ADAPTIVE LEARNING ENVIRONMENTS:

Tutorial dialogues

Disclaimers

Will keep discussion of dialogue high-level

You DO NOT need to know exactly how things are implemented "under the hood" unless this is of particular interest to you

Have a general idea of what's being used now, what type of capabilities feasible or not

Understand why we might choose to do certain things with tutorial dialogues, and do them in certain ways

Why have dialogues in ALEs/ITSs?

Some slides based on Moore, 2004

The idea of dialogue

In ALE, "dialogue" almost always means written "natural language"

- Natural as opposed to *formal languages*
- A few early systems used more formal input

For most systems, idea is to make the teaching process more **naturalistic,** and emulate at least some features of human-human teaching

NL dialogue as highly adaptable, customisable: Key tool for systems to meet goal of *personalisation* (to groups/ profiles, to individuals)

Different forms of dialogue

Communication between at least two parties

Mixed or single initiative:

- Unrestricted more difficult to handle, because of NLU

Through natural language:

- Text or Speech

Through graphical user interface

- Buttons, e.g. hint, help, give answer, give definition (Wallis)
- Direct manipulation interface, e.g. BEETLE, Bob the Builder pipes (www.bobthebuilder.com) etc.

Multimodal:

- Text
- Speech
- Deictic devices (detected and tracked through, e.g. mouse and keyboard actions)
- Embodiment (e.g. ECAs)

Effective Learning

Learning occurs when students:

- engage in active generation of knowledge
  - solve problems independently
- encounter obstacles and work around them
- explain to themselves
  - what worked and what did not
  - how new information fits in with what they already know (generalisation)

(Chi et al. 1989, 1994, 2001; Ohlsson & Rees 1991; Van Lehn 1990)

Dialogue-based learning **

Face-to-face, 1-to-1 tutoring is the most effective form of human instruction (considered a "gold standard")

Much of the success hinges on engaging students in appropriate, relevant natural language (NL) dialogue

NL dialogue offers **indirect techniques** for :

- Signalling (dis)agreement/uncertainty, suggesting solutions, etc.
- Switching topic
- Taking or relinquishing initiative
- Eliciting knowledge construction, via techniques such as co-construction of explanations, and directed lines of reasoning

Dialogue-based learning **

Intelligent tutoring systems lead to learning gains that are half that of human tutoring

SO...

General premise that intelligent tutoring systems be **more effective** if they engaged students in a dialogue

But...**What constitutes effective tutoring?** Should we look at (all) human tutors?

- Not all successful strategies of human tutors may be suitable for computer-based tutoring
- Not all information available to tutors will be equally available to computer tutors and vice versa.

Also, dialogue to what ends? What's the goal?

Effective Tutoring? **

Appropriate guidance, intervention to ensure that factual/ procedural errors are detected and repaired

Human tutors maintain a delicate balance:

- Students do as much of the work as possible
- Tutors provide *just enough* guidance, at right time to keep students from floundering helplessly

Facts aren't the be-all and end all: Students maintain a feeling of control and sense of achievement; reap motivational benefits.

(e.g. see Fox 1993; Lepper & Chabay 1988; Merrill et al. 1992; Graesser & Person 1994)

Tutor's expertise: the KEY!**

Diagnosis: the ability to diagnose the student *in a specific context*

Planning: the ability to plan *appropriate* actions based on the diagnoses

Action: the ability to act upon their diagnosis and plans

PLUS **adaptivity** to unfolding interaction, **iteration** of diagnosis, planning, action.

Tutorial dialogue might need** to adapt to...

- Student interruptions or requests for clarification
- Student skipping ahead (e.g. within problem)
- Student changing topic, potentially to one that is irrelevant outside domain
- Student providing *more* information than expected
- Student repeating *same* responses or actions

But also...

- Failure to recognise student's response *(i.e. type/ category/competence of response)*
- Failure of the tutoring strategy

Types of dialogue

Full, natural-language "conversations" relatively rare

- e.g. Free-text input analysed for meaning
- Tend to be narrowly domain-limited

Many other **"dialogue-like" methods** in use

- Student chooses a "move" via menu or other options
- Templates
- Apply keyword-matching or simple techniques to input

In many cases these "dialogue-like" methods are very effective and accomplish interactional/pedagogical goals at much less "cost" in time, complexity, processing.

