

# A Deep Dive into Knowledge Tracing

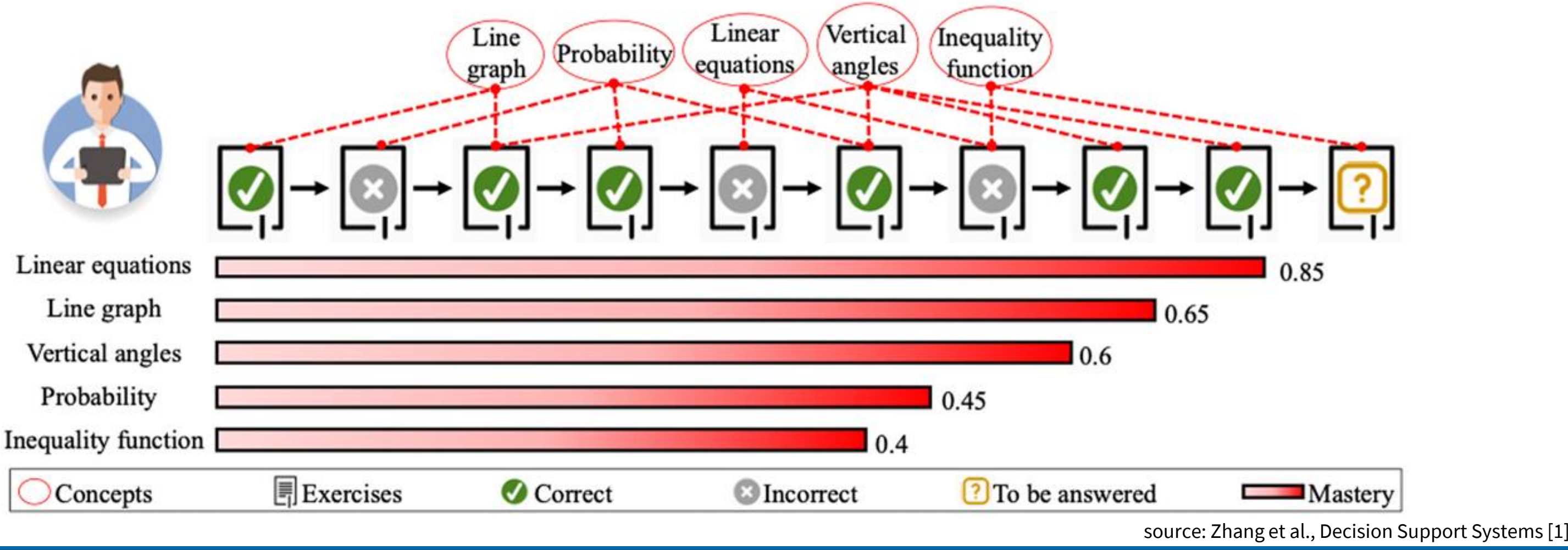
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## Introduction

### Personalized Education

Tailoring educational content and strategies to individual needs using data-driven approaches.

### Knowledge Tracing

Modeling what a student knows and how their understanding changes as they practice and learn [2].

## Key Use Cases

**Highlight Weaknesses:** In real-time learning, choose topics where students are struggling and suggest additional practice.

