CS 681 Fall 2008
Designing Expert Systems

Modeling Expert's Reasoning

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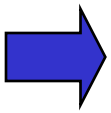
Learning Agents Center
and Computer Science Department
George Mason University

Overview



- Modeling Methodology
- Modeling and Ontology Specification
- Demo: Modeling Editor
- Hands On: Modeling for the PhD Advisor
- Research Problem: Modeling Assistant
- Reading

Modeling Expert's Reasoning

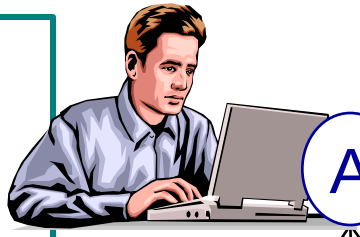
The single most difficult agent training activity for the subject matter experts is to make explicit the way they reason to solve problems.

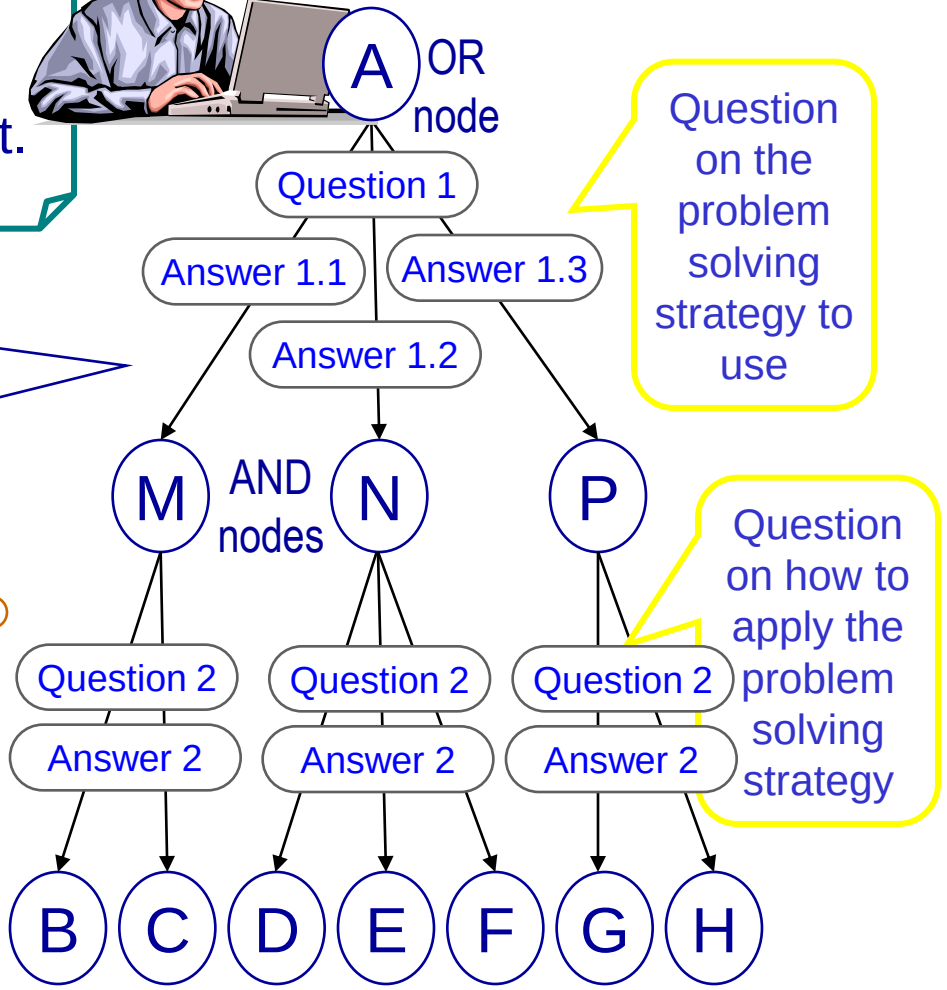
We will present an intuitive modeling language and associated guidelines which help the subject matter experts to express the way they reason.

In essence, the expert follows a problem reduction paradigm, guided by questions and answers, successively reducing a complex problem to simpler problems, until the initial problem is reduced to a set of problems with known solutions.

Problem Reduction based Question-Answering

General problem solving paradigm:
- natural for the human user;
- appropriate for the automated agent.





The reductions and synthesis operations are guided by introspective questions and answers.

"I Keep Six Honest..."

I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who.

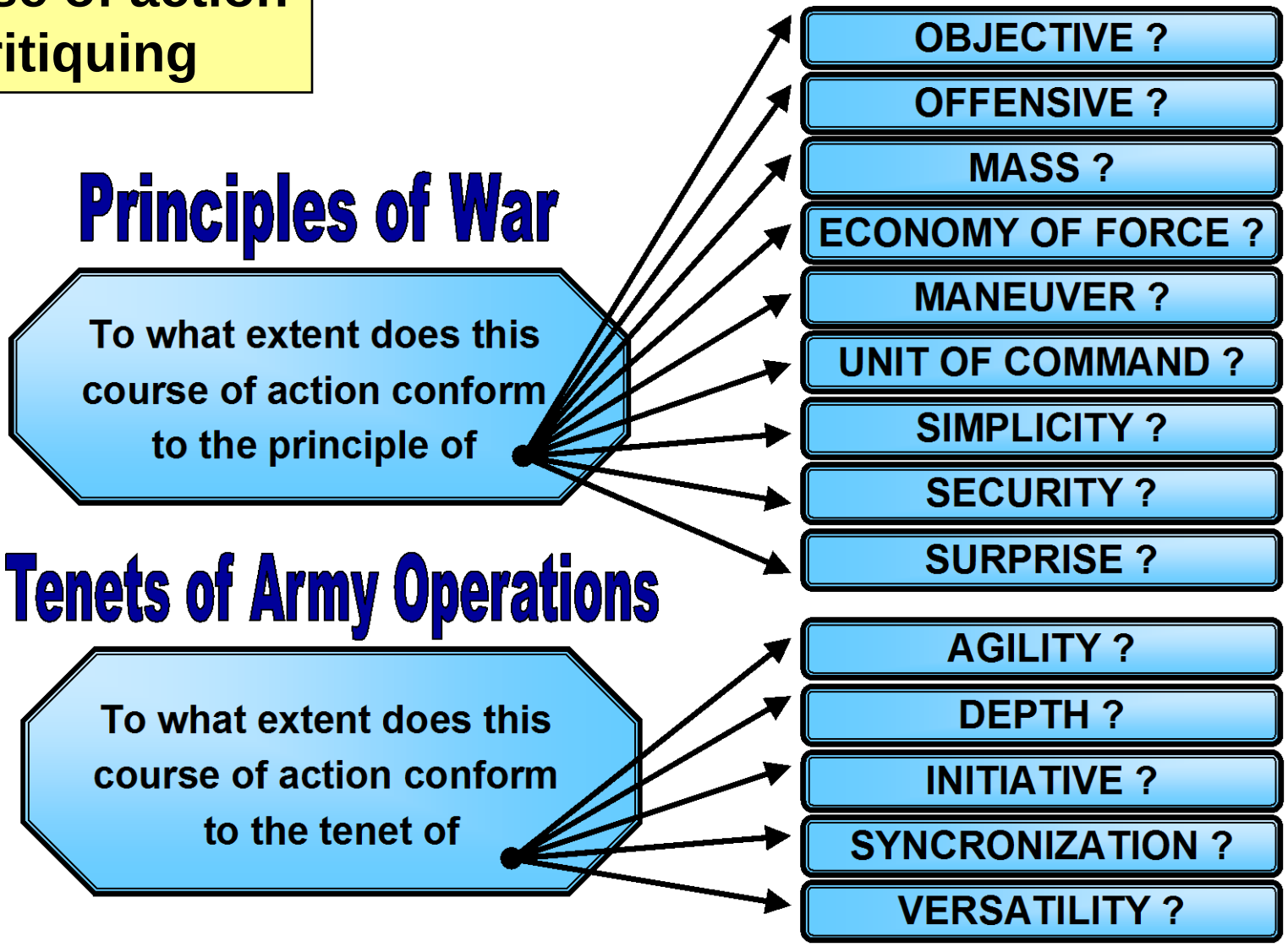
Rudyard Kipling

General Guidelines

- **Partition the domain into classes of problems.**
- **Select representative problems for each class.**
- **Model one class at a time.**
- **Model one example solution at a time.**
- **Organize the top level part of the problem solving tree to identify the class of the problem.**

Partition the Domain into Classes of Problems

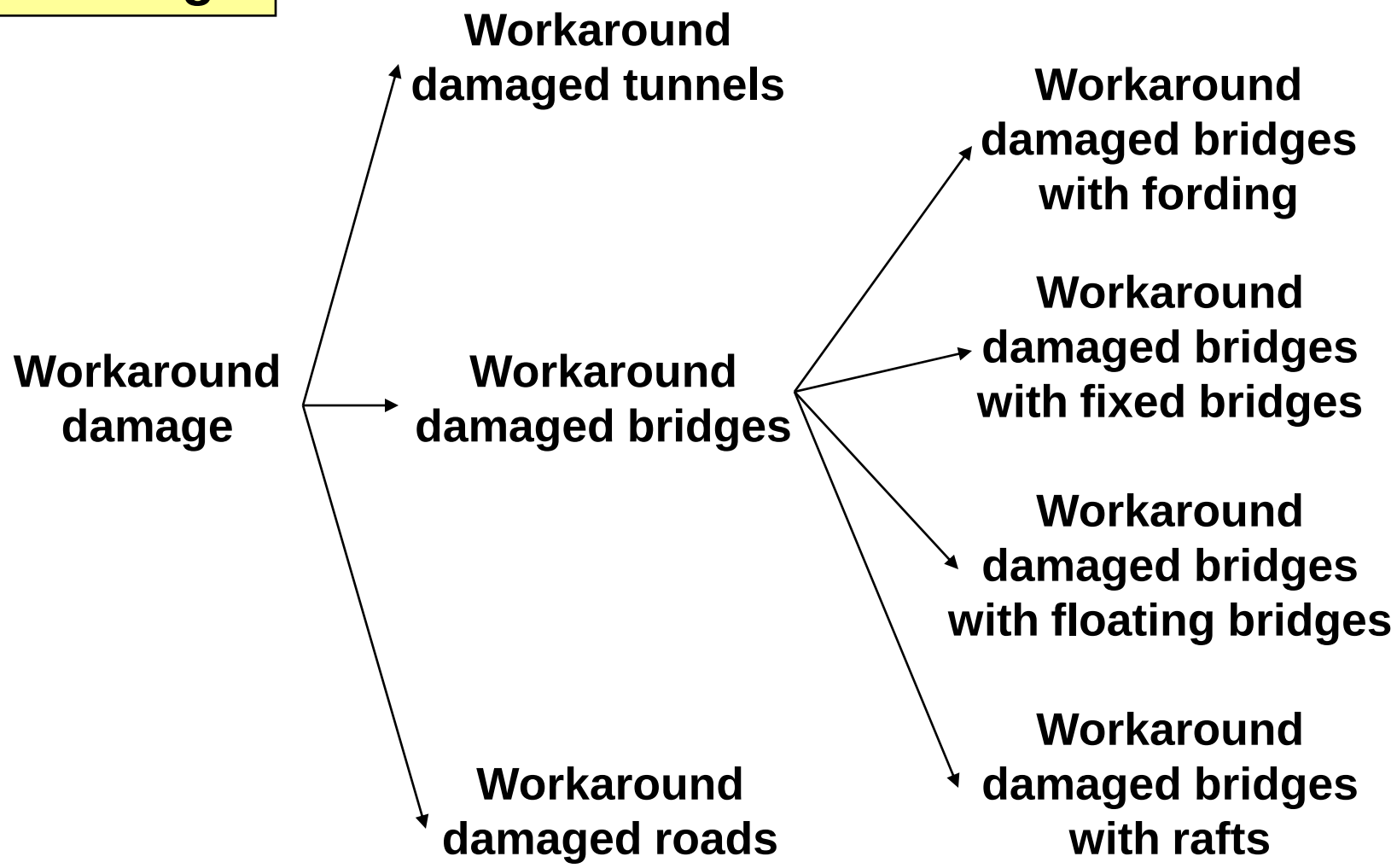
Course of action critiquing



Each principle and tenet leads to a different class of critiquing task.

Partition the Domain into Classes of Problems

Workaround reasoning



Relevant Factors for Selecting a Ph.D. Dis. Director

PhD Advisor

1. What is the reputation of the director within the professional community at large?

2. How responsive is the director? How long does it take to return written material with comments? Is the director a good editor?

3. How accessible is the director for discussion?

4. Is the director likely to remain on the faculty for the duration of your degree program?

5. How many students does the potential dissertation director work with? If none, why? If a large number, does this affect the attention that is paid to individual students?

6. How much time is spent away from campus during the semester? Is the potential director available during the summer?

Relevant Factors for Selecting a Ph.D. Dis. Director

7. How long do students take to complete their degrees with this director?

8. What fraction of this director's students migrate elsewhere?

9. What is the placement record of this director's students?
   Where do they get jobs?

10. How much freedom will you have in your choice of dissertation topic with this director?

11. How expert is the director in your areas of interest?

12. Does the director publish with students?

13. How many publications does the typical student accumulate with this director?

14. Does the director have a research group, or merely a string of individual students?

Relevant Factors for Selecting a Ph.D. Dis. Director

15. Is the director's research work funded?

16. What are the funding prospects for the director's students?

17. Do the director's students get any summer support?

18. Does the director assist students in obtaining their own funding from such outside sources, such as fellowship programs?

19. Do the director's students go to conferences?

20. Do the director's students make presentations of their work at conferences?

21. Does the director have good relations with other faculty?

22. Does the director have a reputation for ethical behavior?

23. Are the director's work habits and expectations compatible with your own?

Partition the Domain into Classes of Problems

- Necessary conditions
- Professional reputation
- Personality and compatibility with student
- Students' learning experience
- Responsiveness to students
- Support for students
- Quality of student results

1. What is the reputation of the director within the professional community at large?
11. How expert is the director in your areas of interest?
14. Does the director have a research group, or merely a string of individual students?
15. Is the director's research work funded?
24. What is the quality of the dissertation produced with this director?

Partition the Domain into Classes of Problems

- Necessary conditions
- Professional reputation
- Personality and compatibility with student
- Students' learning experience
- Responsiveness to students
- Support for students
- Quality of student results

12. Does the director publish with students?
14. Does the director have a research group, or merely a string of individual students?
19. Do the director's students go to conferences?
20. Do the director's students make presentations of their work at conferences?
24. What is the quality of the dissertation produced with this director?

Specific Guidelines for the Modeling Process

1. **Identify the problem to be solved and express it with a clear, thorough, natural language sentence.**

2. **Follow each problem or sub-problem with a single, concise, question relevant to solving it.**

   - Ask small, incremental questions that are likely to have a single category of answer (but not necessarily a single answer). This usually means ask “who”, or “what”, or “where”, or “what kind of”, or “is this or that” etc., not complex questions such as “who and what”, or “what and where”.

3. **Follow each question with one or more answers to that question.**

   - Express answers as complete sentences, restating key elements of the question in the answer.

   - Even well formed, simple questions are likely to generate multiple answers. Select the answer that corresponds to the example solution being modeled and continue down that branch. Go back and explore possible branches in a solution tree when you are ready to model a new example solution.