→Do NOT assume that "full" dialogue necessarily the best option for all systems. May not be needed!

Sophie (Brown et al., 1982) **

A virtual lab, or workbench for electronic circuits

- Goal is NOT explicit instruction
- Instead, try out ideas, have them critiqued, receive advice
- Domain is troubleshooting circuits: Fault inserted for student to debug.

Based on typed input, the system can:

- answer hypothetical questions (what if?)
- evaluate hypotheses (consistent?)
- list all possible hypotheses (generate and test)
- evaluate a new measurement (redundant?)

Illustration of Sophie (Brown et al., '75)**

Student (types): ***What could be wrong?***

SOPHIE: **Here are some faults which explain the measurements you observed:**

the beta of Q3 is low

the beta of Q4 is low

or R22 has the wrong resistance

Student: ***What would the output voltage be if the beta of Q3 were 8?***

SOPHIE: **If the beta of Q3 were 8 under the present setting, the output voltage would be 10.5 volts. In a working circuit it is 19.9 volts.**

Student: ***Is the emitter current of Q4 correct?***

SOPHIE: **The emitter current of Q4 is -61 milliamps. In a working circuit the emitter current of Q4 is -49 milliamps. That value seems to be incorrect.**

Student: ***Could R22 be low?***

SOPHIE: **`Is it OK if I use 25 ohms for the resistance of R22?`**

Student: ***Yes***

SOPHIE:**`That fault agrees with all the measurements you have made.`**

SOPHIE uses ***semantic grammars*** to decompose student input into domain concepts *(semantic categories).*

- E.g. Measurable quantities, locations [in the circuit], prepositions
- Turn input into internal representation of functions with arguments
- Method was **very robust** in limited domain, good at handling incompleteness, variable wording.

Initiative: Who talks?

Dialogue initiative= literally, who takes the initiative and drives the interaction?

Mixed= system or user can begin a given interaction, and generally continue by taking turns

- Potentially more collaborative
- New challenges for system, such as recognising which student "move" introduces new topic, etc.
- So far, hard to handle off-topic or non-domain material

Single= for that ITS, it is either the system OR the user that *always* initiates, leads the interaction.

- Both parties may be restricted to short turns, answers

Dialogue DOES THINGS

Dialogue is a route to pedagogical and other goals

- embodiment of **teaching strategies** (e.g. Socratic method)
- embodiment of **theory** (e.g. Constructivism, ACT-R)

Depending on the view of what **"the point" of teaching/ learning is**, system designers may make very different choices about dialogue

- Level of capability ("full" NL vs. limited methods)
- *Who* has the initiative (student, system, both)
- *What* types of things may be included (only domain content, affective or metacognitive content...)
- *How* those things are communicated

Teaching: What's the point?

Teaching as communicating

Teaching as transmitting

Teachers as fostering learners' meaningful knowledge construction

Teachers present information, learner's job to acquire it

(see Moreno, Mayer, Spires, & Lester, 2001)

