Adaptive Learning Systems

EDUC 5100 | Fall 2022

Guest lecture by Elizabeth Cloude

Welcome!

- Brief introduction

Please call me Liz!

I study how humans self-regulate their learning by measuring cognition, emotions, metacognition, and motivation during learning with educational technologies including ITSs.

- Example: MetaTutor (which we will be discussing today!)

Today’s discussion

- Intelligent tutoring systems built to scaffold metacognition and self-regulated learning (SRL) skills

1. Help Tutor, an ITS for scaffolding help seeking (Aleven et al., 2016)
2. MetaTutor, an ITS for scaffolding SRL (Bouchet et al., 2016)

Today’s discussion cont’d…

- First, what is metacognition and self-regulated learning (SRL)?

- Second, why does it matter that learners demonstrate metacognition and SRL skills?

- Finally, how are metacognition and SRL relevant to building adaptive learning systems like ITSs?

What is metacognition and self-regulated learning?

- Most ITSs and adaptive learning systems are limited to scaffold one aspect of learning: ***cognition***

- Yet, human learning is a dynamic and complex combination of:
  - Cognition, emotions, motivation, metacognition
  - Environment
  - Time
  - Individual characteristics (personality, beliefs, values, race, gender, sex, background, experiences, and so on and so forth)

  … that continuously evolve over time and contexts (domains, settings, etc.)

What is metacognition and self-regulated learning? Cont'd…

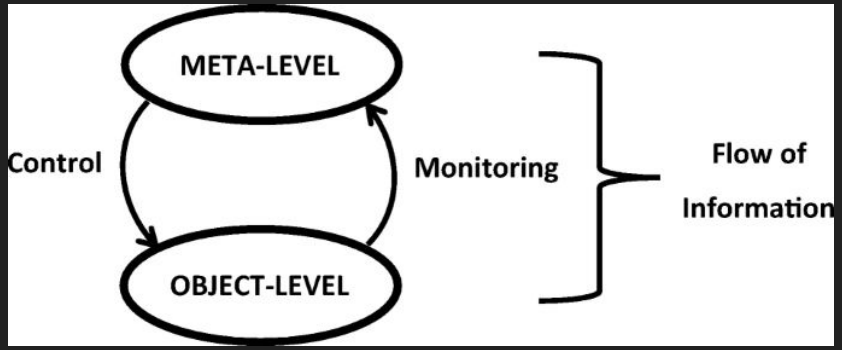
Main ideas:

- SRL involves continuously **monitoring and controlling learning processes** (e.g., motivation, emotions, cognition) in pursuit of learning goals (Winne, 2018; Pintrich, 2004; Wigfield, Klauda, & Cambria, 2011)

- Metacognition is at the heart of SRL: Monitoring and controlling of cognitive processes

- SRL skills are a positive predictor of academic achievement, employability, and career progression (Schunk & Greene, 2018)

What is metacognition and self-regulated learning? Cont'd…



Nelson and Naren's model of metamemory (1994)

Why does it matter that students demonstrate SRL skills?

- What are the benefits of having effective SRL skills?

- What is the goal of education and learning?

- How to solve societal problems when they are continuously changing and becoming more and more complex in the real-world?

How is it relevant for building ITSs and adaptive learning systems?

Current challenges in the field:

- Solely focusing on cognition misses critical information on students' learning
  - E.g., Motivation, emotions, and metacognition of which cognition could not occur without

Important open questions:

- How to build adaptive learning systems like ITSs to help students acquire adequate skills in SRL that transfer to real-world settings?

"Give a Person a Fish, and You Feed Them for a Day. Teach a Person To Fish, and You Feed Them for a Lifetime"

Comments? Questions?