**Highlight Strengths:** In real-time learning, choose topics which students mastered and reduce their focus.

**Optimize Learning Sequences:** Build adaptive learning paths tailored to each student's progress in real-time.

**Latent structure:** Identify connections between questions.

## Datasets

### Synthetic – 15 skills



### ASSISTments [3] – 109 skills



## Bayesian Knowledge Tracing (BKT)

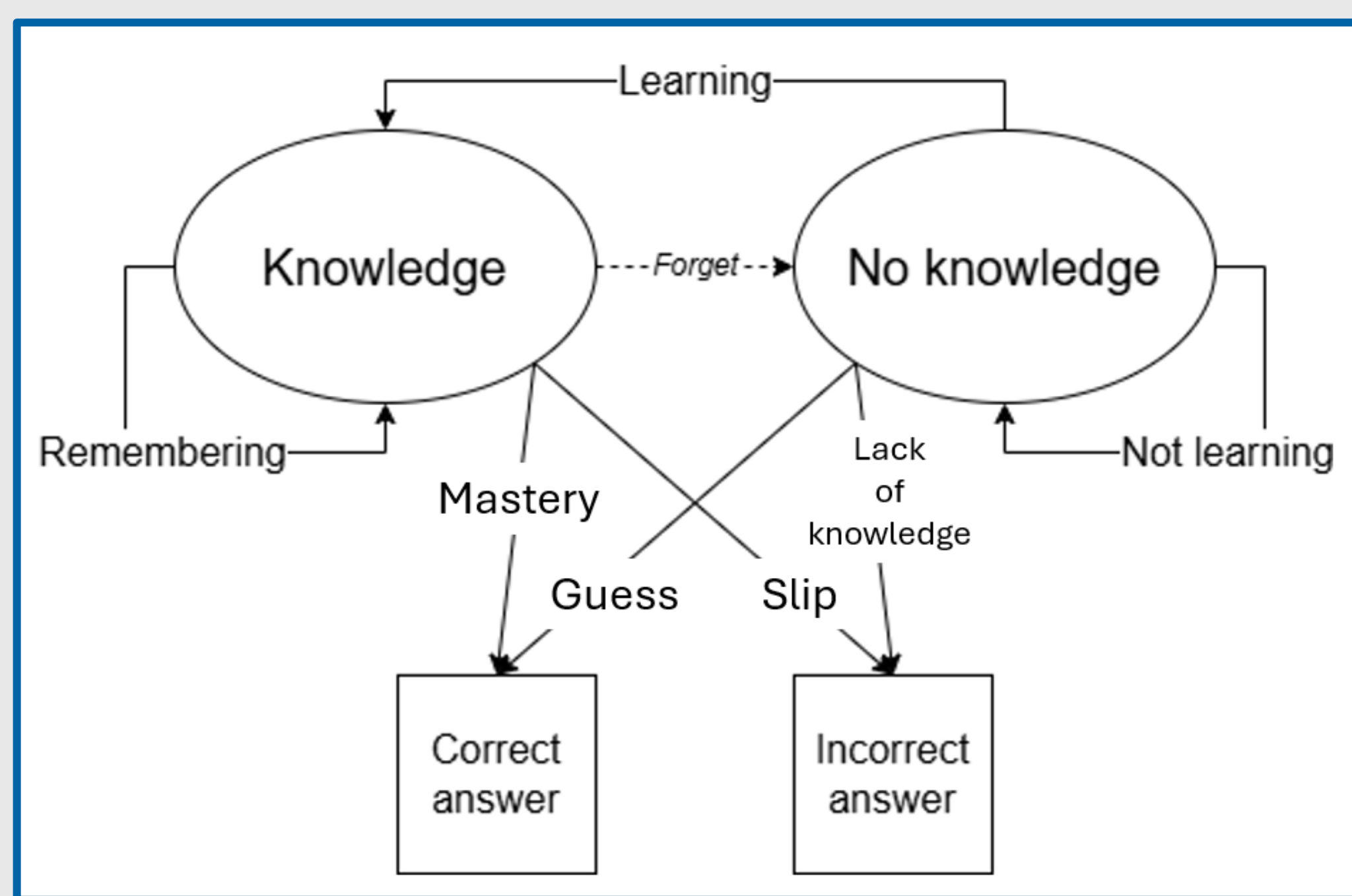
### Definition:

modeling knowledge tracing with HMMs

### Flaws:

- assumes that different skills are independent
- each skill needs a separate model