Specific Guidelines for the Modeling Process

4. **Evaluate the complexity of each question and its answers. When a question leads to apparently overly complex answers, especially answers that contain an "and" condition, rephrase the question in a simpler, more incremental manner leading to simpler answers.**

5. **For each answer, form a new sub-problem, or several sub-problems, or a solution corresponding to that answer, by writing a clear, thorough, natural language sentence describing the new sub-problems or solution.**

   - To the extent that it is practical, incorporate key relevant phrases and elements of preceding problem names in sub-problem names to portray the expert's chain of problem solving thought and the accumulation of relevant knowledge.

   - If the answer has led to several sub-problems, then model their solutions in a depth-first order.

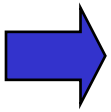
Specific Guidelines for the Modeling Process

6. After completing a solution tree for an example solution, revisit the potential branches of that tree to model additional example solutions within that category of solutions, reusing existing model components to the greatest extent possible.

7. Utilize the tools and learning ability of Disciple to the greatest extent possible to minimize the amount of modeling required.

8. Only completely model solutions that are unique in their entirety. Entirely unique solutions will be rare.

Overview



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PhD Advisor: Modeling and Ontology Specification

1. Identify instances and concepts to be represented in the ontology

We need to

Assess whether John Doe is a potential PhD advisor for Bob Sharp.

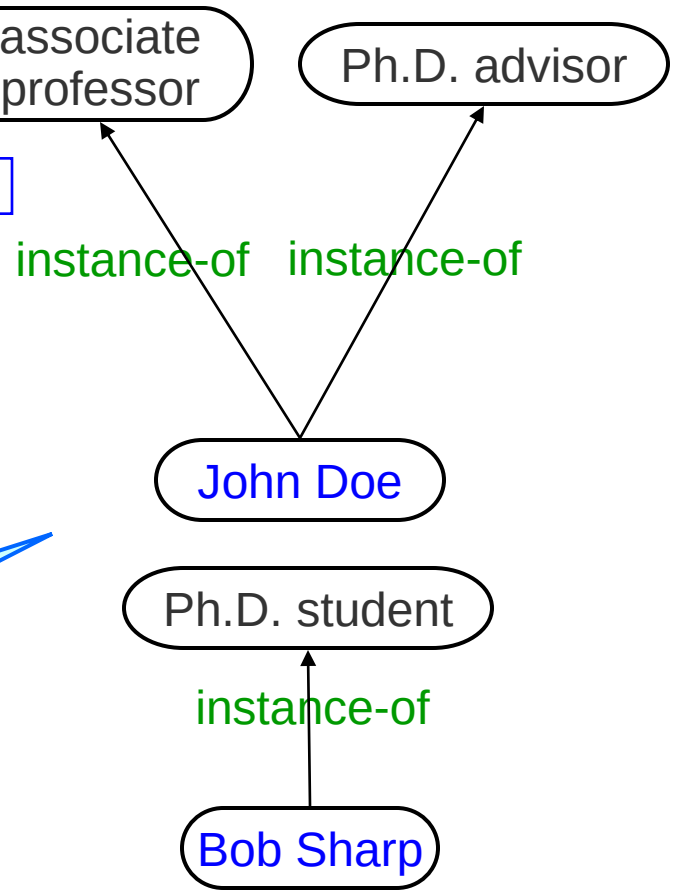
Is Bob Sharp interested in the area of expertise of John Doe?

Yes because Bob Sharp is interested in Artificial Intelligence which is the area of expertise of John Doe.

Therefore we need to

Assess whether John Doe is a potential PhD advisor for Bob Sharp in Artificial Intelligence.

...

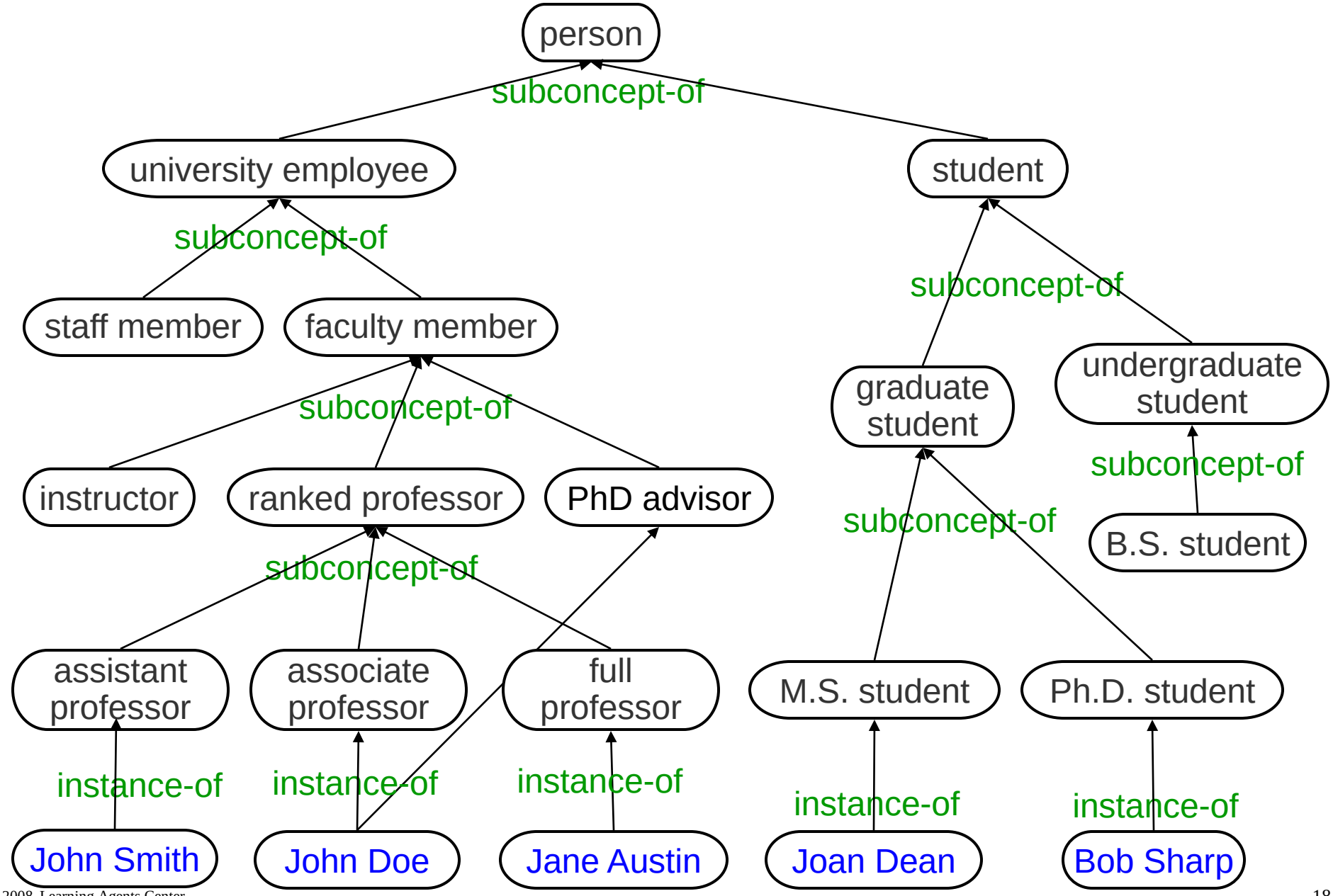


2. Specify a representation for the identified instances and concepts

3. Specify additional instances and concepts

What other concepts should we add?

Ontology Specification: Refinement



Ontology Specification

We need to

Assess whether John Doe is a potential PhD advisor for Bob Sharp.

Is Bob Sharp interested in the area of expertise of John Doe?

Yes because Bob Sharp is interested in Artificial Intelligence which is the area of expertise of John Doe.

Therefore we need to

Assess whether John Doe is a potential PhD advisor for Bob Sharp in Artificial Intelligence.

Is John Doe likely to stay on the faculty of George Mason University for the duration of Bob Sharp 's dissertation?

Yes because John Doe has a tenured position which is a long term position.

Therefore we need to

Assess whether John Doe would be a good PhD advisor for Bob Sharp in Artificial Intelligence.

1. Identify and represent instances and concepts

2. Identify the relationships between the instances

What instances concepts and relationships should we define?

Ontology Specification

Guideline: Instance or Concept?
The agent learns by generalizing instances to concepts, to perform a similar reasoning for the siblings of the instances.
Think of a similar reasoning to decide how to represent the entities.

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Yes because John Doe has a tenured position which is a long term position.

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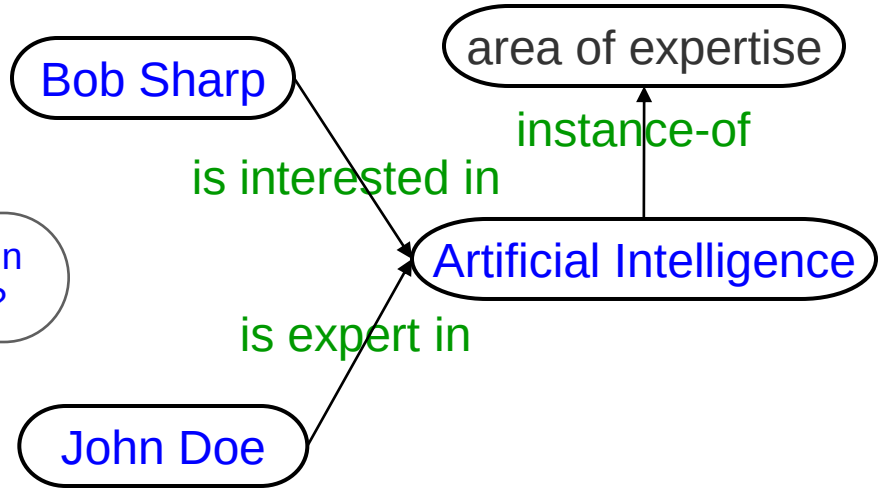
Assess whether John Doe would be a good PhD advisor for Bob Sharp in Artificial Intelligence.

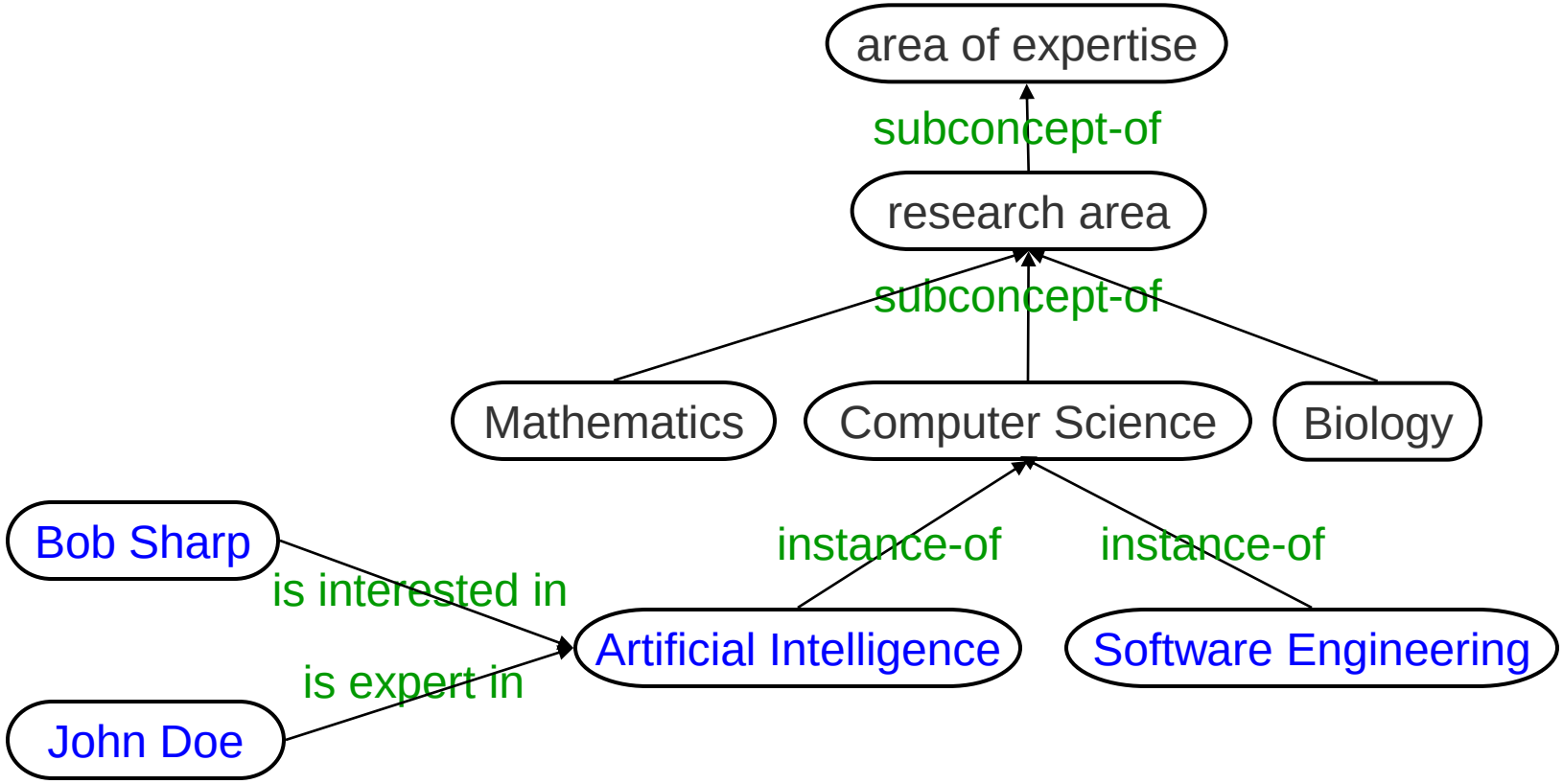
Is Ann Tip interested in the area of expertise of Joe Rig?

Yes because Ann Tip is interested in Software Engineering which is the area of expertise of Joe Rig.