ITSs, metacognition, and SRL today…

Help Tutor (Aleven et al., 2016)

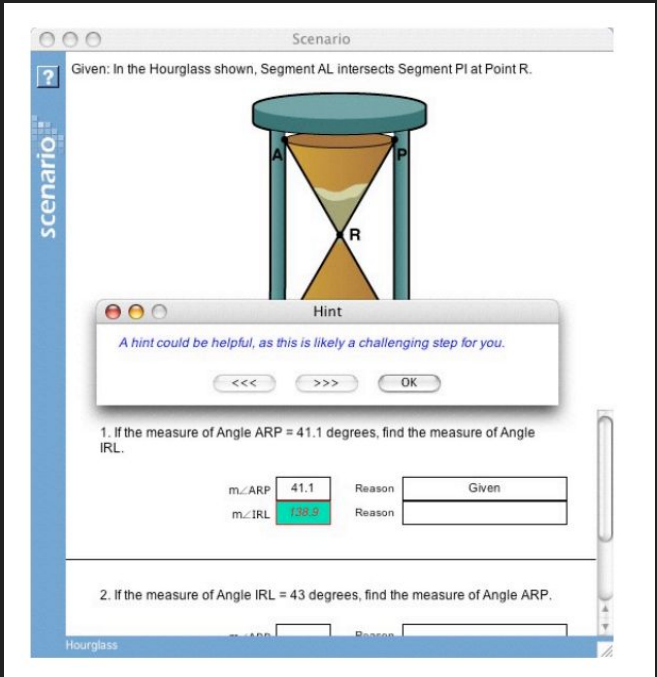
- Help-seeking is a form of self-regulated learning, but students struggle to utilize help/hint features effectively with ITSs
  - Help abuse (e.g., gaming the system; Baker et al., 2004)
  - Help avoidance (Aleven et al., 2004)

Hypothesis:

Help tutor = students acquire skills in seeking and using help effectively that will transfer to other environments.

Help Tutor cont'd…

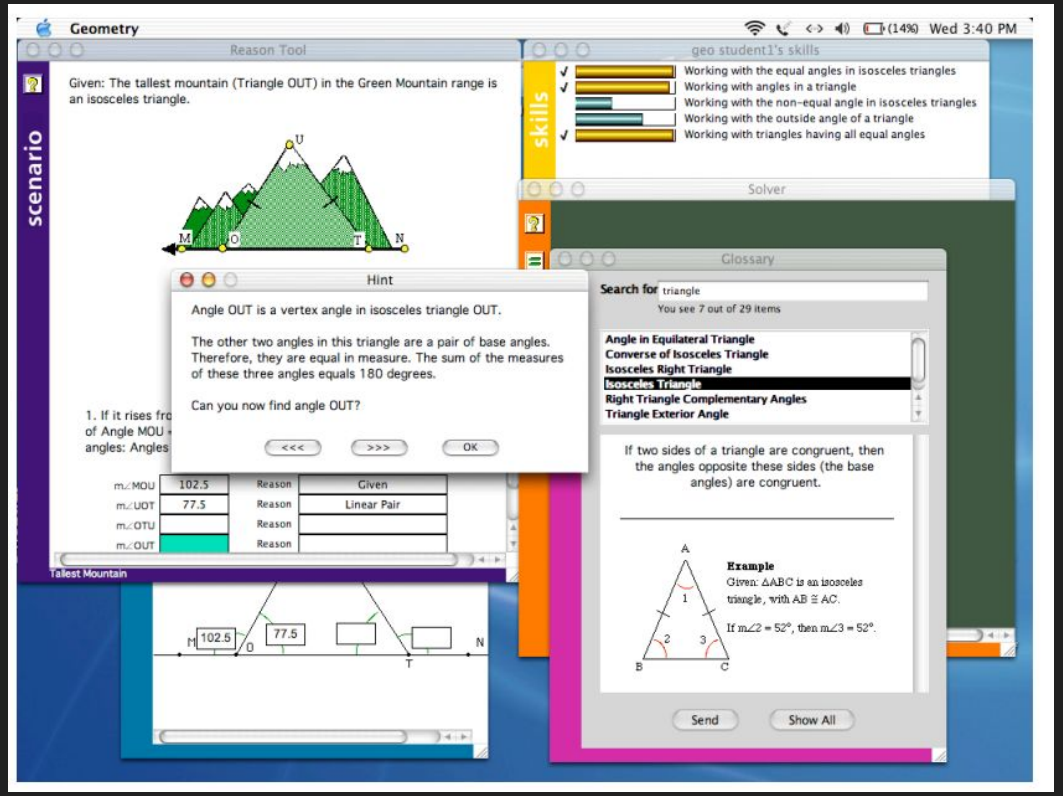
- Help Tutor that provide real-time feedback on help seeking during problem solving with the ITS
  1. Using model-tracing algorithm
  2. Principle-based hints
  3. Bottom-out hints - self-explanation