Activity: Dialogue in core systems

Dialogue & teaching in core systems

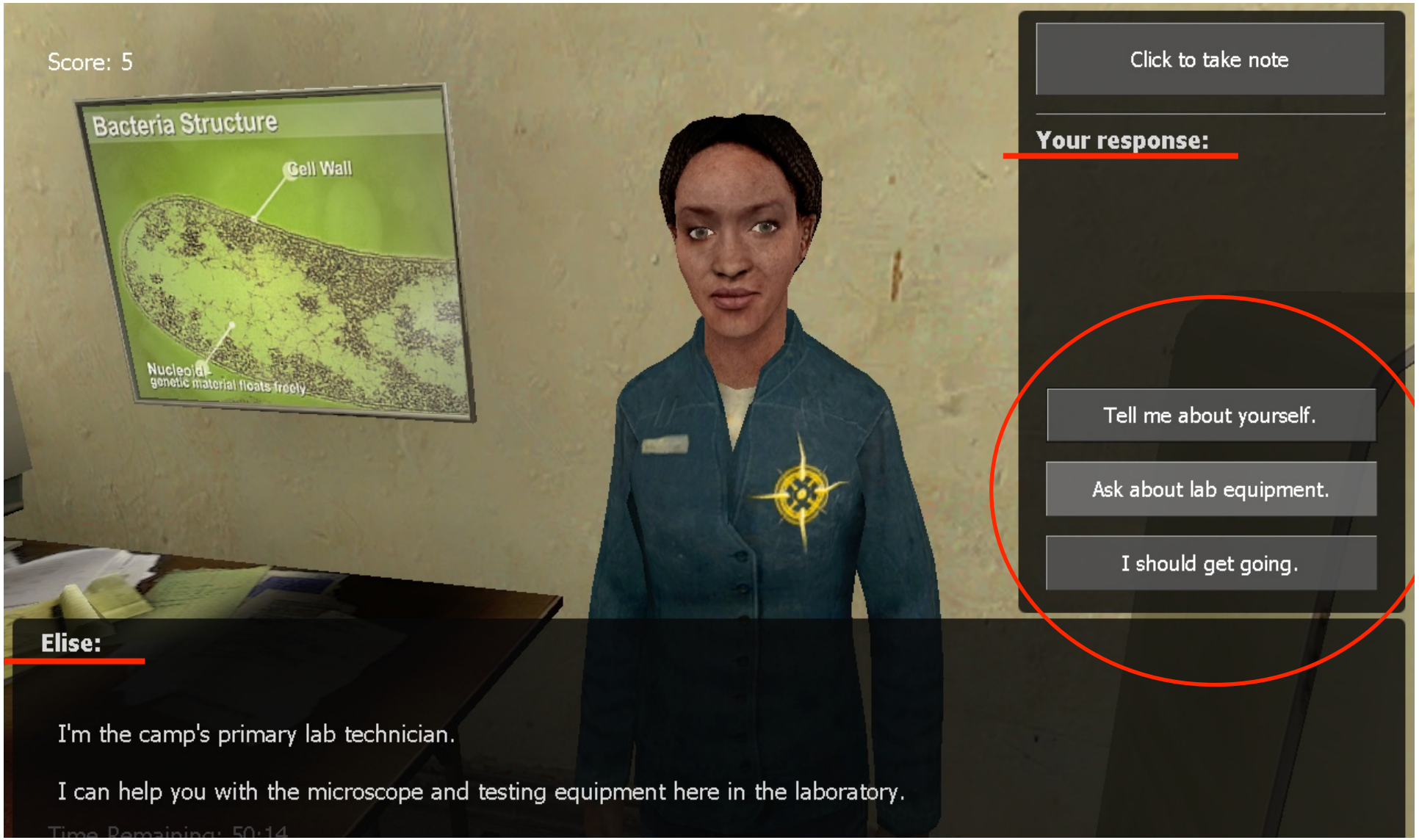
1. **TEACHING:** identify the view of teaching (or balance of the views) that appears to be implicitly or explicitly present in that system.

2. **DIALOGUE:** What type(s) of dialogue-based interactions are present in the system?

3. **TEACHING VIA DIALOGUE:** How does the dialogue in the system embody that view of teaching, and work to achieve the system goals?

Core systems: Some examples

Crystal Island



CI dialogue example

ELISE: I'm the camp's primary lab technician. I can help you with the microscope and testing equipment here in the laboratory.

What does this utterance do?

Not do?

STUDENT can choose one move:

"Tell me about yourself."

or Ask about lab equipment.

or "I should get going."

What type of actions are possible?

When/ why might the student select them?

Geometry SE tutor

- **SE = Self explanation** (this is a recent-ish version of the Geometry Cognitive Tutor)

- At various points, has tested both natural-language *and* menu-based dialogue for students explaining own problem-solving steps (e.g. Aleven et al., 2003)
  - Inconclusive results re: which is "better" for learning
  - Authors point out typed input takes more time, BUT
    - Tutor has much better opportunity to diagnose student's (mis)understanding

    → IS possible to choose a reason [for a step] from menu without being able to explain it, or which parts are important!