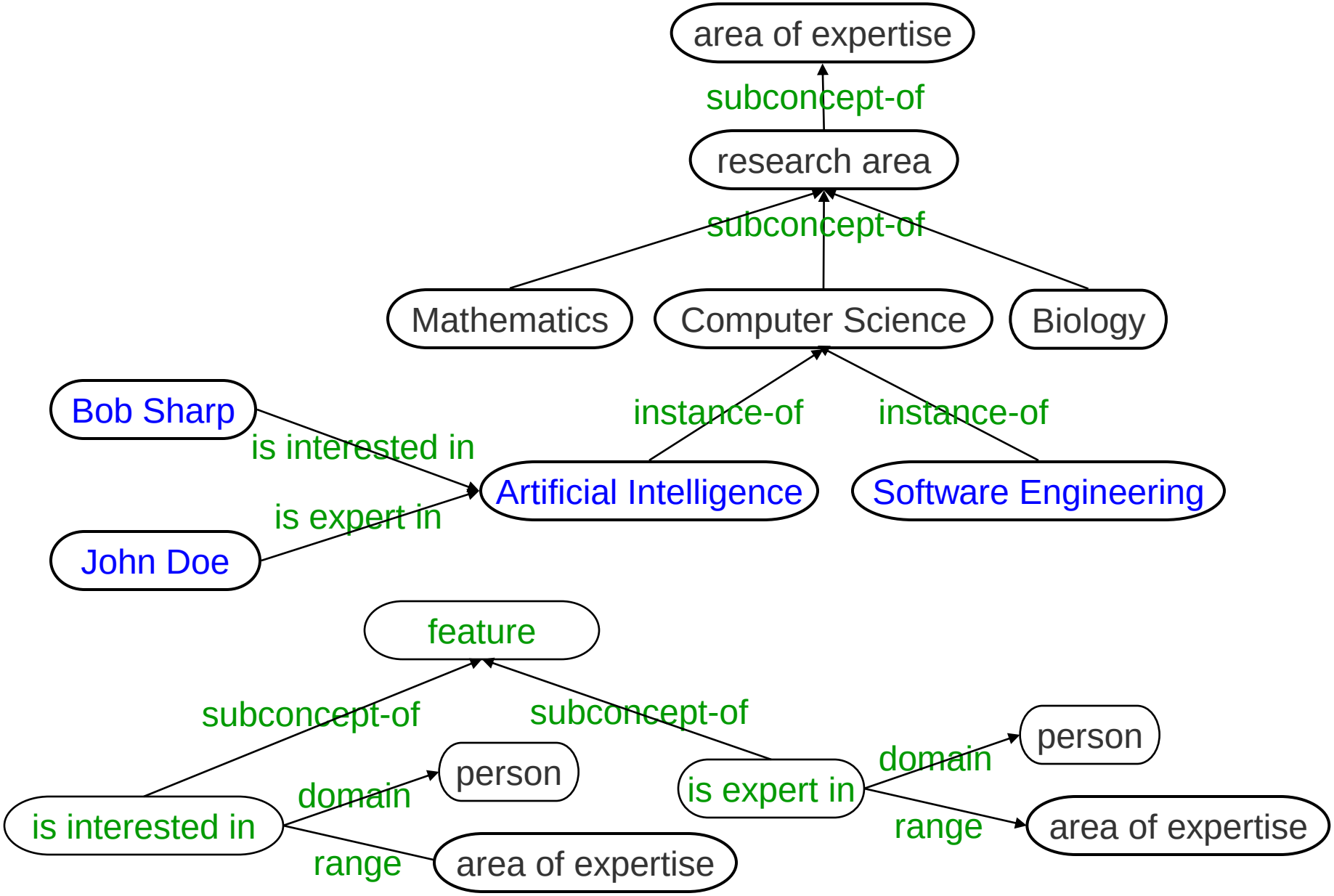
What other concepts and instances should we add?

Ontology Specification



How to define the features “is interested in” and “is expert in”?

Ontology Specification



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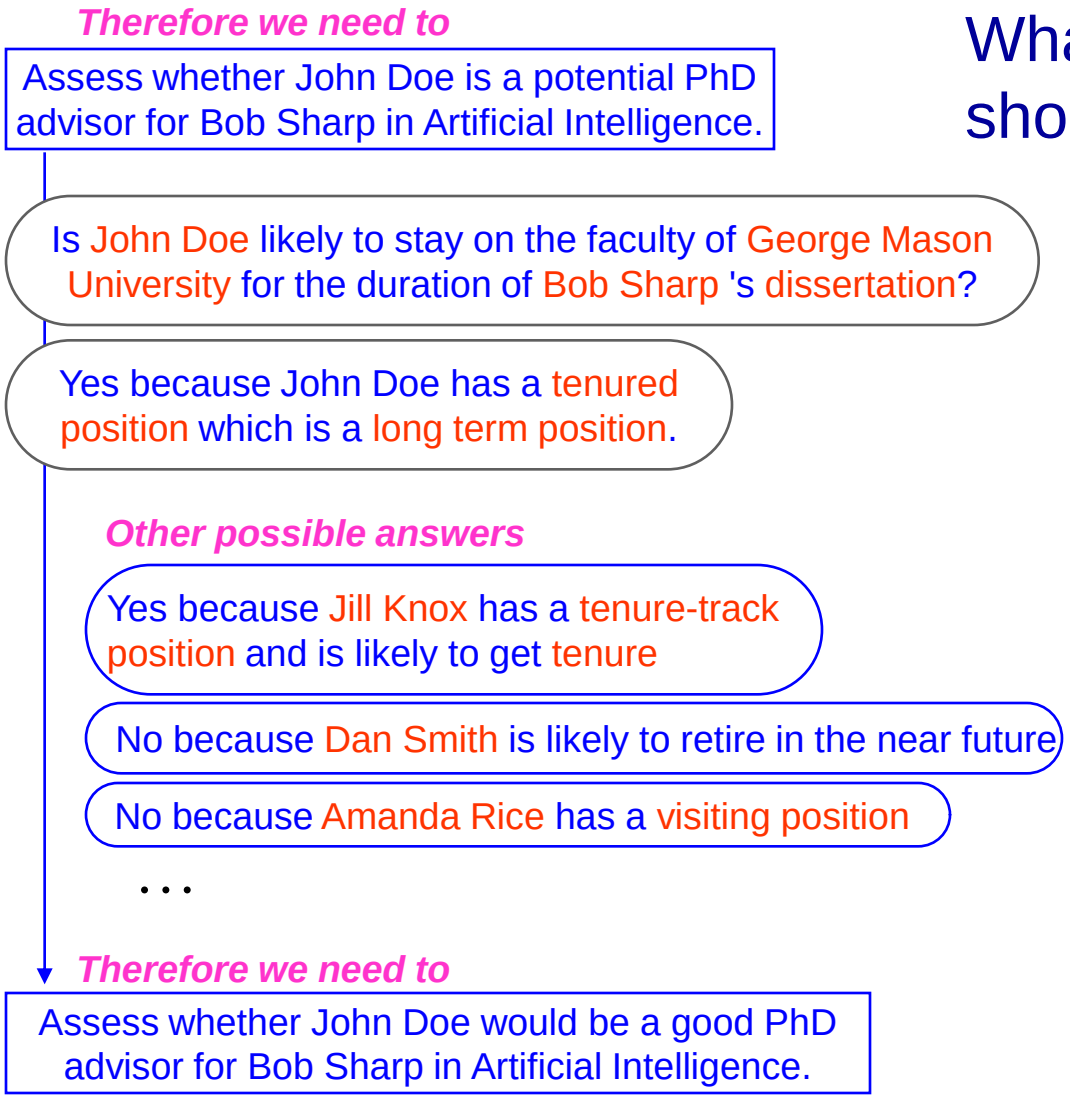


What concepts and instances should we define?

Ontology Specification

Therefore we need to

Assess whether John Doe is a potential PhD advisor for Bob Sharp in Artificial Intelligence.

university

subconcept-of

George Mason University

Is John Doe likely to stay on the faculty of George Mason University for the duration of Bob Sharp 's dissertation?

Yes because John Doe has a tenured position which is a long term position.

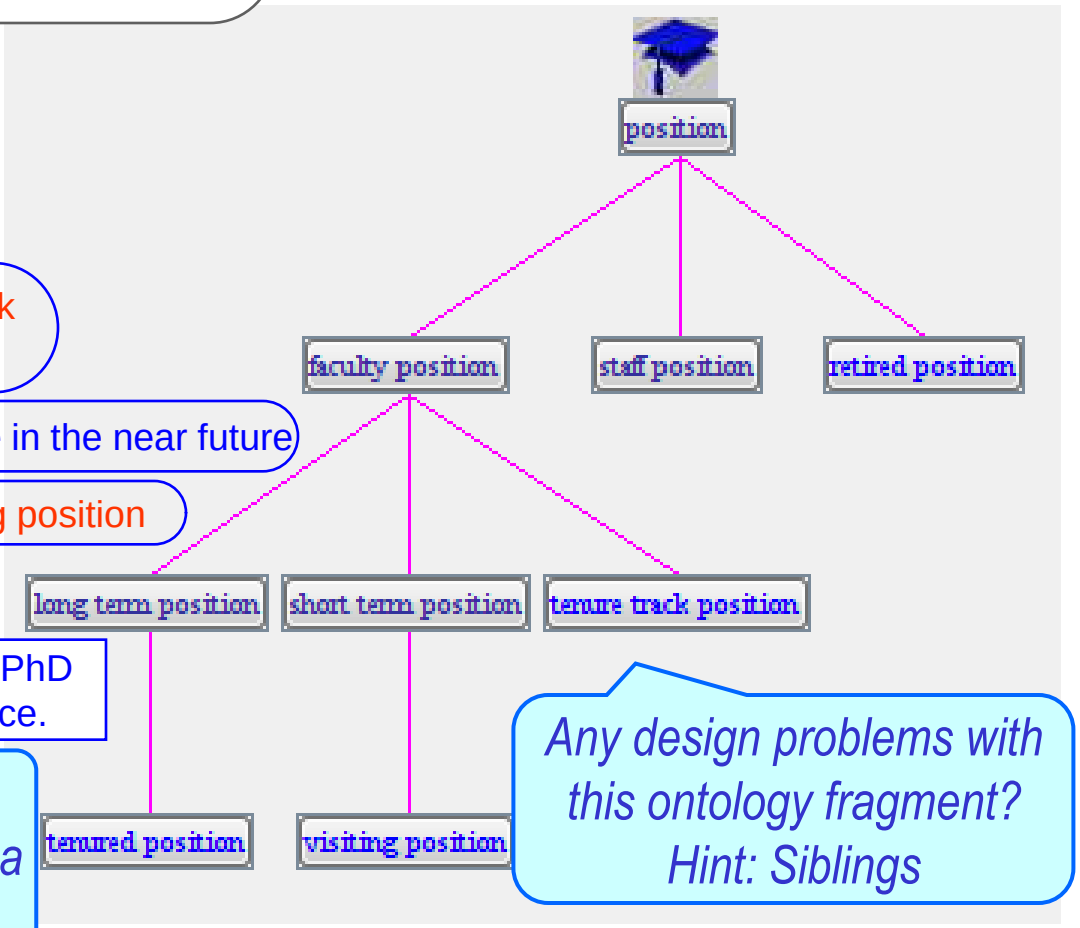
Other possible answers

Yes because Jill Knox has a tenure-track position and is likely to get tenure

No because Dan Smith is likely to retire in the near future

No because Amanda Rice has a visiting position

. . .



Therefore we need to

Assess whether John Doe would be a good PhD advisor for Bob Sharp in Artificial Intelligence.

Guideline: Instance or Concept?
If an entity (e.g. "tenure-track position") is a value of a feature, define it as an instance.

Any design problems with this ontology fragment?
Hint: Siblings

Ontology Specification

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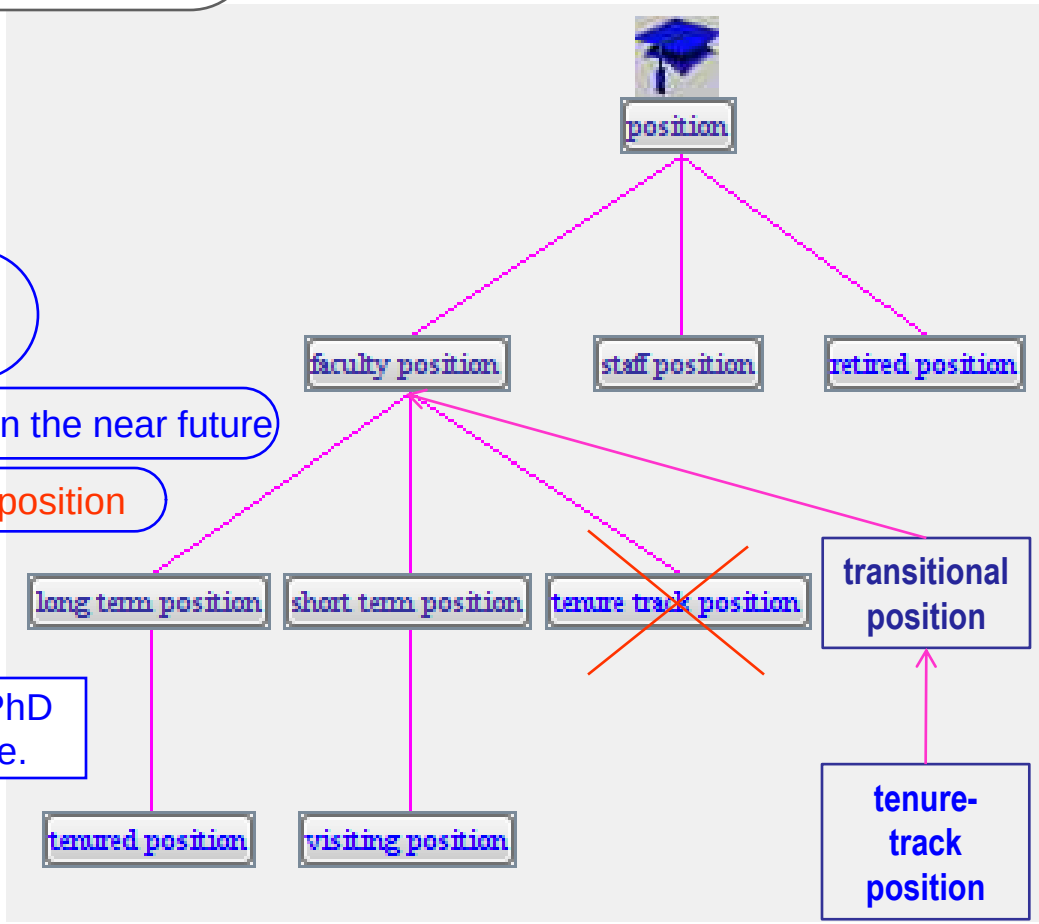

Ontology Specification

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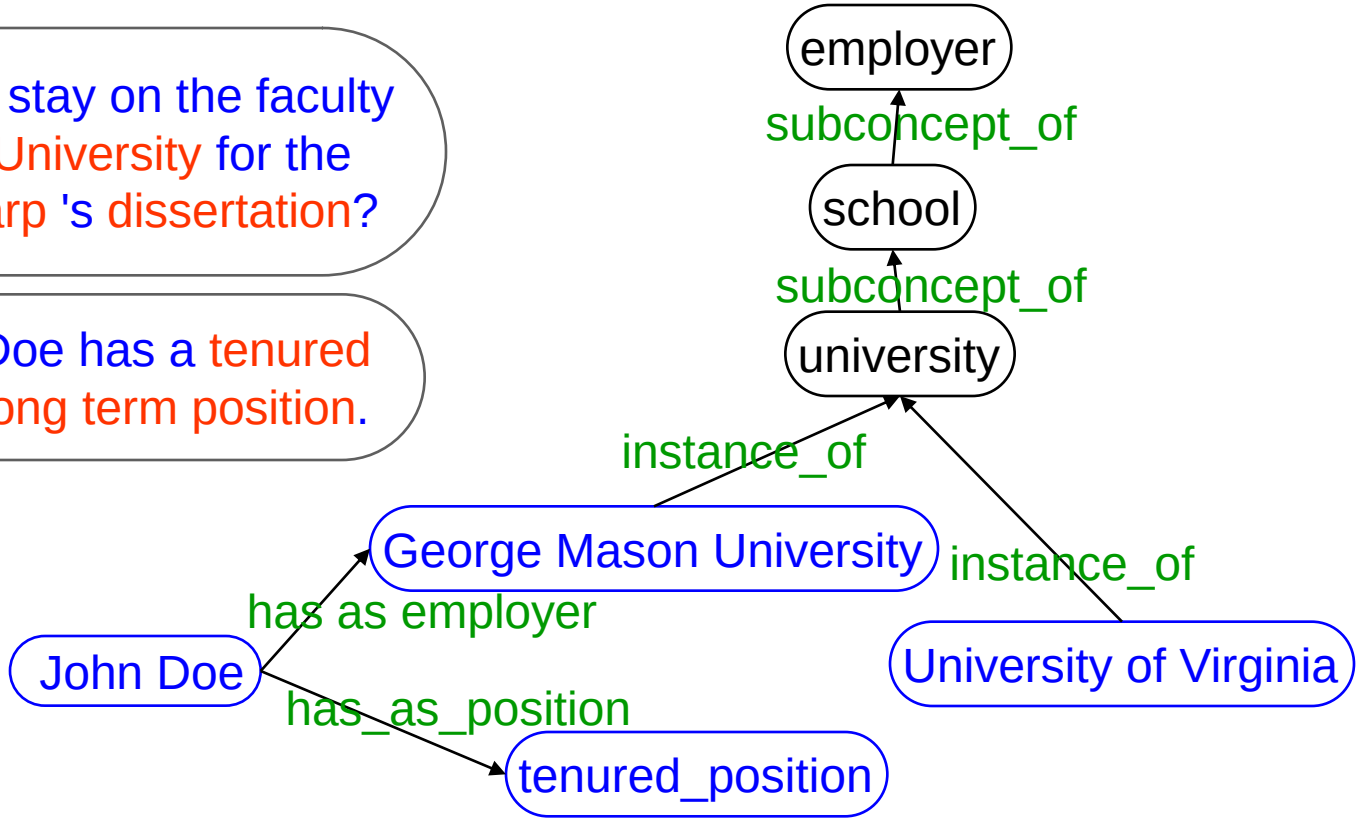


