Designing AdvGeo Learning Environment

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1. Proactive scaffolding on problem solving steps

What if we have an ITS that is rather too officious at the beginning to teach everything, but gradually fit the student's need? The basic idea is that the tutor starts from providing help on every single cognitive step, namely, all possible scaffolding is turned on at the beginning. The tutor might let the student start proof by asking "*the goal is to prove X. What do you need to prove X?*"

Lit review on the difficult factor analysis as well as the cognitive task analysis in geometry theorem proving helps find out subjects of scaffolding. (Noboru's report on "Cognitive Skills in Proof Writing" dated on February 25, 2002 and "Difficulty Factors Analysis towards Effective Instruction for Proof Writing" dated on February 6, 2002)

Scaffolding for "operationalization" of domain principles

- Students have difficulty to apply domain principles especially definitions, which are described in a declarative form, to a problem solving context backwards, which requires a description of goals appeared as a condition. The definition of parallelogram that says "*A parallelogram is a quadrilateral whose opposite sides are parallel*" must be transformed into an executable operator like "*to prove a quadrilateral is a parallelogram, you need to prove that two pair of opposite sides are parallel.*"

- The system can provide an operational description of the target theorem: "*Remember two base angles of an isosceles triangle are equal. That means if you want to prove two angles is equal then you may want to prove that a triangle that contains those two angles is an isosceles triangle*."
- The system can provide a question asking postulate that justifies a deduction. "*Given X, we can conclude Y. What postulate do you know that support this deduction?*"

Scaffolding for problem-solving steps

- Even they understand domain principles, the students might still have difficulty to make an inference.

- Operator selection:

  - The system can provide an operator that should be applied next.
  - The system can provide a set of operators that can be applied
- Operator instantiation:
  - The system can provide an instantiation of the selected operator.
  - The system can provide a set of possible instantiations
- Operator execution:
  - The system can provide subgoals/conclusions that are logical consequence of operator application.
  - The system can provide a set of possible subgoals/conclusions

Scaffolding for strategy

- For hard problems, students have difficulty to maintain their search and/or break down the problem into manageable one.

- The system can ask the student to make a backward chain for the current goal
- The system can ask the student to make a legal forward chain
- Goal stack shows a history of subgoaling originated in the top-level goal.
- Solution tree provides a representation of forward and backward chaining.

2. Learning environment with restricted input

We can provide various level of freedom on student's exploration by changing degree of restriction for student's input. A number of studies that compare explorative and strict-model tracing tutoring show that those variations follow the time-achievement trade off.

3. Learning environment with feedback

4. Extremely unrestricted learning environment