Geometry SE tutor

Example from Aleven et al. (2003), dialogue condition:
Tutor helps student to refine an explanation so that s/he does not focus on irrelevant concepts or incorrect rules

1.	**Student:**	in an isosceles triangle, base angles are the same
2.	**Tutor:**	You gave a correct statement of a geometry rule, but that rule is not needed here.Please focus on a different rule.
3.	**Student:**	interior angles are congruent
4.	**Tutor:**	You may be thinking of the wrong geometry rule. Please focus on a different rule.
5.	**Student:**	when two parallel lines are cut by a transversal, the interior angles are congruent
6.	**Tutor:**	Your explanation looks good. However, you do not need to talk about interior angles here. So it is better to delete or change this part.
7.	**Student:**	when two parallel lines are cut by a transversal, the exterior angles are congruent
8.	**Tutor:**	Yes, you are on the right track. One thing, though: mentioning exterior angles here is not correct. So you should probably change that part of your explanation.
9.	**Student:**	when two parallel lines are cut by a transversal, the corresponding angles are congruent
10.	**Tutor:**	[accepts as correct and complete explanation by means of implicit feedback]

Figure 2: Example dialogue between a student and the Geometry Explanation Tutor

Modelling Tutors' feedback

(Porayska-Pomsta, 2004)

Tutors' Feedback

What language do tutors' produce in corrective situations?

- Dialogues analysis

What drives the selection of tutors' responses?

- Contextual factors relevant to tutors' decisions
- Politeness considerations

How can the process of selecting tutors' responses be modelled formally?

- Outline of the model of tutors selecting corrective responses
- Model's implementation and evaluation

Example of feedback variation

Tutor's question: What is needed to light a light bulb?

Student's answer: Heat. (incorrect)

Tutor's possible feedback:

1. No, that's incorrect.
2. Try again.
3. Well, why don't you try again?
4. Are you sure about that?
5. Well, if you put the light bulb in the oven it will certainly get a lot of heat, but is it likely to light up?
6. Is it the heat or the source that are needed to light a light bulb?
7. Why?

What language do tutors produce in corrective situations?

Approx. 50% of all dialogue moves produced by tutors are questions.

A distinction between communicatively "straight" acts, testing acts and corrective acts, e.g.:

What do you mean by this? (a straight act)

vs.

What are the main components needed to light a light bulb? (a testing act)

vs.

Well, if you put the light bulb in the oven it would get heat, but would it light up? (a corrective act)

What is the difference?

Indirectness:

Illocutionary specificity:

the degree to which the teacher hides the rejection of the student's answer (saving face)

Content Specificity:

the degree to which the teacher gives the relevant content away.

Why do possible responses vary?

Because they allow the tutor to achieve slightly different communicative and educational goals to various degrees,

e.g.

- ***tell the student*** his answer was problematic
- ***prompt/guide the student*** to make further attempts at finding a solution.
- ***boost the student'***s confidence and curiosity

Form of response determined by context

Based on the tutor's awareness of contextual factors, e.g.,

- student's characteristics,
- the characteristics of the material taught,
- time and place of teaching, etc.

Strategies are chosen to preserve "Face", in the sense of the student's self-image

- Need for *approval,* maintenance of positive image
- Need for *autonomy,* freedom to discover knowledge

(e.g., Lepper and Chabay 1988; Graesser 1995; Person 1995; deVicente 2003; etc.)

Identifying situational variables relevant to tutors' corrective response selection

1. **Temporal factors:**

   (from observation of the dialogues)

   amount of time available ***amount of material left***

2. **Characteristics of the material taught:**

   (Lepper and Chabbay 1988; Person et al. 1995; Chi 2001)

   difficulty of the material ***importance of the material***

3. **Characteristics of the student:**

   (Lepper and Chabbay 1988; Person et al. 1995; Chi 2001; deVicente 2003)