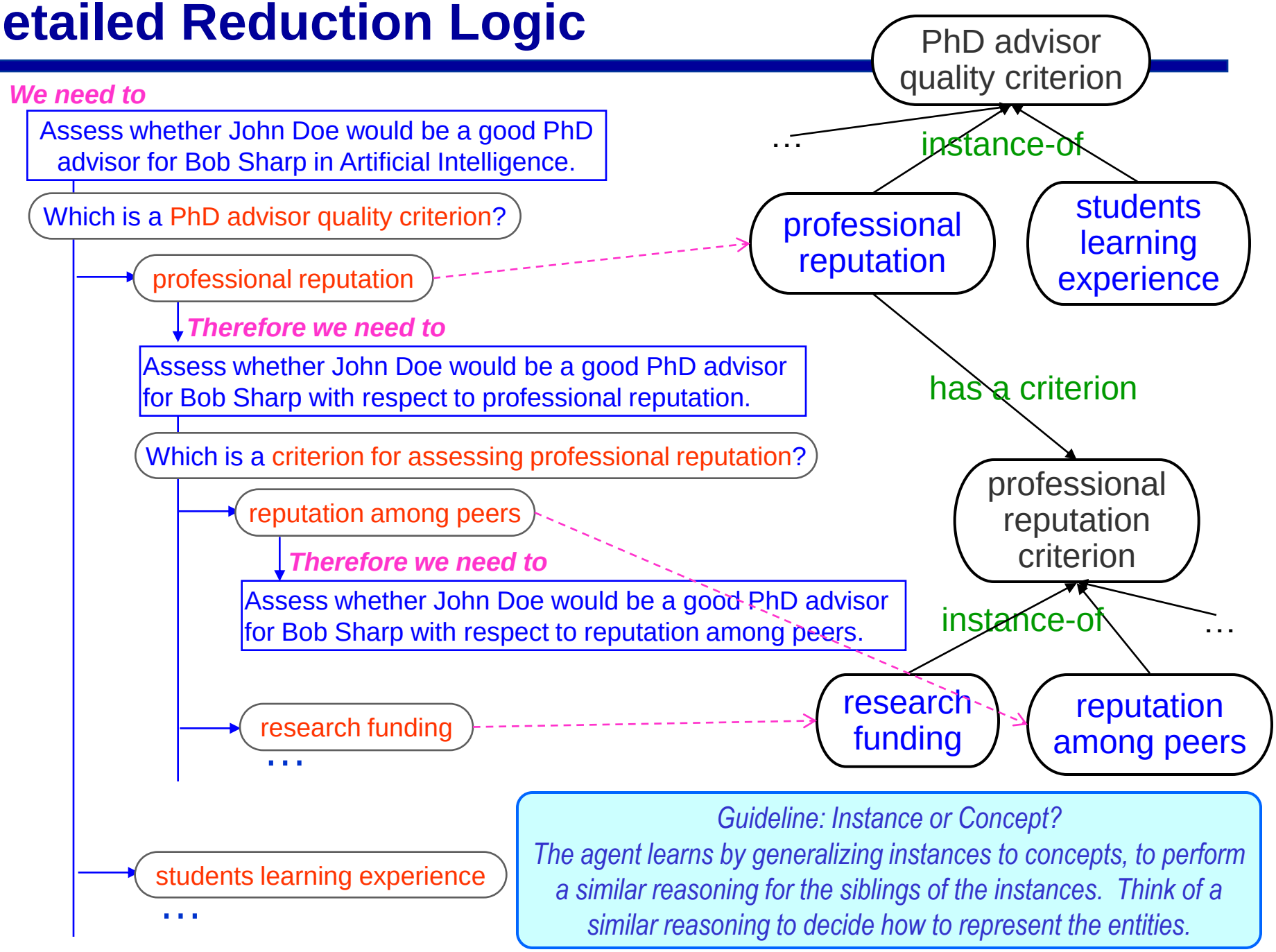
How to define the features “has as employer” and “has as position”?

Ontology Specification

Is John Doe likely to stay on the faculty of George Mason University for the duration of Bob Sharp 's dissertation?

Yes because John Doe has a tenured position which is a long term position.

Detailed Reduction Logic



Detailed Reduction Logic

We need to

Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to reputation among peers.

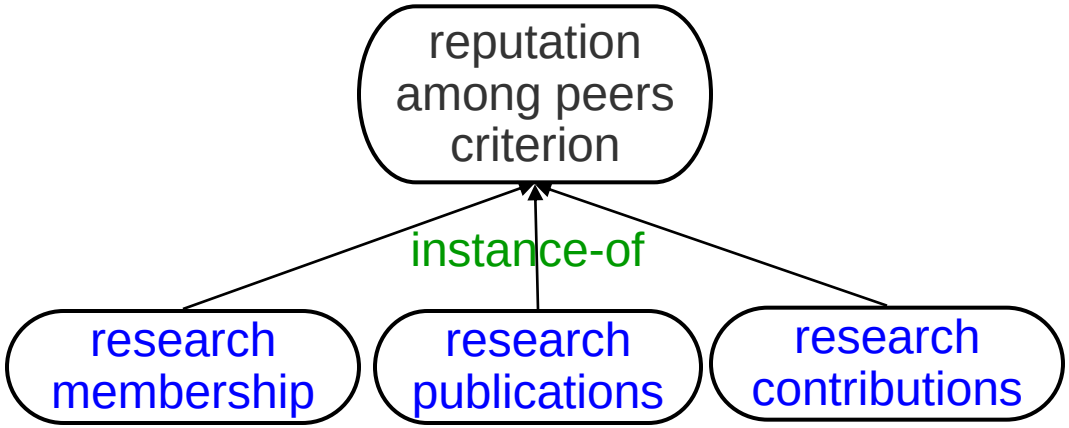
Which is a criterion for assessing reputation among peers?

- research contributions

  Therefore we need to

  Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to research contributions.

- research publications
- ...
- research memberships
- ...



Detailed Reduction Logic

We need to

Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to research contributions.

Which is a criterion for assessing research contributions?

citations in publications *

Therefore we need to

Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to citations in publications.

What publication cites John Doe?

Rice 2007 because it cites Doe 2000 which is authored by John Doe.

Therefore we conclude that

John Doe is cited in Rice 2007.

...

Knox 2003 because it cites Doe 2001 which is authored by John Doe.

Therefore we conclude that

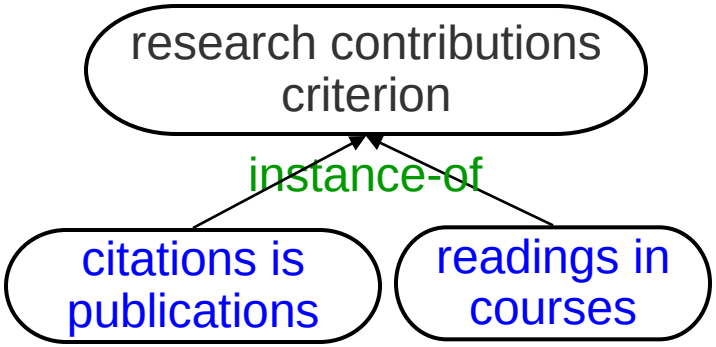
John Doe is cited in Knox 2003.

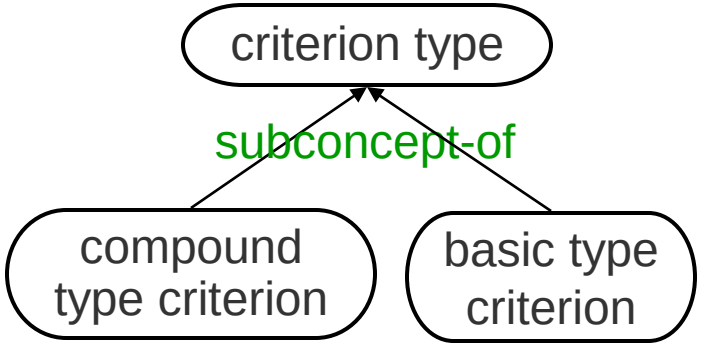
readings in courses *

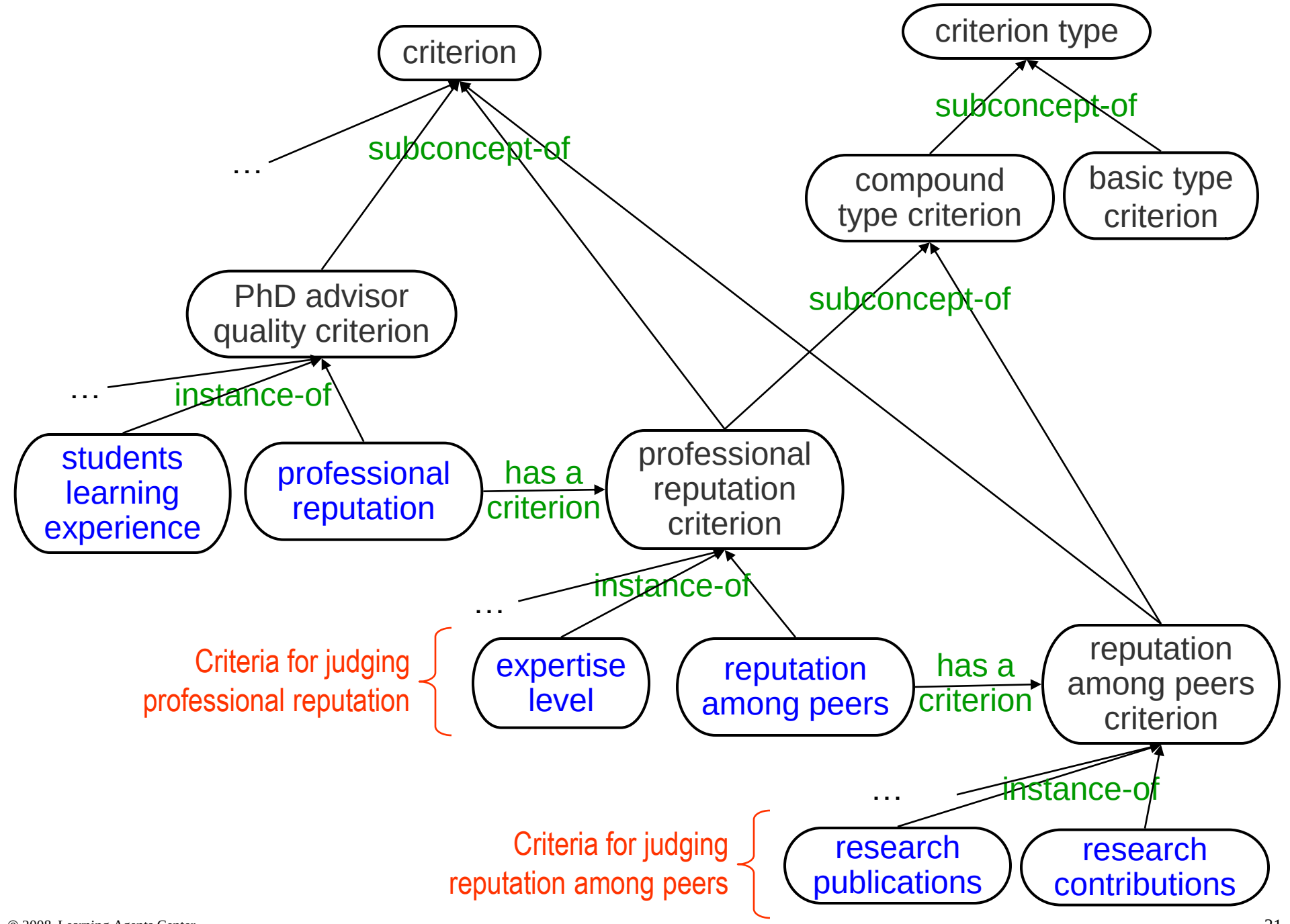
Therefore we need to

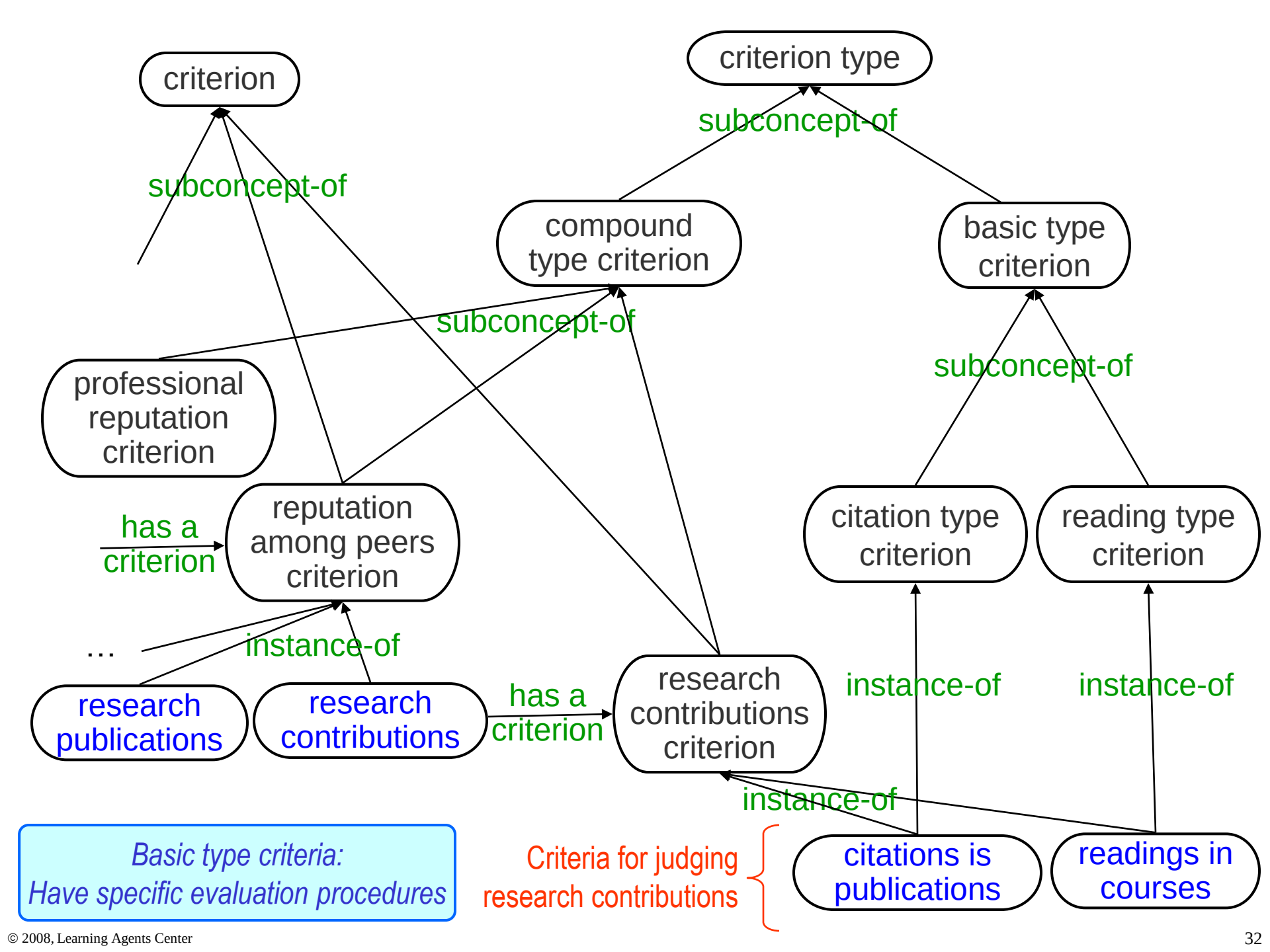
Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to readings in courses.