Help Tutor cont'd…

- Production-system Model: Rule-based model that collects adaptive and non-adaptive help-seeking actions
    1. Contextual features - conditions in which help was adaptive or non-adaptive
    2. Students' judgment on whether help was sufficient in problem solving
    3. 80 production rules - including a taxonomy of non-adaptive help-seeking behaviors categories: Help Abuse, Help Avoidance, Try-step Abuse, and more detailed sub-categories

Help Tutor cont'd…



Help Tutor cont'd…

Sample hint sequence of the Geometry Cognitive Tutor

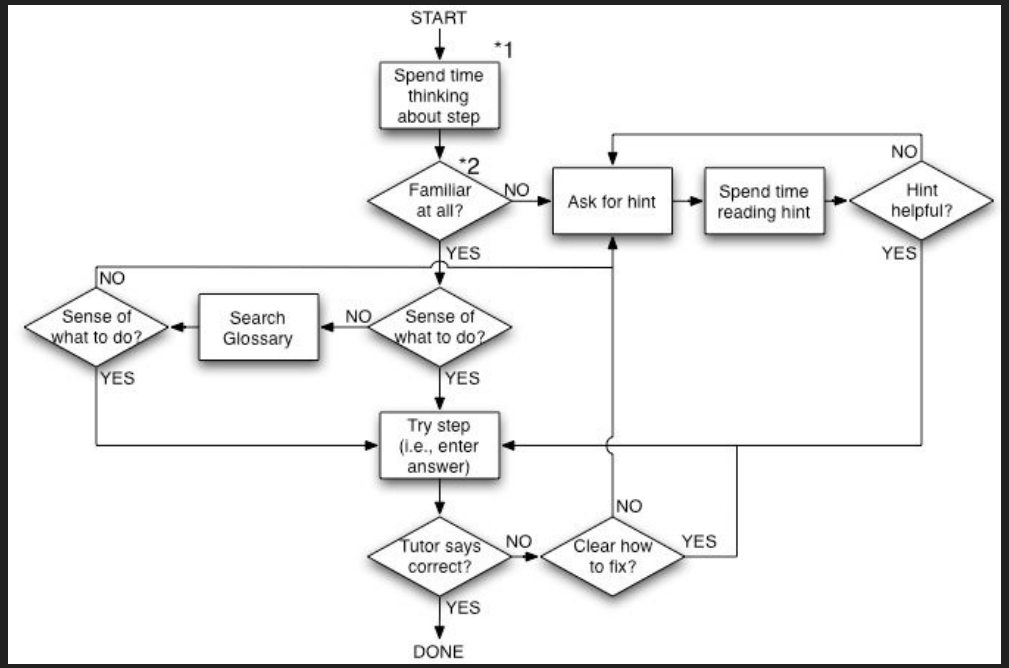
1. As you can see in the diagram, Angles UOT and MOU are adjacent angles. Together they form segment MT. How can you use this fact to find the measure of Angle UOT?
2. Look in the Glossary for reasons dealing with adjacent angles.
3. Some rules dealing with adjacent angles are highlighted in the Glossary. Which of these reasons is appropriate? You can click on each reason in the Glossary to find out more.
4. The sum of the measures of a linear pair of angles is 180°. Angle UOT and Angle MOU form a linear pair.
5. The sum of the measures of angles UOT and MOU is equal to 180 degrees.
6. The measure of Angle UOT is equal to 180 degrees minus the measure Angle MOU.
7. $m\angle UOT = 180° - m\angle MOU$.

Help Tutor cont'd…

Example of production rules for defining help seeking behaviors (Aleven et al., 2006)

Help-seeking categories:

1. Help Abuse: help that avoids careful reading and sense making



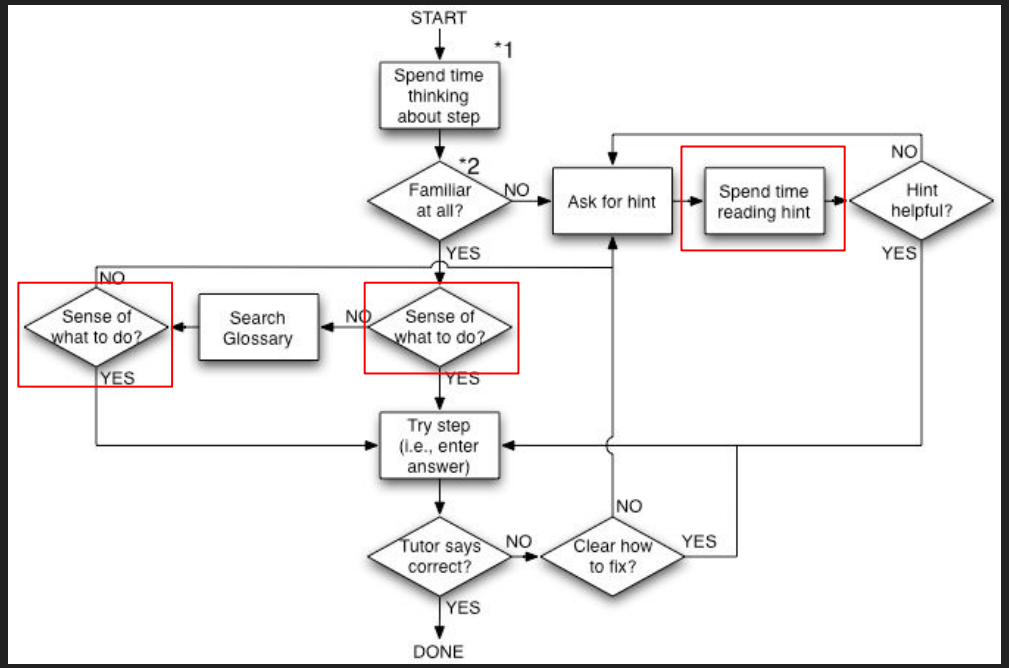
Help Tutor cont'd…

Example of production rules for defining help seeking behaviors (Aleven et al., 2006)

Help-seeking categories:

1. Help Abuse: help that avoids careful reading and sense making

Example: clicking through hints and spending little time reading hints



Help Tutor (Aleven et al., 2016)

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Hypothesis:

Help tutor = students acquire skills in seeking and using help effectively that transfer to other environments.

Findings and Contributions

Results showing improved “local domain-level learning” and changes in how deliberately students use help, but no transfer to other domains or environments.

Beyond state-of-the-art for ITS research by

- Focusing on learning in context
- Taxonomy of maladaptive help seeking behaviors that were operationally linked to theoretical constructs (knowledge engineering)

Future Directions

1. Prioritize collecting data on sense making during the help-seeking process
    - Metacognitive monitoring?
    - What data might allow us to measure sense making?