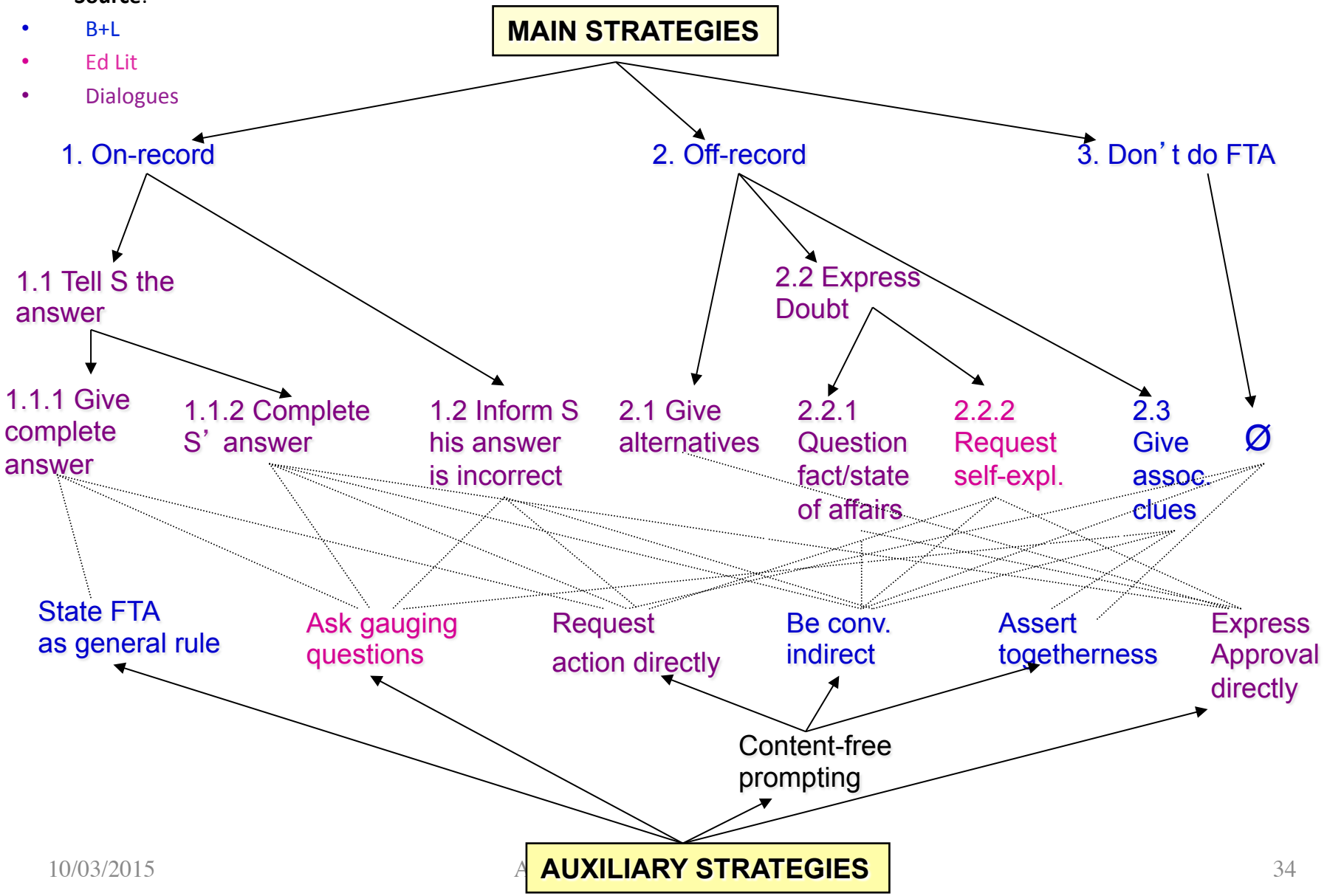
   student's ability ***correctness of student's answer***

   student's confidence ***student's interest***

Validated through empirical study with teachers

The strategic system

- **Source**:
- B+L
- Ed Lit
- Dialogues



Autonomy, Approval and Linguistic Choice

- *"No, that's not right."* (Aut: 1.0, App: 0.1)
- *"Are you sure that this is the right way to de-energize the circuit?"* (Aut: 0.8, App: 0.4)
- *"Not quite, why don't you try again?"* (Aut: 0.6, App: 0.4)
- *"Removing the wire does not de-energize the circuit."* (Aut 0.4, App: 0.1)
- *"If you remove the wire, then this will break the circuit but does it de-energize it?"* (Aut: 0.3, App: 0.5)
- *"Isn't this breaking the circuit rather than de-energizing it?"* (Aut: 0.2, App: 0.3)

Next: Back to affect, motivation, and why “how we say it” matters

Final issue: Speech

NL almost always text BUT there are a examples using spoken language. Start with:

Experiments tried marrying **Autotutor** to commercial speech recognition software– spoken input seemed to make no difference to learning gains

- SEE *D'Mello, S. K., Dowell, N., & Graesser, A. (2011).*

See the **LISTEN reading tutor** for a long-running project built on tutoring spoken input

- Jack Mostow is a key researcher to know for this project.
- Described briefly in Woolf ch 5 (see reading list)