* *Basic type criteria:*
Have specific evaluation procedures









Detailed Reduction Logic

We need to

Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to research contributions.

Which is a criterion for assessing research contributions?

- citations in publications

  Therefore we need to

  Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to citations in publications.

  What publication cites John Doe?

  - Rice 2007 because it cites Doe 2000 which is authored by John Doe.

    Therefore we conclude that

    John Doe is cited in Rice 2007.

  - ...

  - Knox 2003 because it cites Doe 2001 which is authored by John Doe.

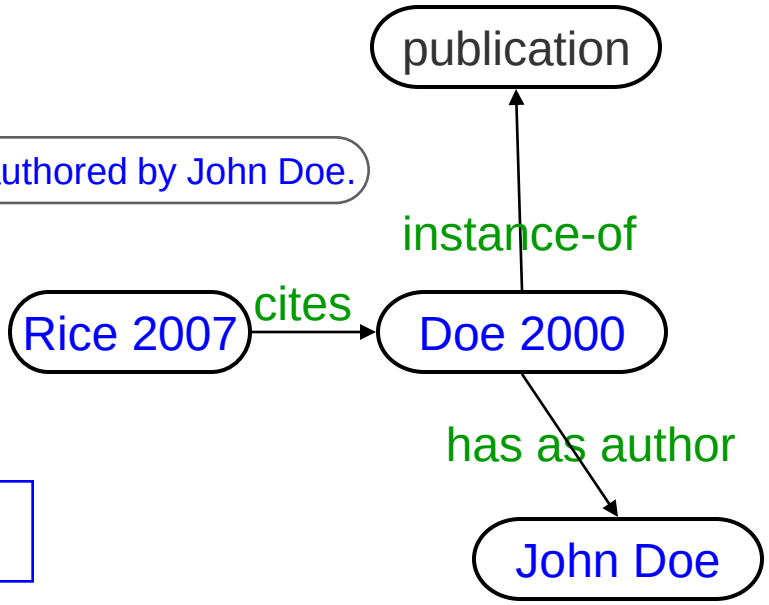
    Therefore we conclude that

    John Doe is cited in Knox 2003.

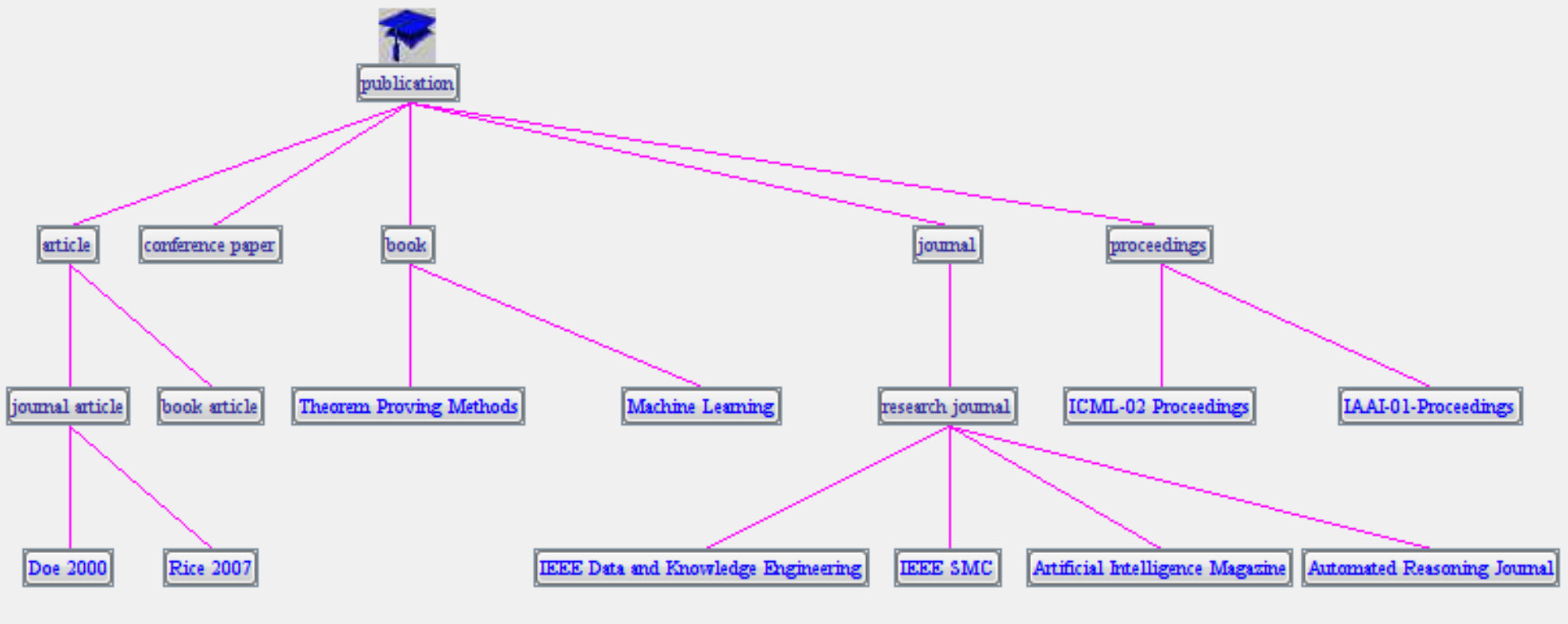
- readings in courses

  Therefore we need to

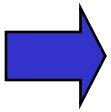
  Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to readings in courses.



Sample Publication Ontology



Overview



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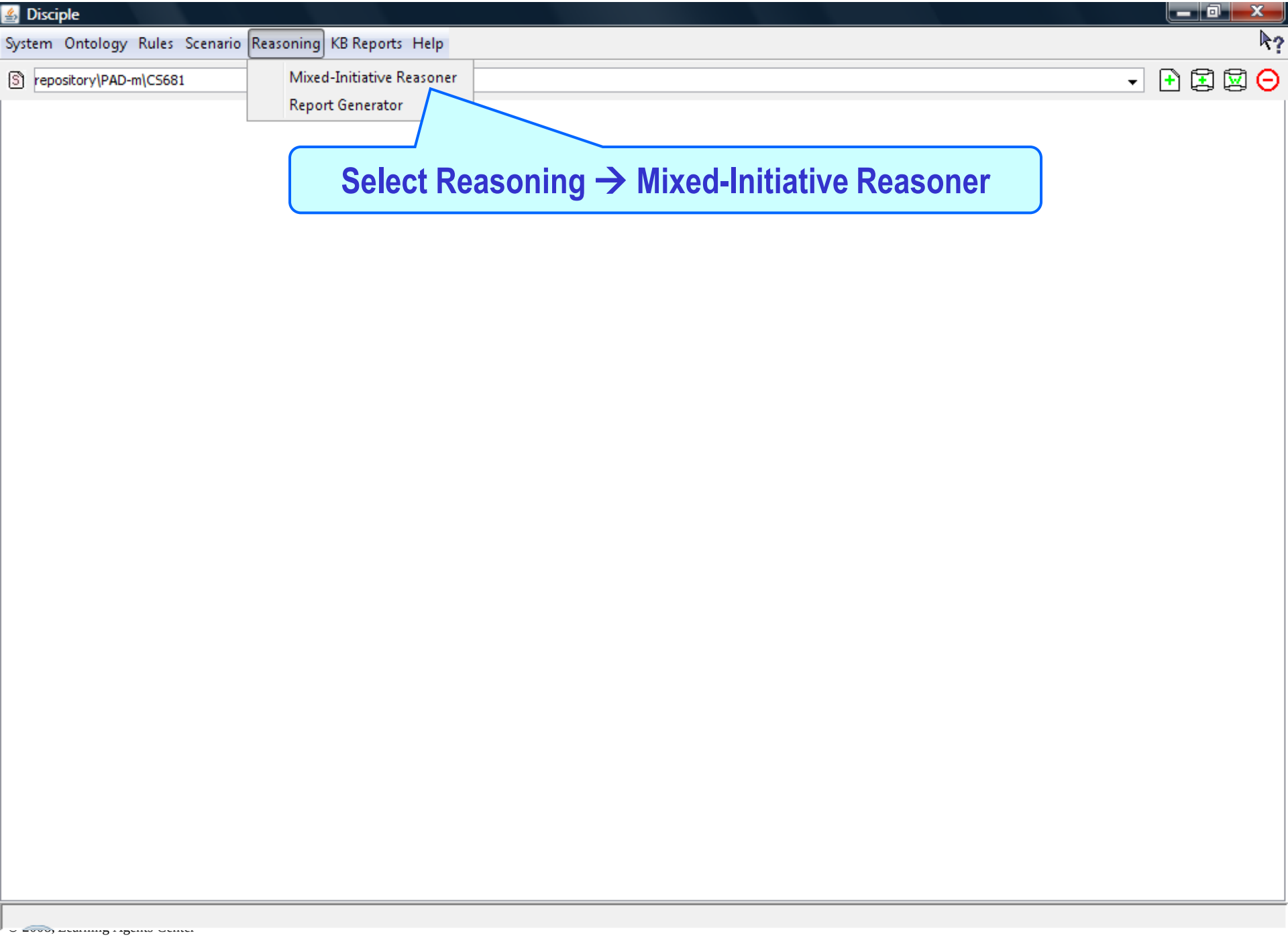
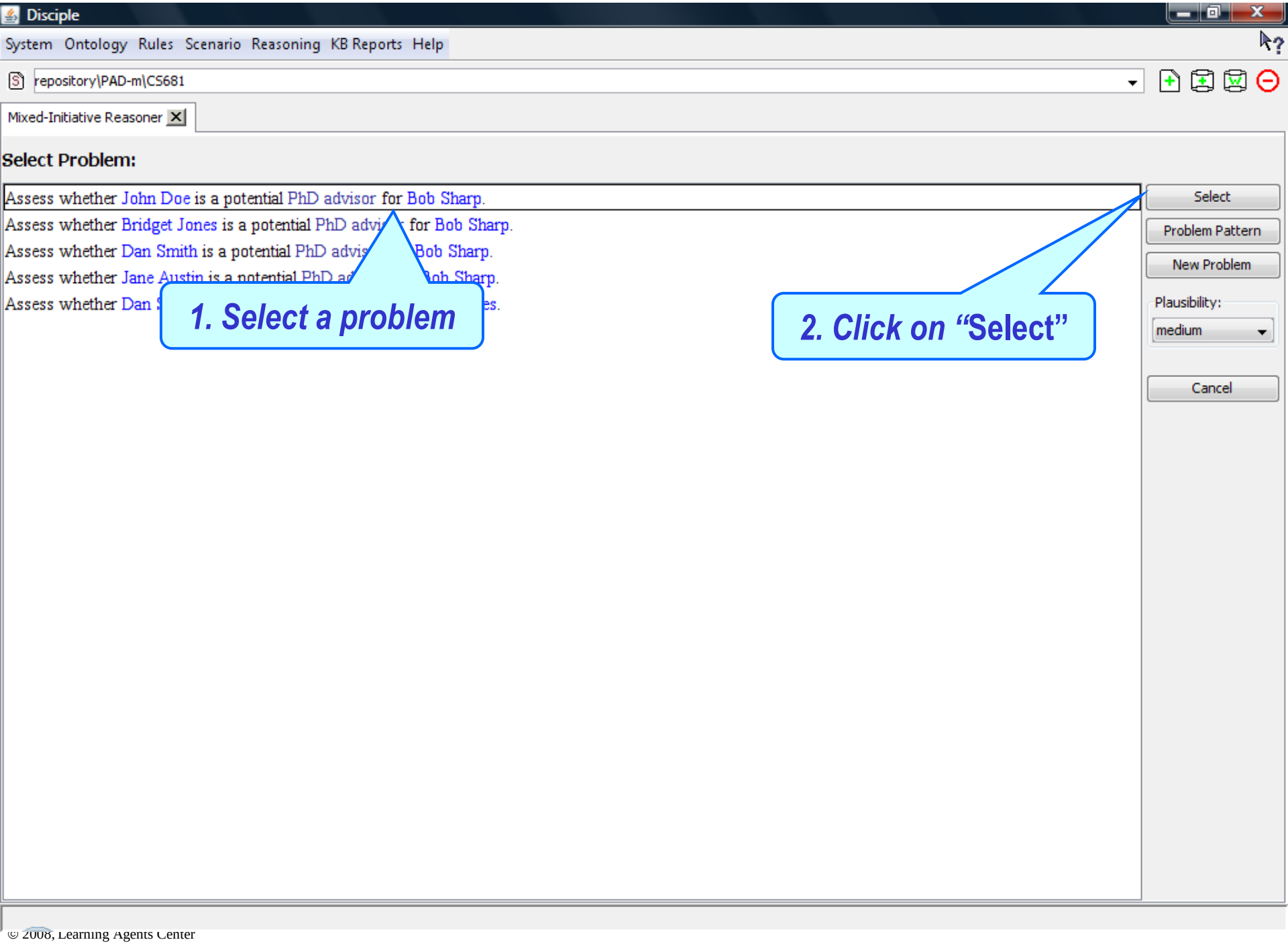
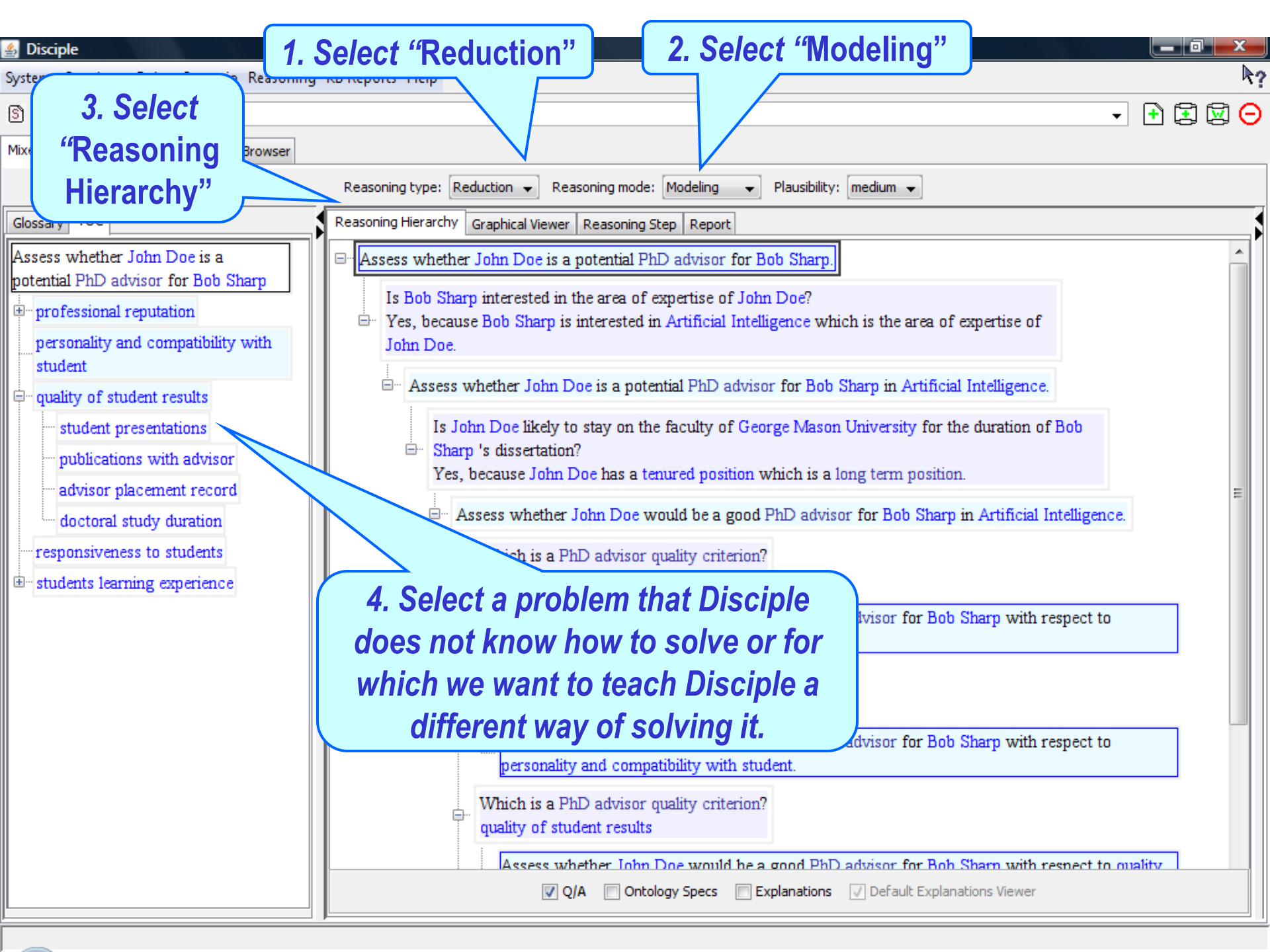
Demo: Modeling Editor