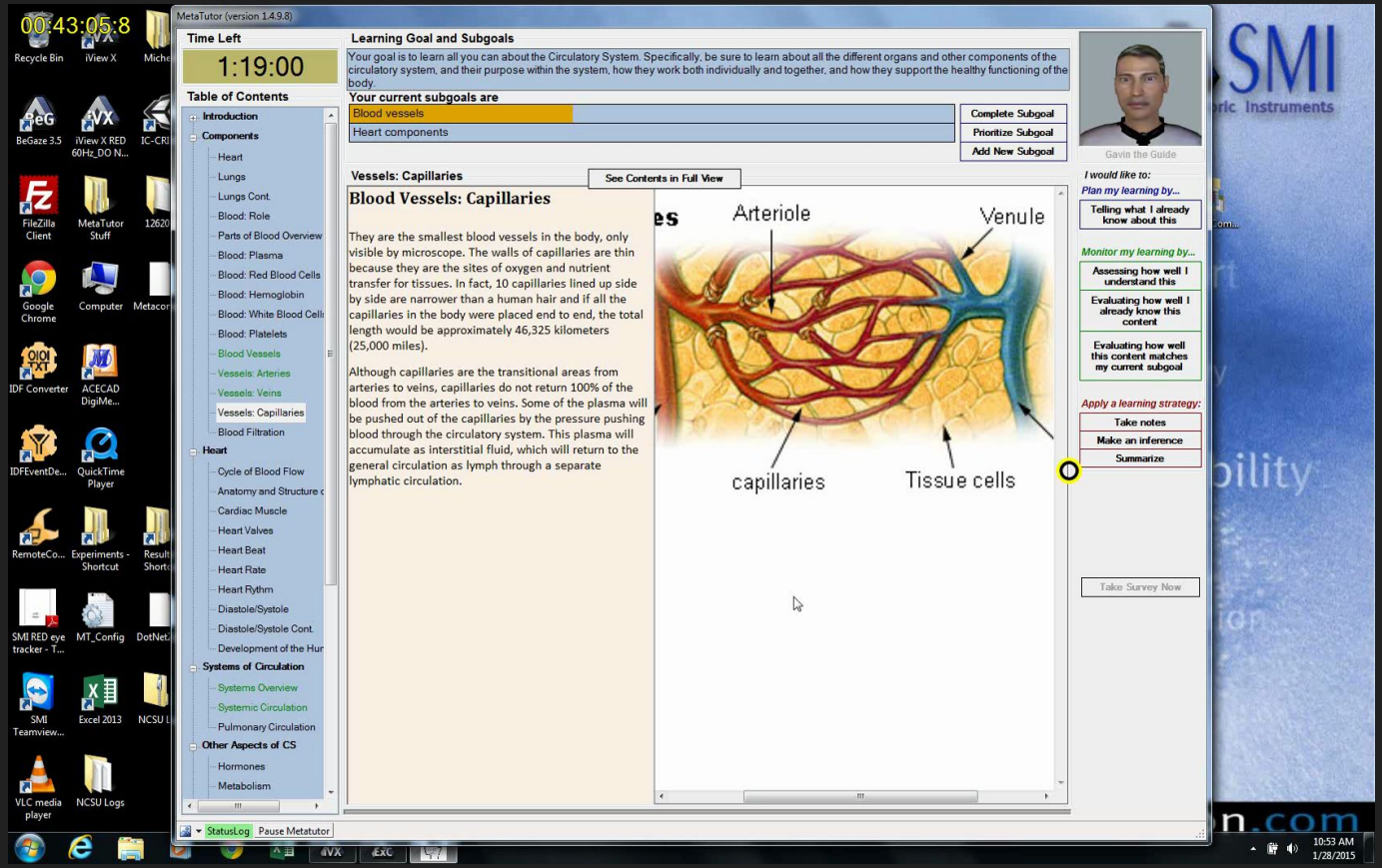
Comments? Questions?

Scaffolding SRL with MetaTutor (Bouchet et al., 2016)