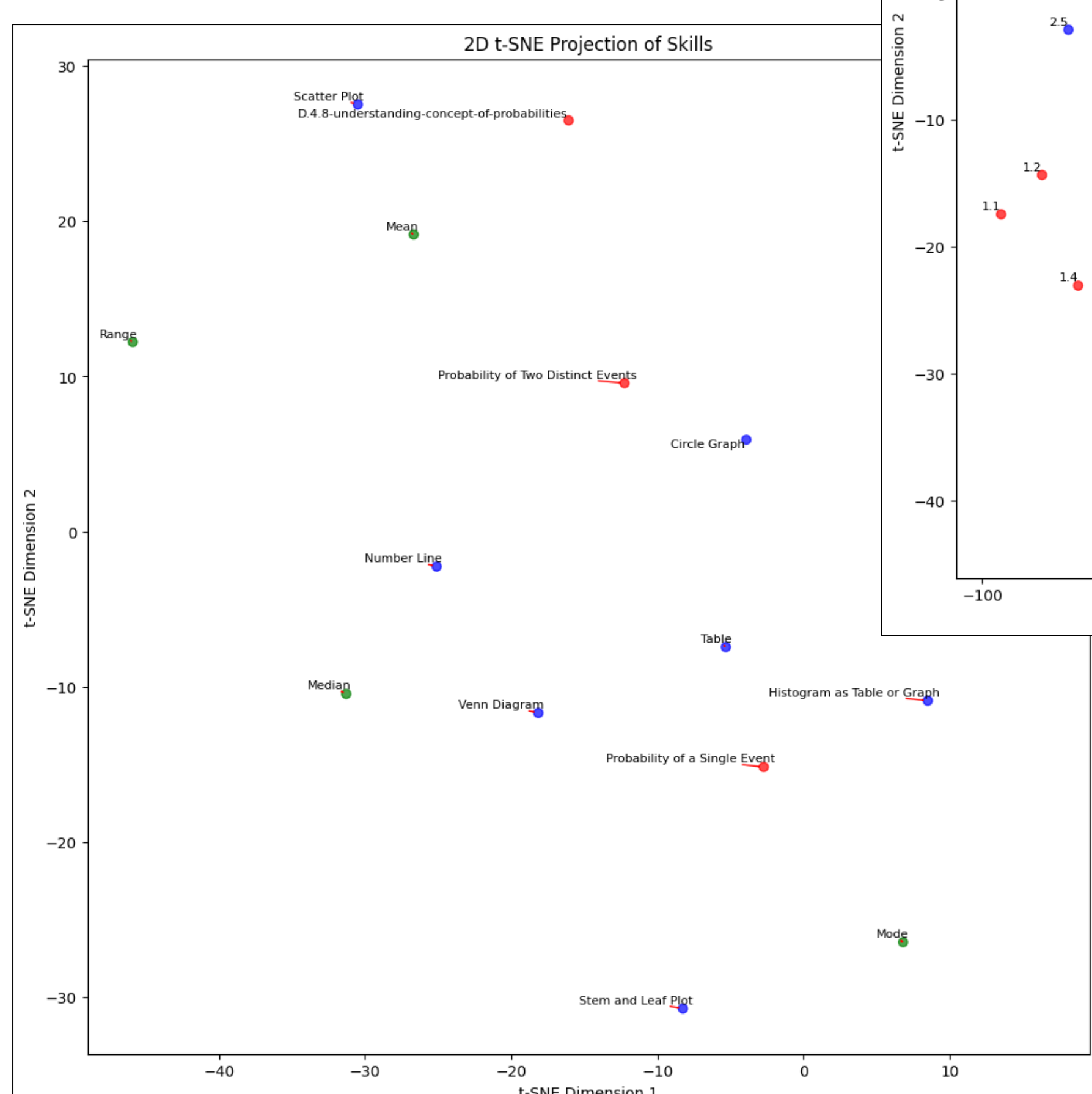
### Solution: DKT [4]