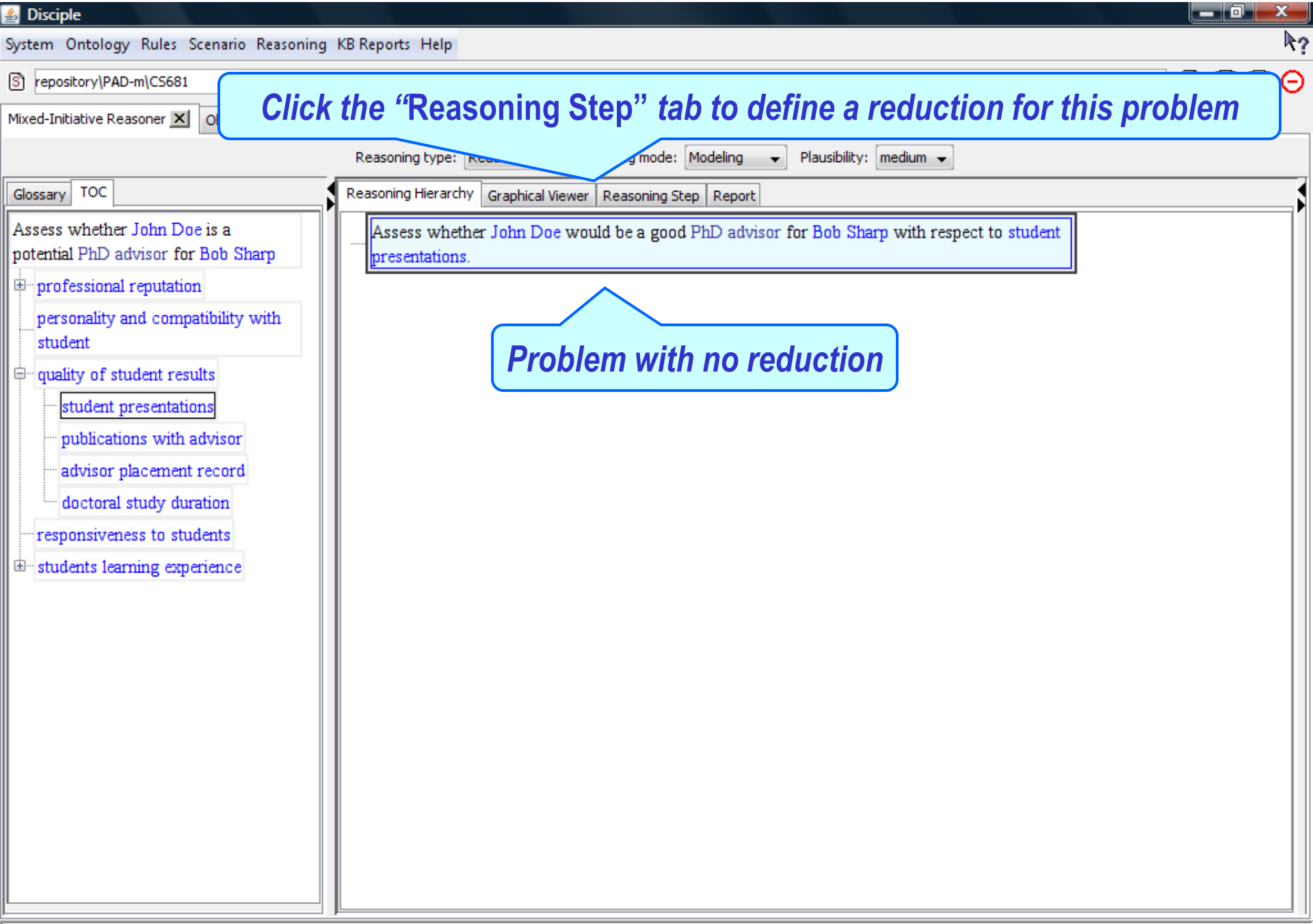
The Modeling Editor is a tool that allows the subject matter expert to express his/her reasoning by using the problem-reduction paradigm.

The next slides show how to use this tool.


Disciple
System Ontology Rules Scenario Reasoning KB Reports Help
repository\PAD-m\CS681
Mixed-Initiative Reasoner
Report Generator
Select Reasoning → Mixed-Initiative Reasoner




1. Select "Reduction"
2. Select "Modeling"
3. Select "Reasoning Hierarchy"
4. Select a problem that Disciple does not know how to solve or for which we want to teach Disciple a different way of solving it.
Disciple
Reasoning type: Reduction
Reasoning mode: Modeling
Plausibility: medium
Reasoning Hierarchy
Graphical Viewer
Reasoning Step
Report
Assess whether John Doe is a potential PhD advisor for Bob Sharp
professional reputation
personality and compatibility with student
quality of student results
student presentations
publications with advisor
advisor placement record
doctoral study duration
responsiveness to students
students learning experience
Assess whether John Doe is a potential PhD advisor for Bob Sharp.
Is Bob Sharp interested in the area of expertise of John Doe?
Yes, because Bob Sharp is interested in Artificial Intelligence which is the area of expertise of John Doe.
Assess whether John Doe is a potential PhD advisor for Bob Sharp in Artificial Intelligence.
Is John Doe likely to stay on the faculty of George Mason University for the duration of Bob Sharp 's dissertation?
Yes, because John Doe has a tenured position which is a long term position.
Assess whether John Doe would be a good PhD advisor for Bob Sharp in Artificial Intelligence.
Which is a PhD advisor quality criterion?
personality and compatibility with student.
Which is a PhD advisor quality criterion?
quality of student results
Q/A
Ontology Specs
Explanations
Default Explanations Viewer


Disciple
System Ontology Rules Scenario Reasoning KB Reports Help
repository\PAD-m\CS681
Mixed-Initiative Reasoner
Click the "Reasoning Step" tab to define a reduction for this problem
Reasoning type:
mode: Modeling
Plausibility: medium
Glossary TOC
Assess whether John Doe is a potential PhD advisor for Bob Sharp
professional reputation
personality and compatibility with student
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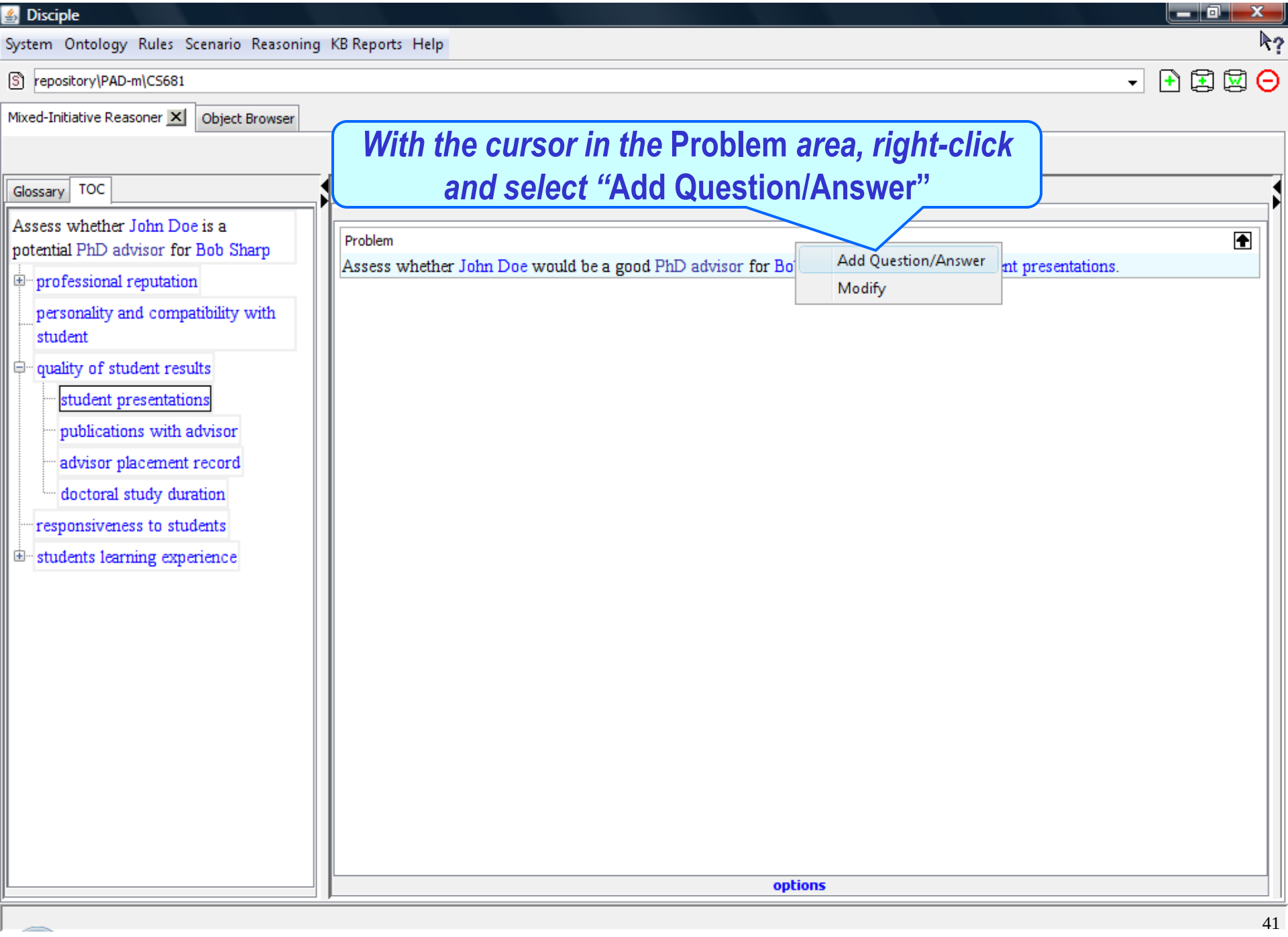
publications with advisor
advisor placement record
doctoral study duration
responsiveness to students
students learning experience
Reasoning Hierarchy Graphical Viewer Reasoning Step Report
Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to student presentations.
Problem with no reduction