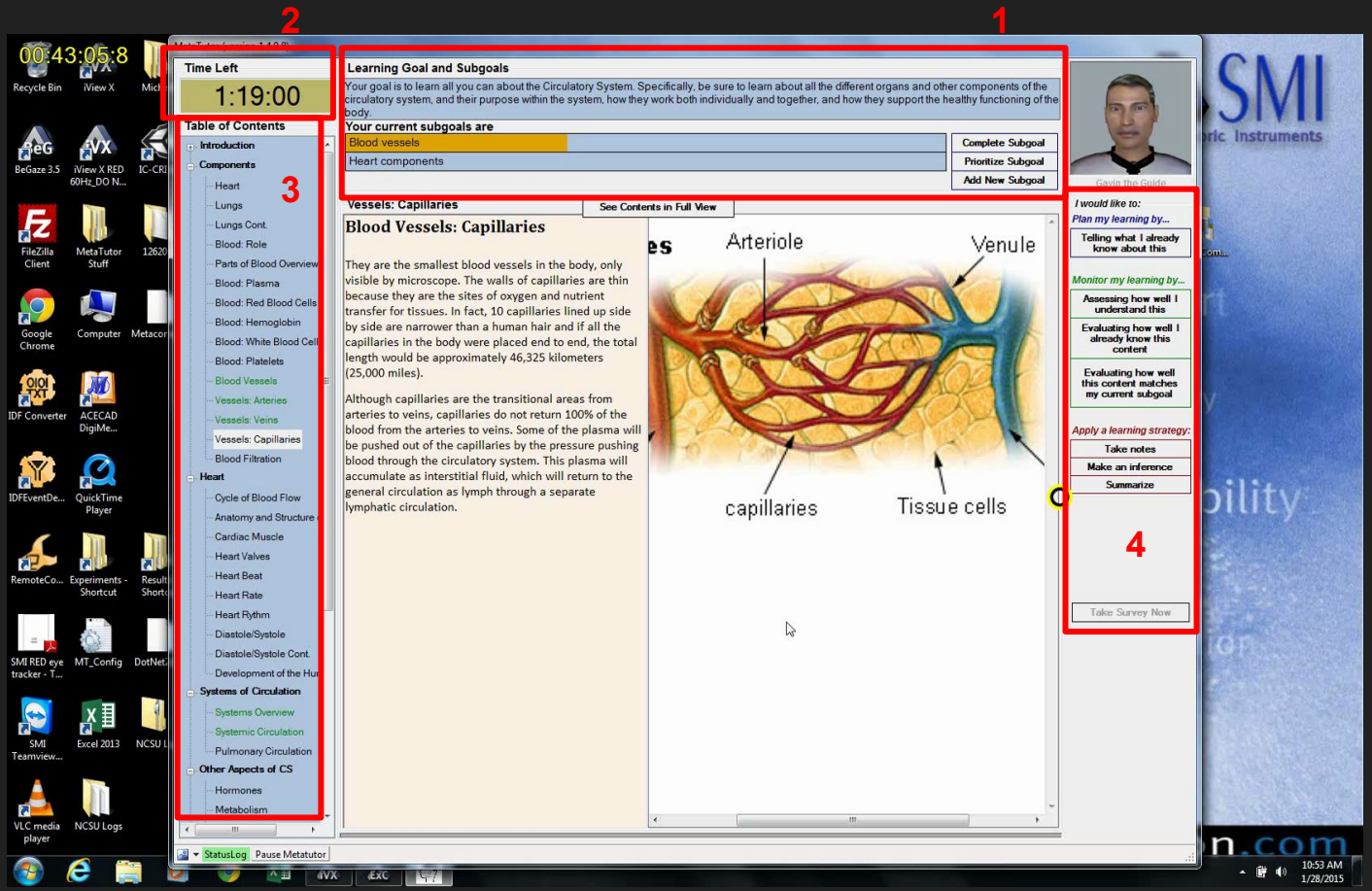
MetaTutor is built on production rules to scaffold SRL and teach students about biology (human circulatory system; Azevedo et al., 2022)

- Event- and time-based production rules that trigger tutoring agents to scaffold learners' SRL in real-time
  - Via tools on the interface
  - 4 pedagogical agents

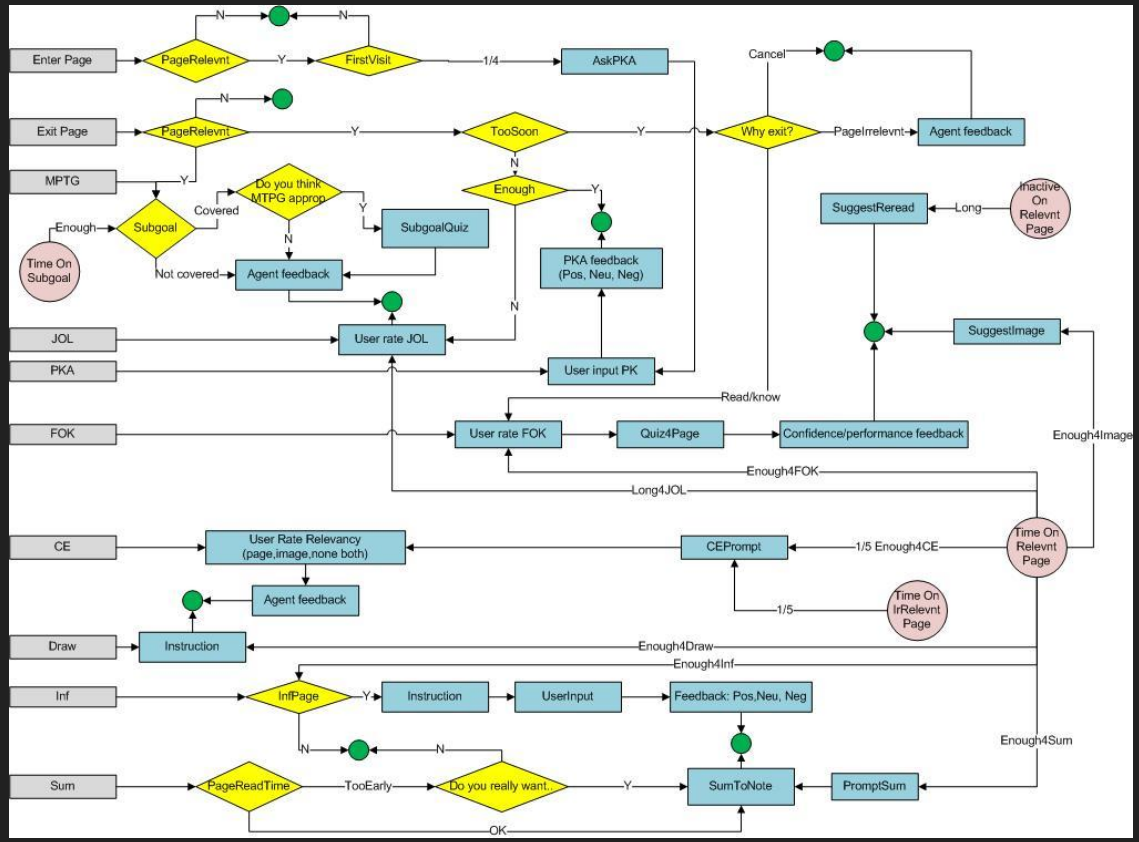
Scaffolding SRL with MetaTutor Interface



