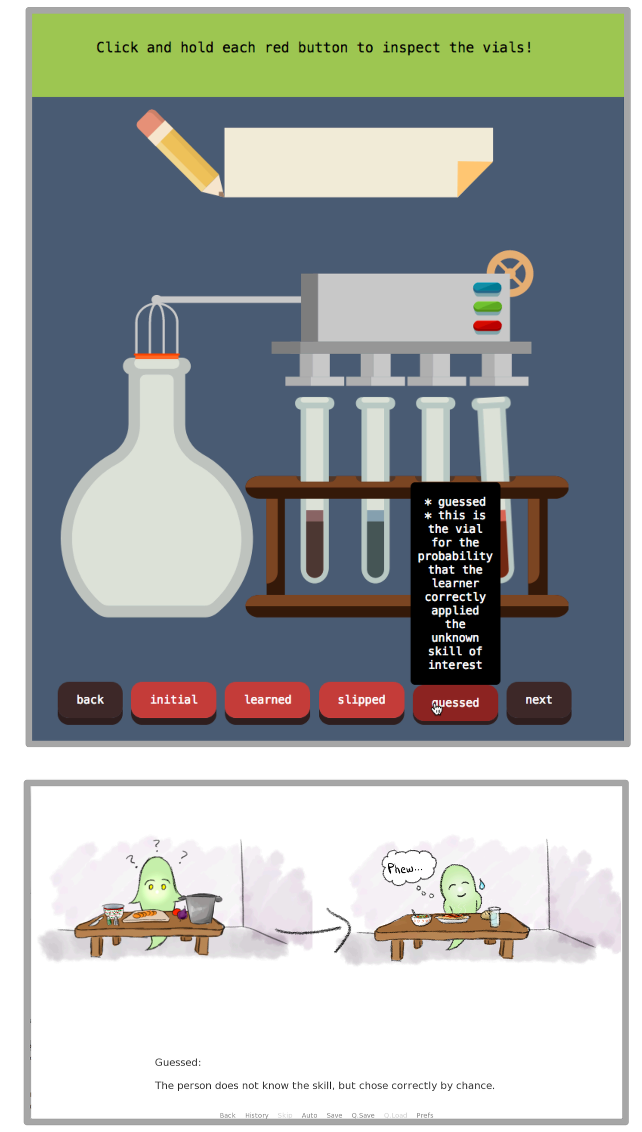
Visual Cooking Narrative implemented in ren.py



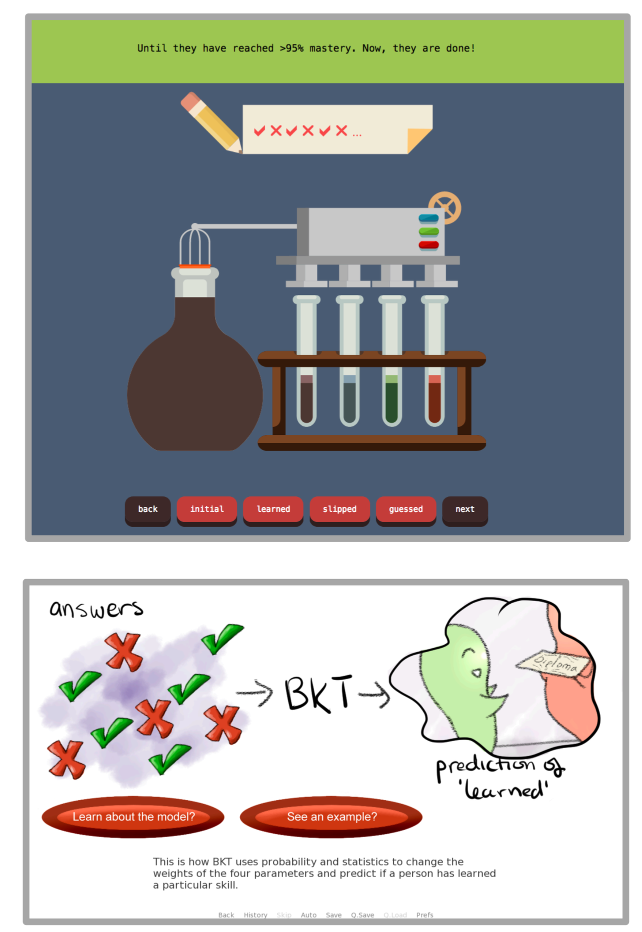
Interactive Alchemy implemented in HTML/CSS:



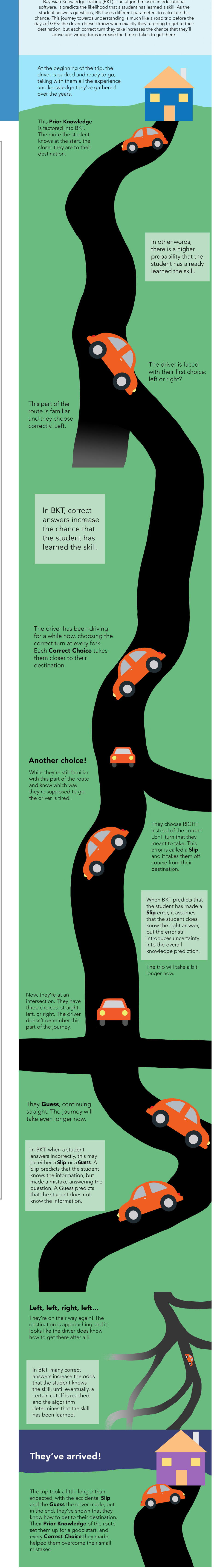
GUESS PARAMETER



MODEL PREDICTION



A BKT Road Trip



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