## Latent Structure

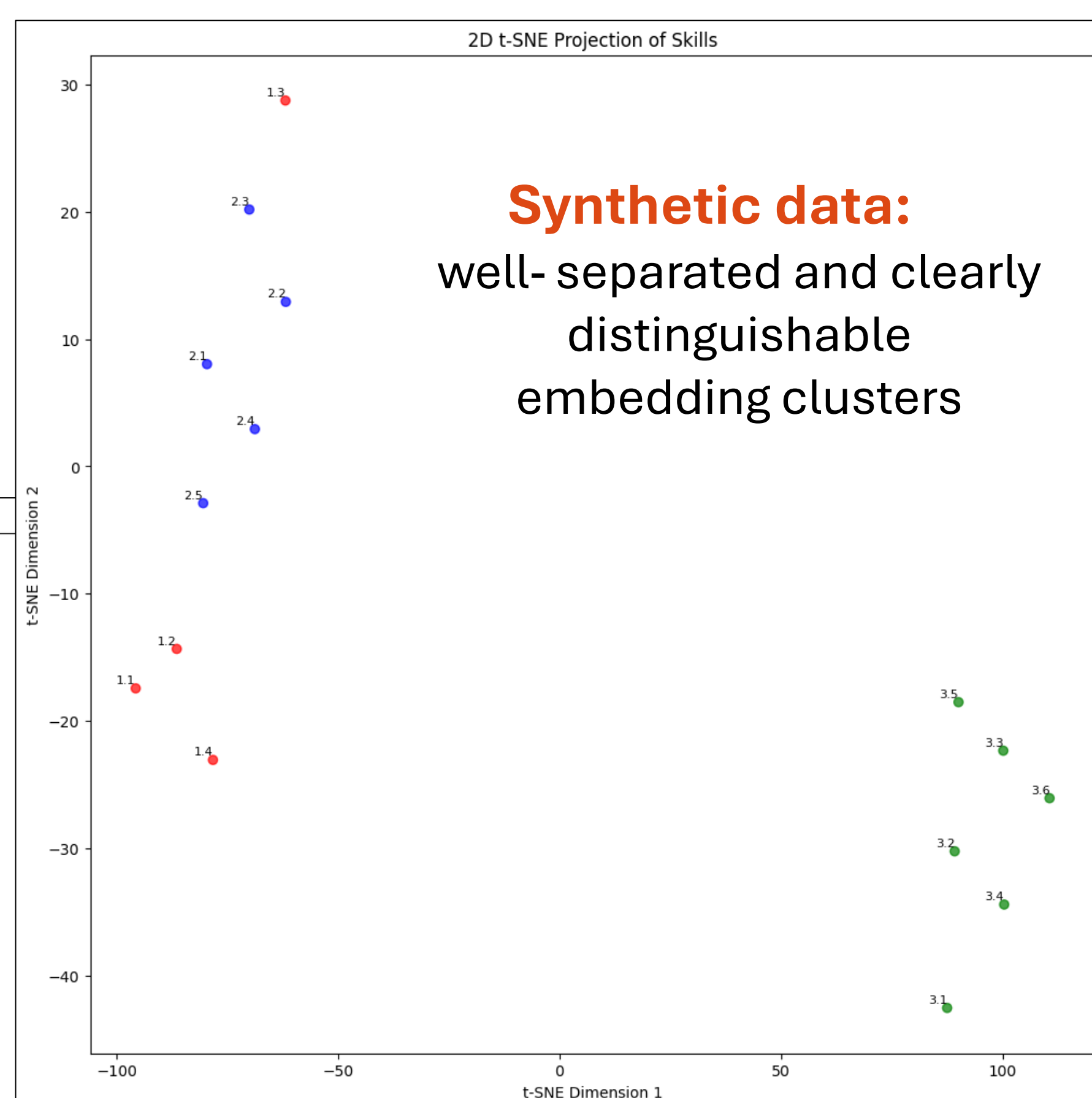
### Hypothesis:

similar skills  
↓  
similar embeddings



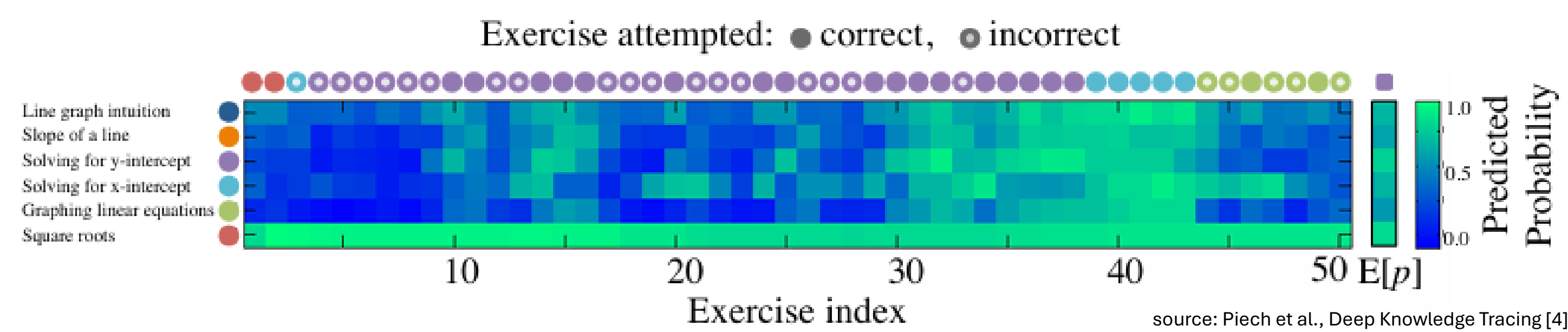
### Synthetic data:

well-separated and clearly distinguishable embedding clusters



### ASSISTments data:

largely unstructured  
↓  
the issue likely lies in the data



## Deep Knowledge Tracing (DKT)

### Definition:

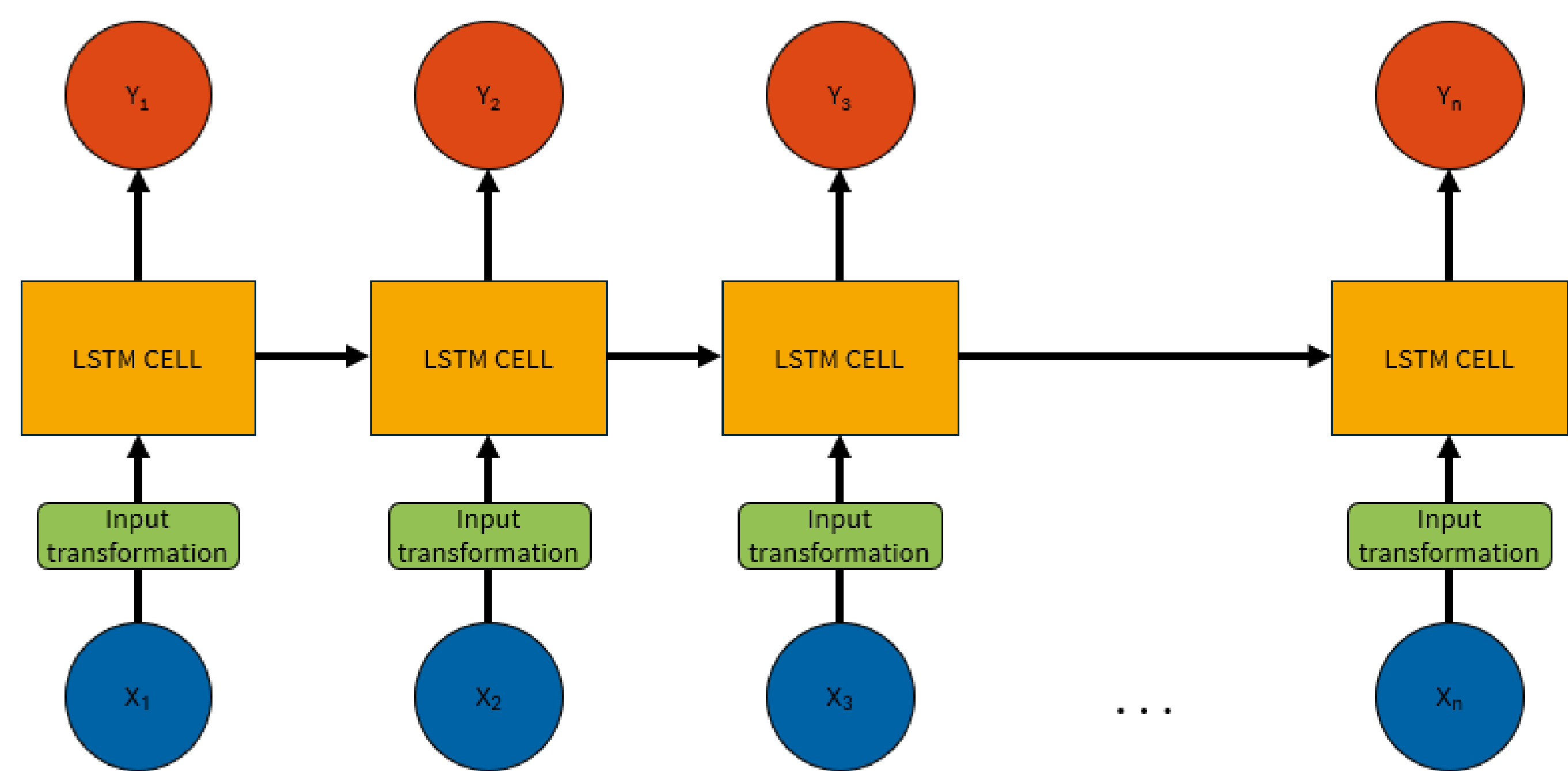
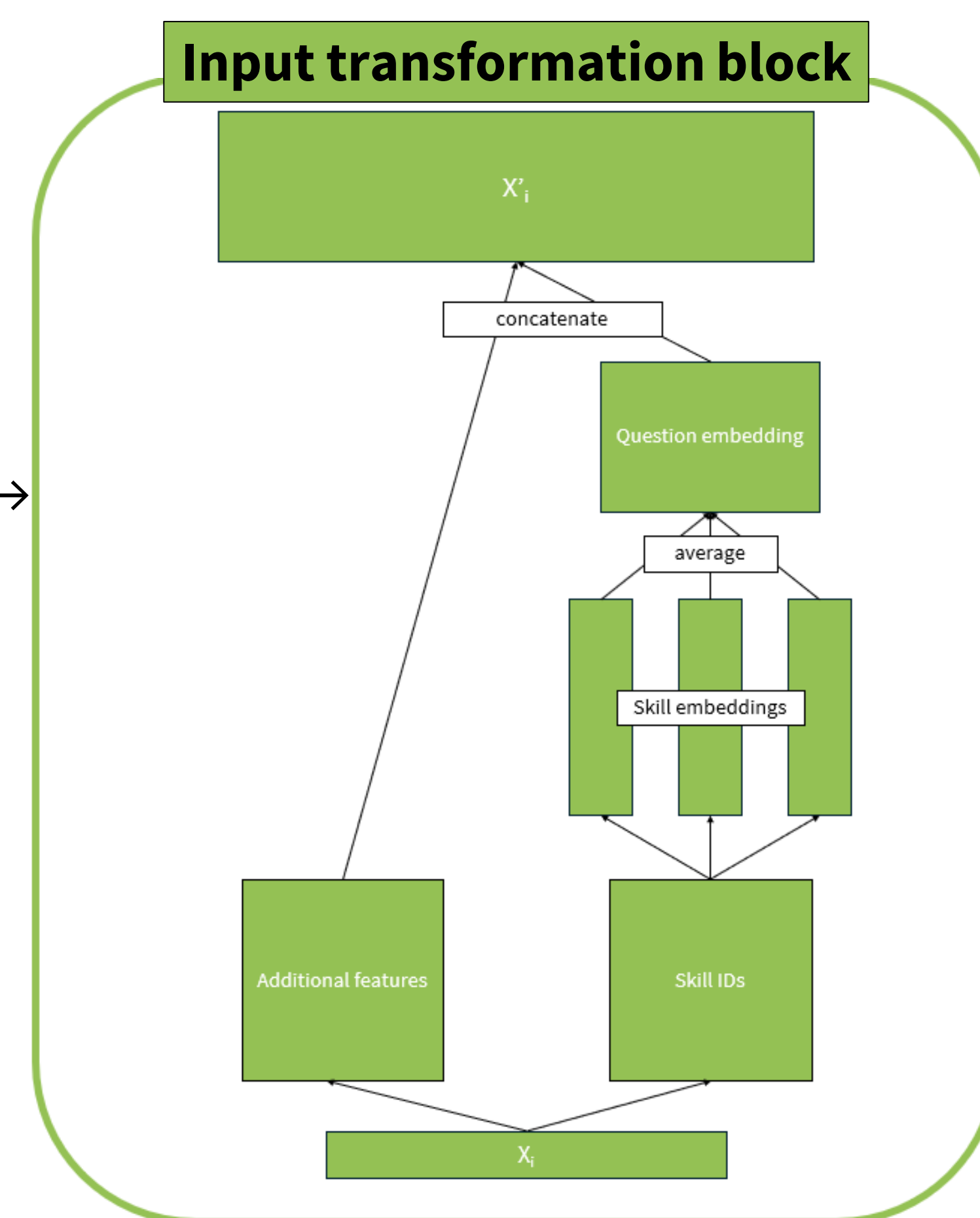
modeling knowledge tracing with NNs

### Model architecture:

Skill ID Embedding → concatenated with other inputs → LSTM → Dropout → Predictions  
 $X_i$  := the first  $i-1$  answers in a student's learning sequence  
 $Y_i$  := predicted knowledge level for all skills after the first  $i-1$  answers

### Novel approach:

learning skill embeddings to identify latent structure



## Experimental results

Dataset	BKT	BKT+	DKT	DKT+	DKT benchmark
Synthetic	0.88	0.88	0.90	-	-
ASSISTments	0.67	0.70	0.79	0.80	0.86

AUC scores evaluated on unseen samples

## Conclusion

The DKT model with learnable skill embeddings achieves **competitive performance** in knowledge tracing. It successfully uncovers latent skill structures in simpler datasets, though it **struggles with** more **complex** ones. These findings highlight the challenges in accurately modelling student learning and emphasize the **need of further experiments**.

## References

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- C. Piech, R. S. J. Baker, D. J. Bernstein, J. Cescovini, and S. Wong. Deep knowledge tracing.