Disciple
System Ontology Rules Scenario Reasoning KB Reports Help
repository\PAD-m\CS681
Mixed-Initiative Reasoner
Object Browser
With the cursor in the Problem area, right-click and select "Add Question/Answer"
Glossary
TOC
Assess whether John Doe is a potential PhD advisor for Bob Sharp
professional reputation
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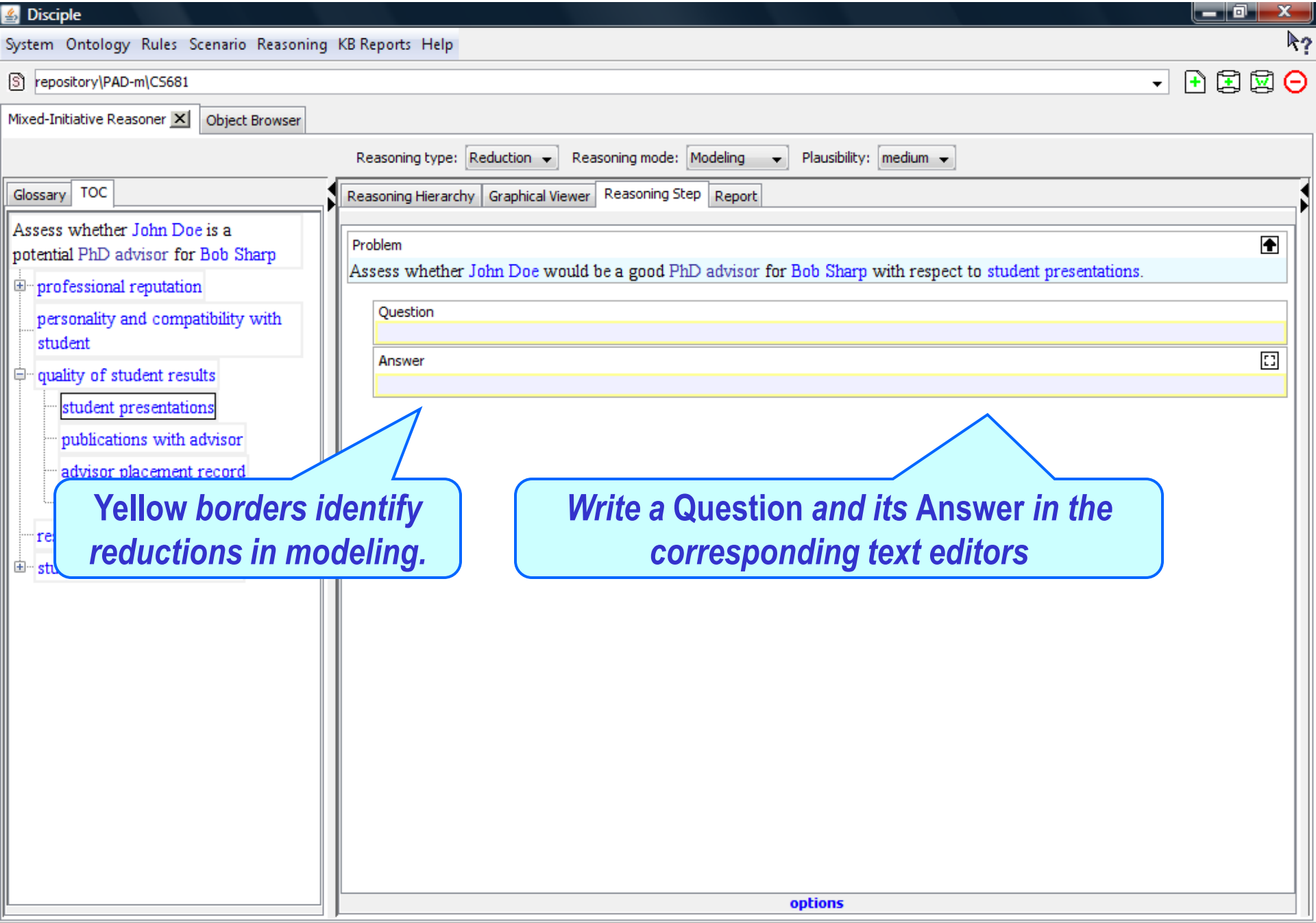
advisor placement record
doctoral study duration
responsiveness to students
students learning experience
Problem
Assess whether John Doe would be a good PhD advisor for Bo
nt presentations.
Add Question/Answer
Modify
options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Object Browser
Reasoning type: Reduction
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TOC
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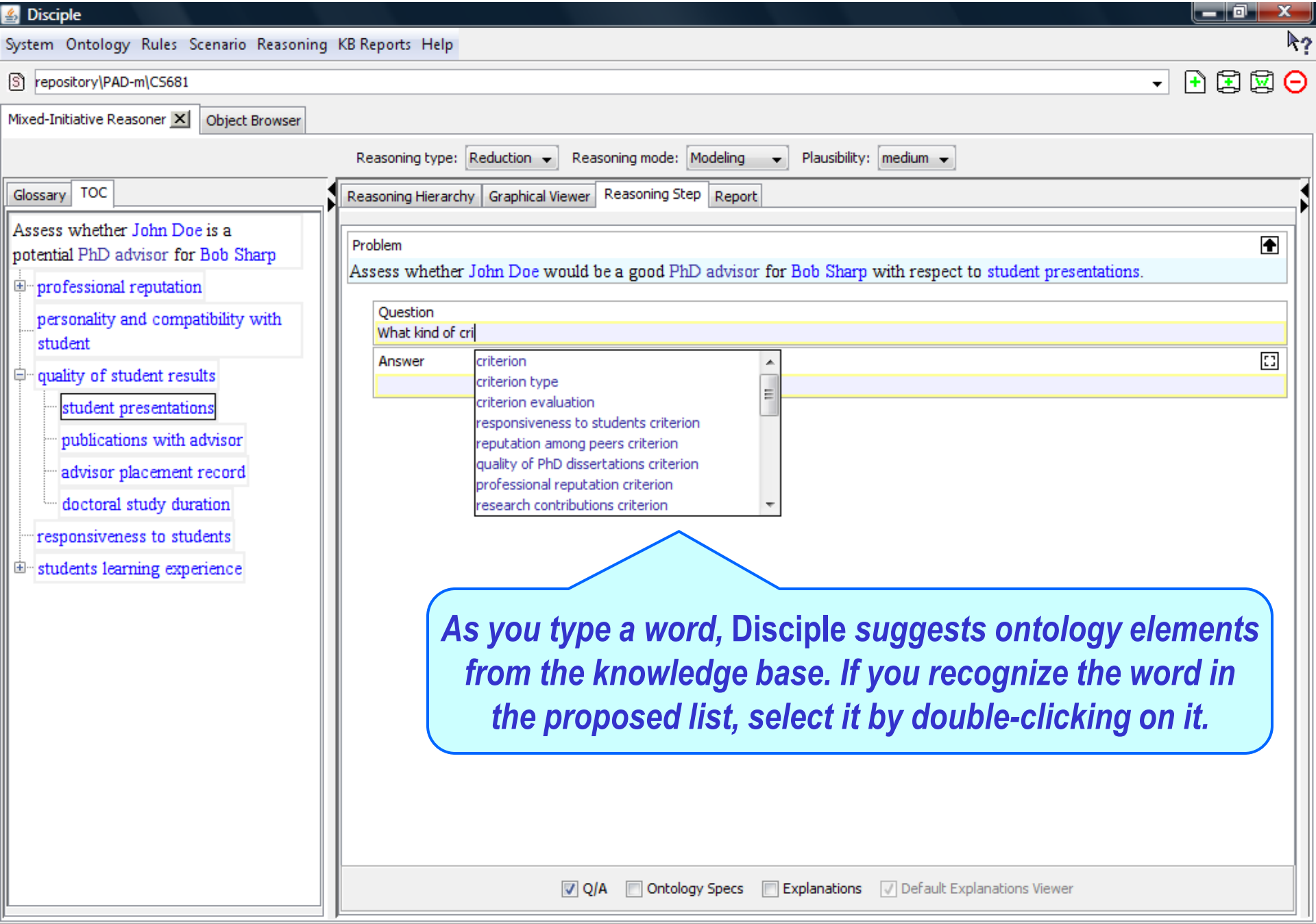
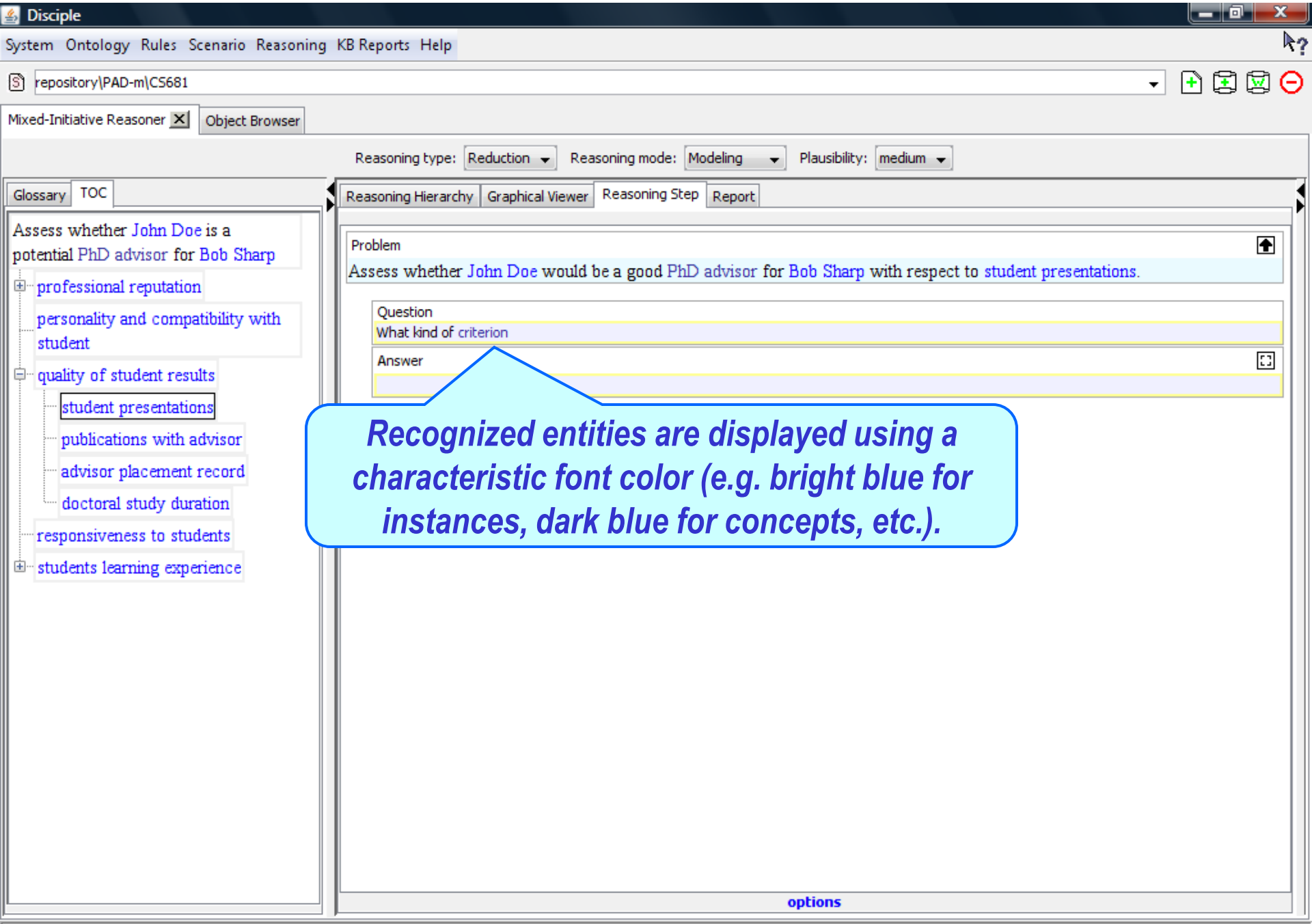
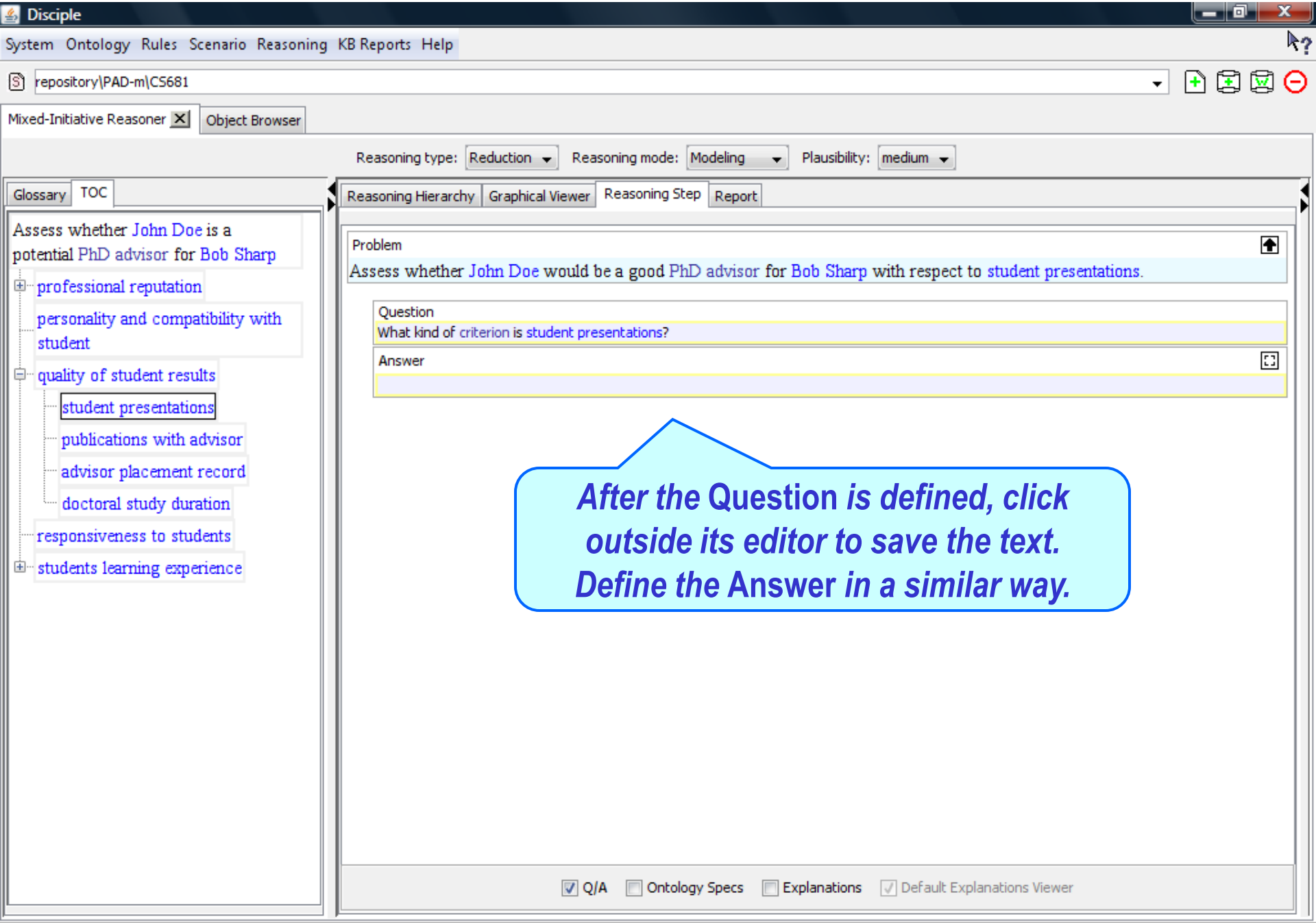
personality and compatibility with student
quality of student results
student presentations
publications with advisor
advisor placement record
Reasoning Hierarchy
Graphical Viewer
Reasoning Step
Report
Problem
Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to student presentations.
Question
Answer
options
Yellow borders identify reductions in modeling.
Write a Question and its Answer in the corresponding text editors



As you type a word,* Disciple *suggests ontology elements from the knowledge base. If you recognize the word in the proposed list, select it by double-clicking on it.



Recognized entities are displayed using a characteristic font color (e.g. bright blue for instances, dark blue for concepts, etc.).