Scaffolding SRL with MetaTutor Interface Cont'd…



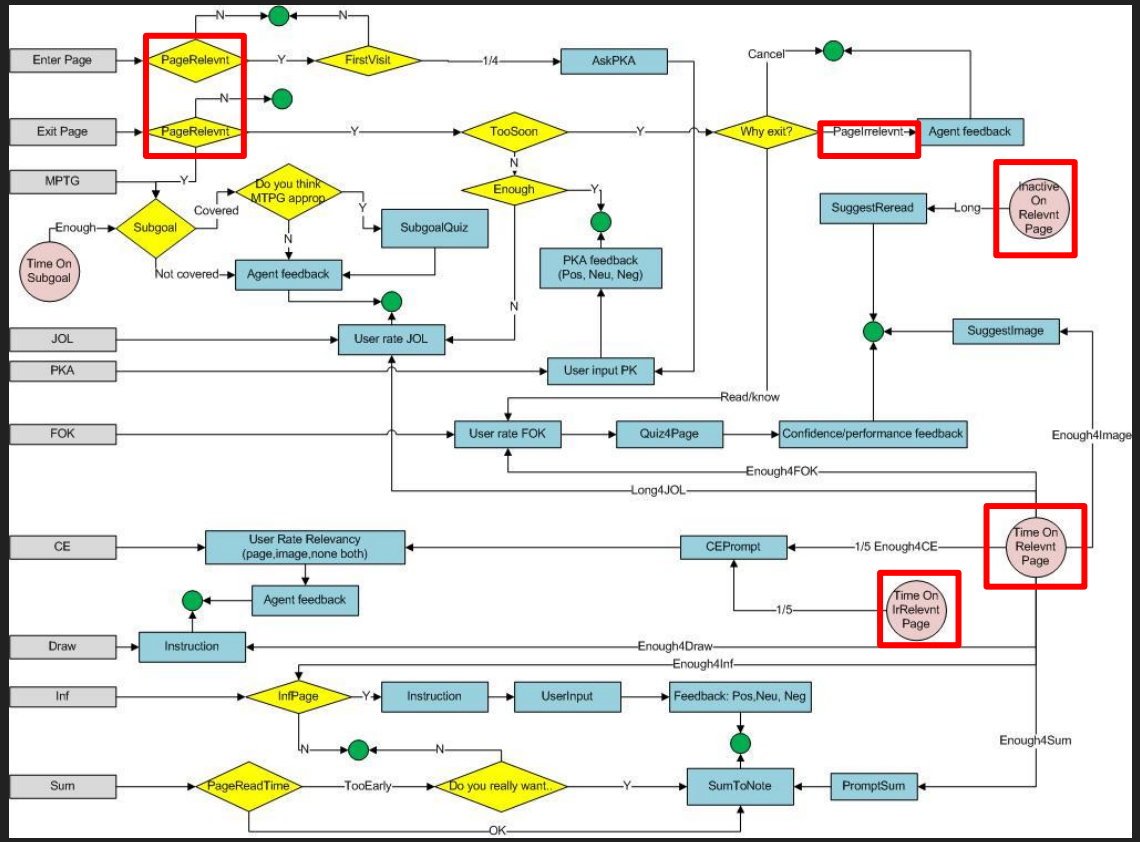
Production Rules for Scaffolding SRL with MetaTutor



Production Rules for Scaffolding SRL with MetaTutor

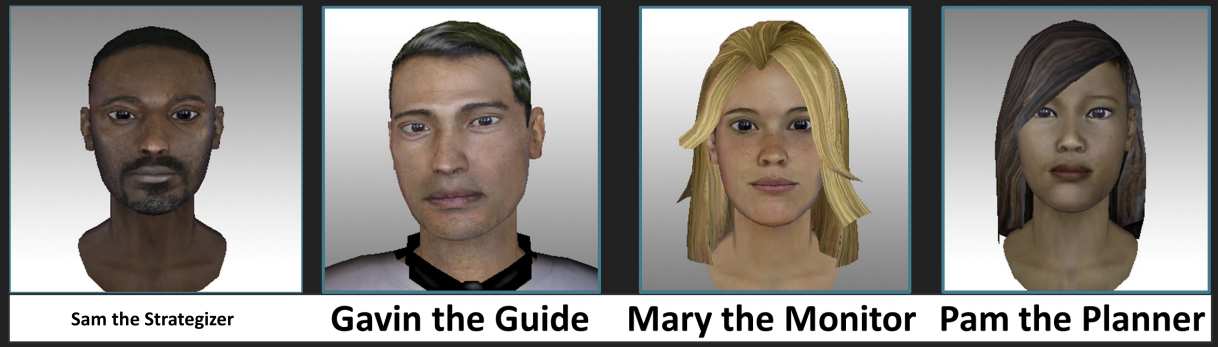
Data on SRL

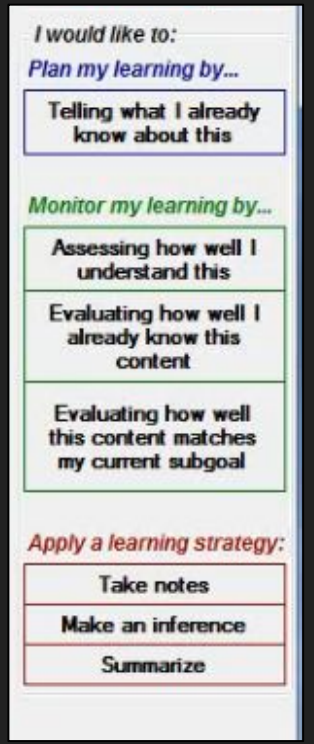
1. Quantity - time and frequency of SRL processes via logfiles
2. Quality - time and frequency of visiting **relevant and irrelevant** pages based on subgoals set



Scaffolding SRL with MetaTutor Interface Cont'd…

- SRL palette used to prompt SRL use via pedagogical agents via production rules





Bouchet et al (2016) MetaTutor study

Examined 116 participants across three conditions designed to scaffold the quantity and quality of SRL via prompts:

1. Control (Non-adaptive prompting)
2. Fading prompts based on learners' SRL deployment
3. Increasing prompts based on learners' failed SRL deployment

Bouchet et al (2016) MetaTutor study

Overall findings:

1. Benefit of adaptive prompting on (self-)initiated SRL behaviors

2. Adaptive prompting did not lead to differences in learning between conditions

Conclusions and Future Directions

Limitations:

1. SRL processes deployed without using the SRL palette were missed
2. Data on all aspects of SRL were missed

Future directions:

1. How to design production rules and/or ITS interface to account for all aspects of SRL?
2. What data might provide insight into emotions and motivation?
3. What methods learned in previous lectures might be useful to this work?

Comments? Questions?

What are important things to consider when tutoring metacognition and SRL?

How do we “get it” right?

Is it a promising technology?

Is it widely used today? Mostly no.

But there is CSMLearn

https://www.smilabs.org/solutions/individuals

General Open Questions in the Field

What are we missing?

1. Immersion in real-world context?

2. Diversity aspects (populations, cultures, background, etc.)?

3. Motivation?

4. Emotions?

Comments? Questions?

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