Disciple
System Ontology Rules Scenario Reasoning KB Reports Help
repository\PAD-m\CS681
Mixed-Initiative Reasoner
Object Browser
Reasoning type: Reduction
Reasoning mode: Modeling
Plausibility: medium
Glossary
TOC
Assess whether John Doe is a potential PhD advisor for Bob Sharp
professional reputation
personality and compatibility with student
quality of student results
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doctoral study duration
responsiveness to students
students learning experience
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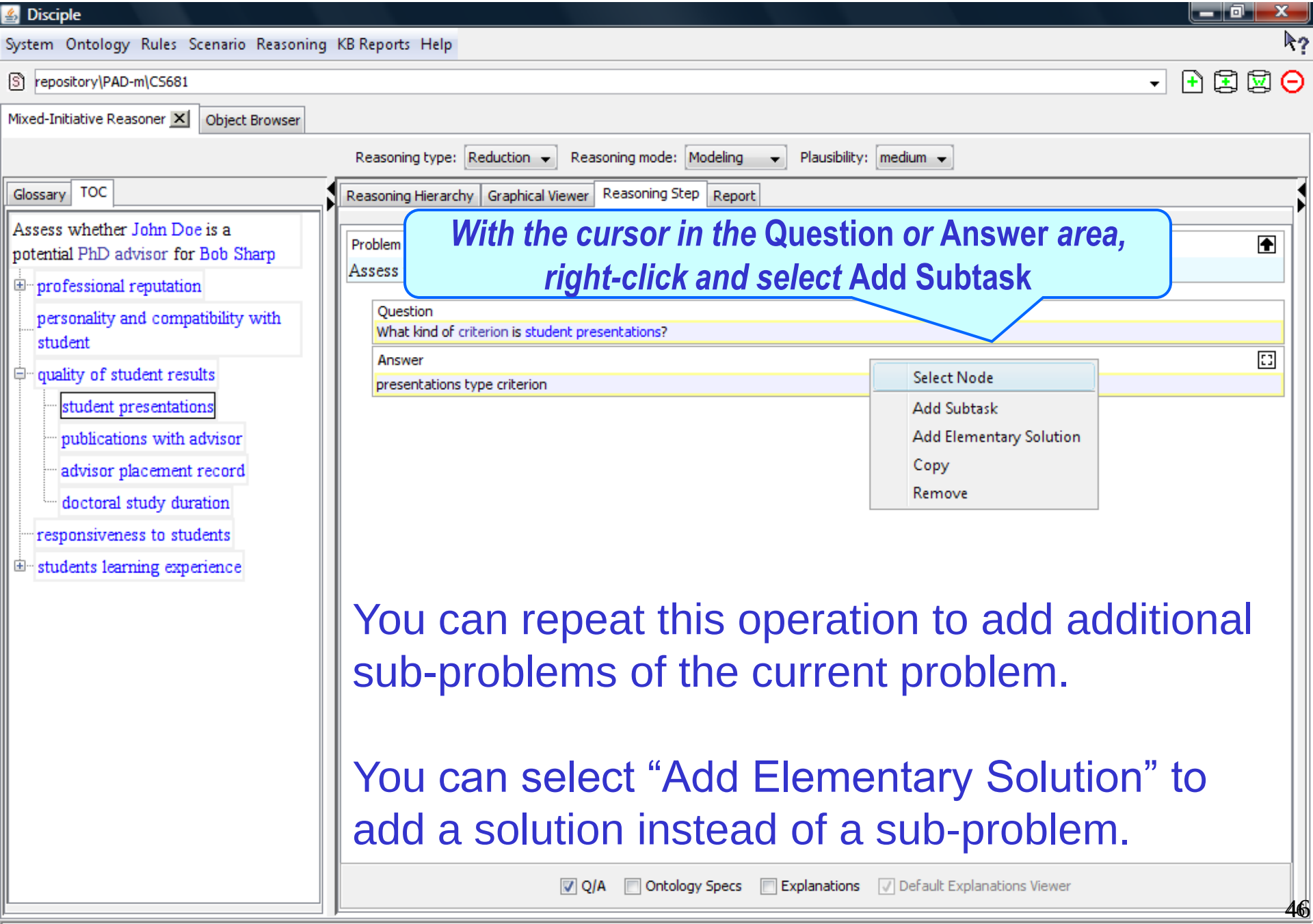
Problem
Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to student presentations.
Question
What kind of criterion is student presentations?
Answer
After the Question is defined, click outside its editor to save the text. Define the Answer in a similar way.
Q/A
Ontology Specs
Explanations
Default Explanations Viewer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repository\PAD-m\CS681
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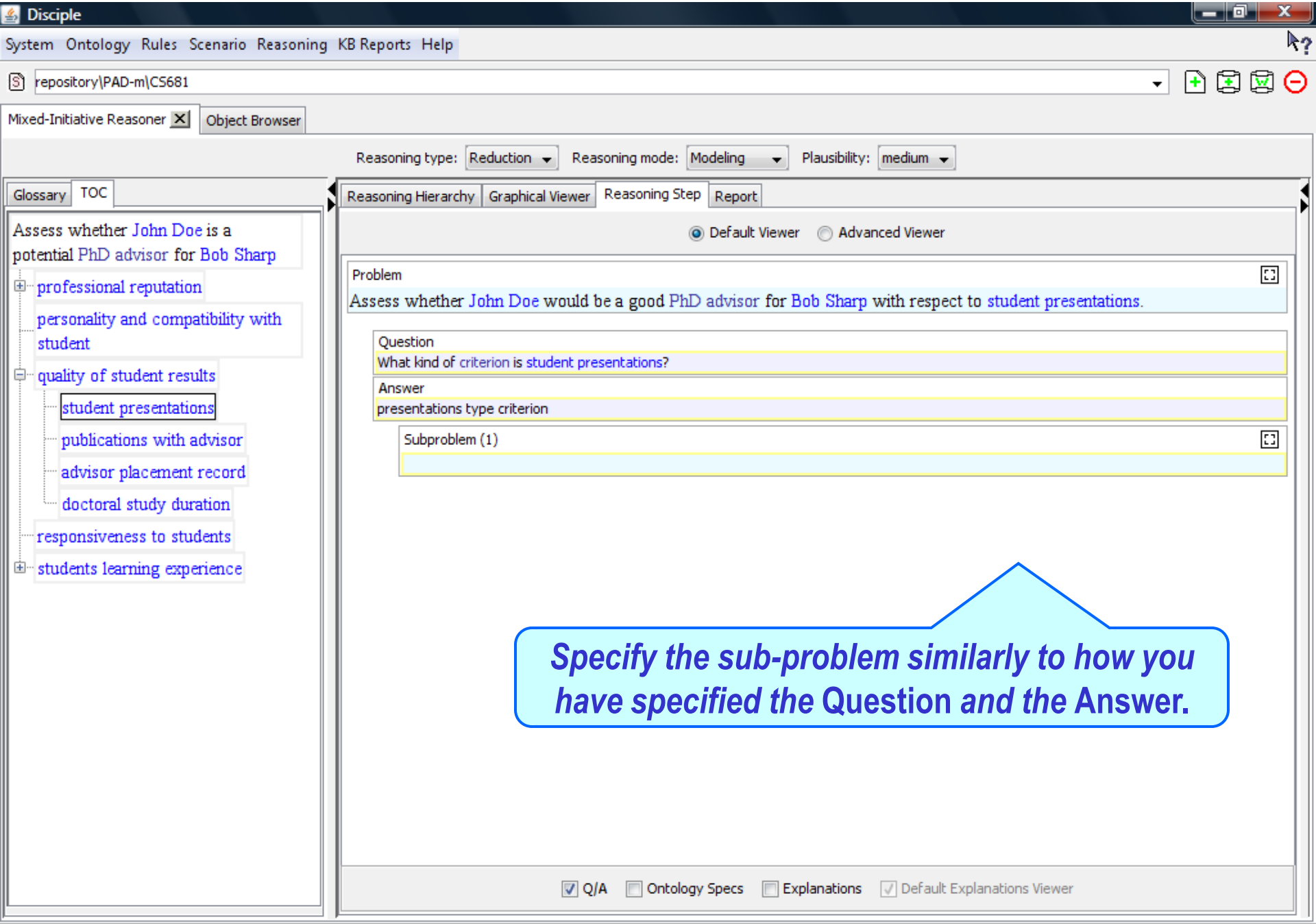
Reasoning Step
Report
With the cursor in the Question or Answer area, right-click and select Add Subtask
Problem
Assess
Question
What kind of criterion is student presentations?
Answer
presentations type criterion
Select Node
Add Subtask
Add Elementary Solution
Copy
Remove
You can repeat this operation to add additional sub-problems of the current problem.
You can select “Add Elementary Solution” to add a solution instead of a sub-problem.
Q/A
Ontology Specs
Explanations
Default Explanations Viewer


Disciple
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repository\PAD-m\CS681
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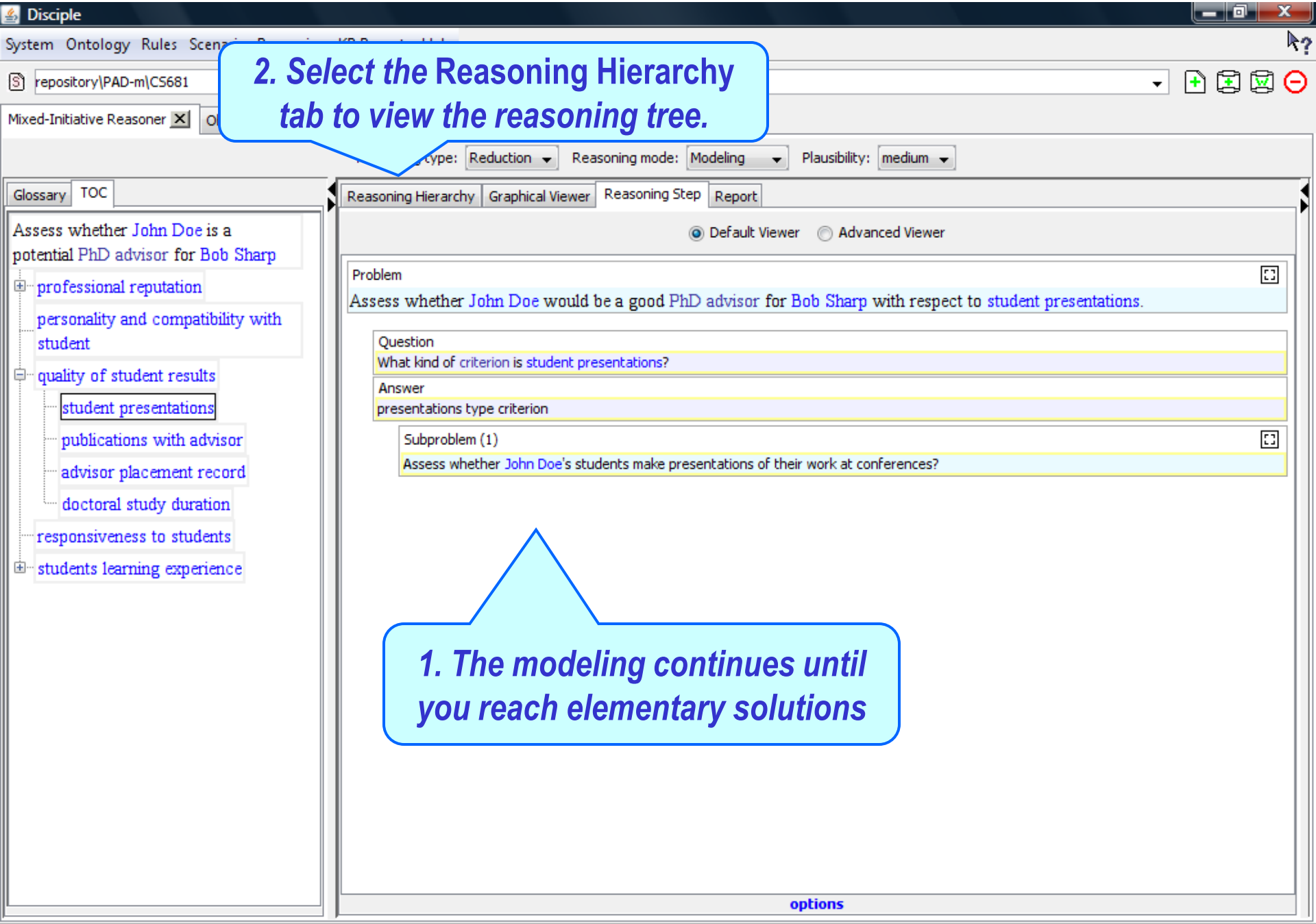
Reasoning Hierarchy
Graphical Viewer
Reasoning Step
Report
Default Viewer
Advanced Viewer
Problem
Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to student presentations.
Question
What kind of criterion is student presentations?
Answer
presentations type criterion
Subproblem (1)
Specify the sub-problem similarly to how you have specified the Question and the Answer.
Q/A
Ontology Specs
Explanations
Default Explanations Viewer


Disciple
System Ontology Rules
repository\PAD-m\CS681
Mixed-Initiative Reasoner
2. Select the Reasoning Hierarchy tab to view the reasoning tree.
type: Reduction
Reasoning mode: Modeling
Plausibility: medium
Glossary
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Reasoning Step
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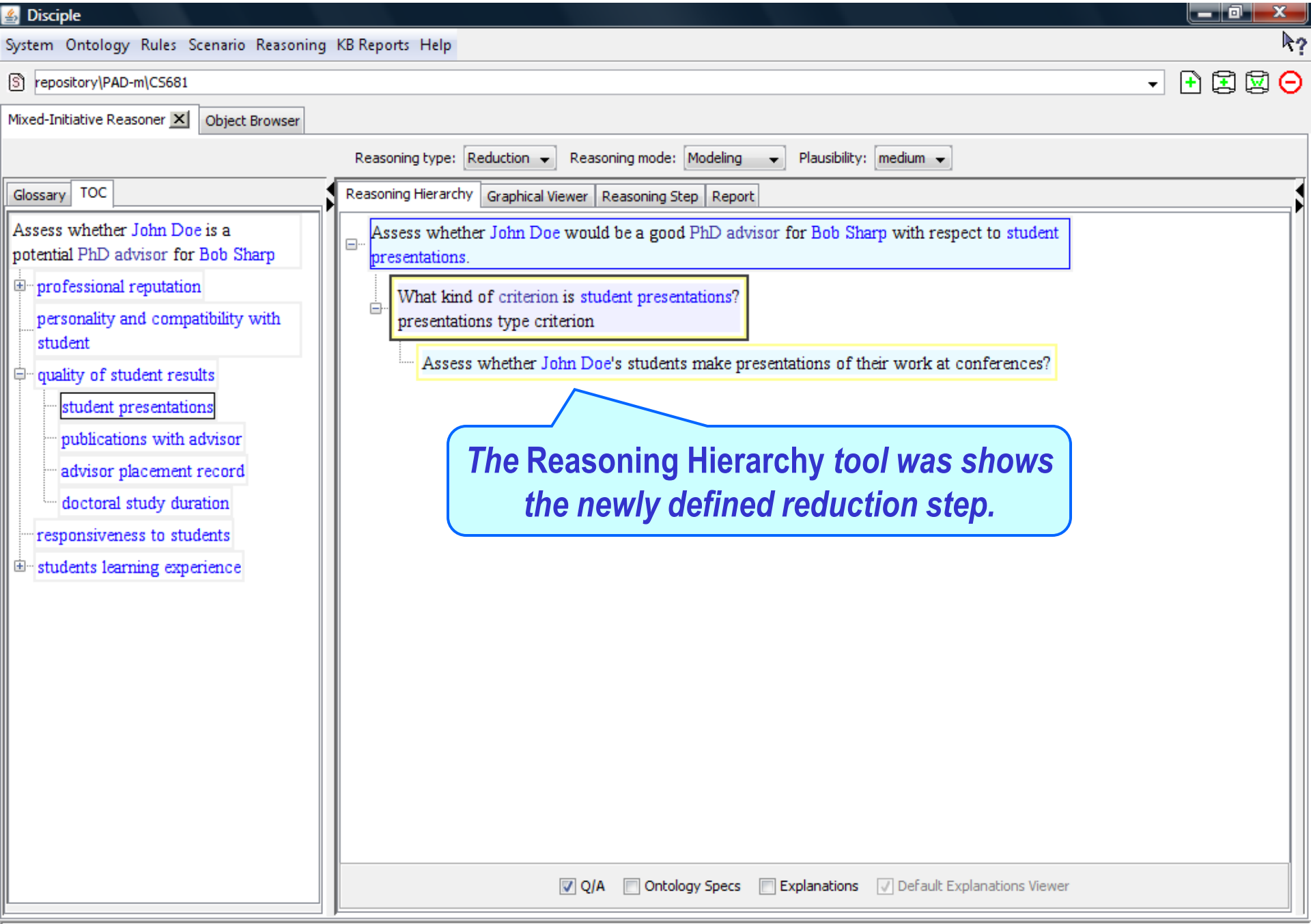
Default Viewer
Advanced Viewer
Problem
Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to student presentations.
Question
What kind of criterion is student presentations?
Answer
presentations type criterion
Subproblem (1)
Assess whether John Doe's students make presentations of their work at conferences?
1. The modeling continues until you reach elementary solutions
options


Disciple
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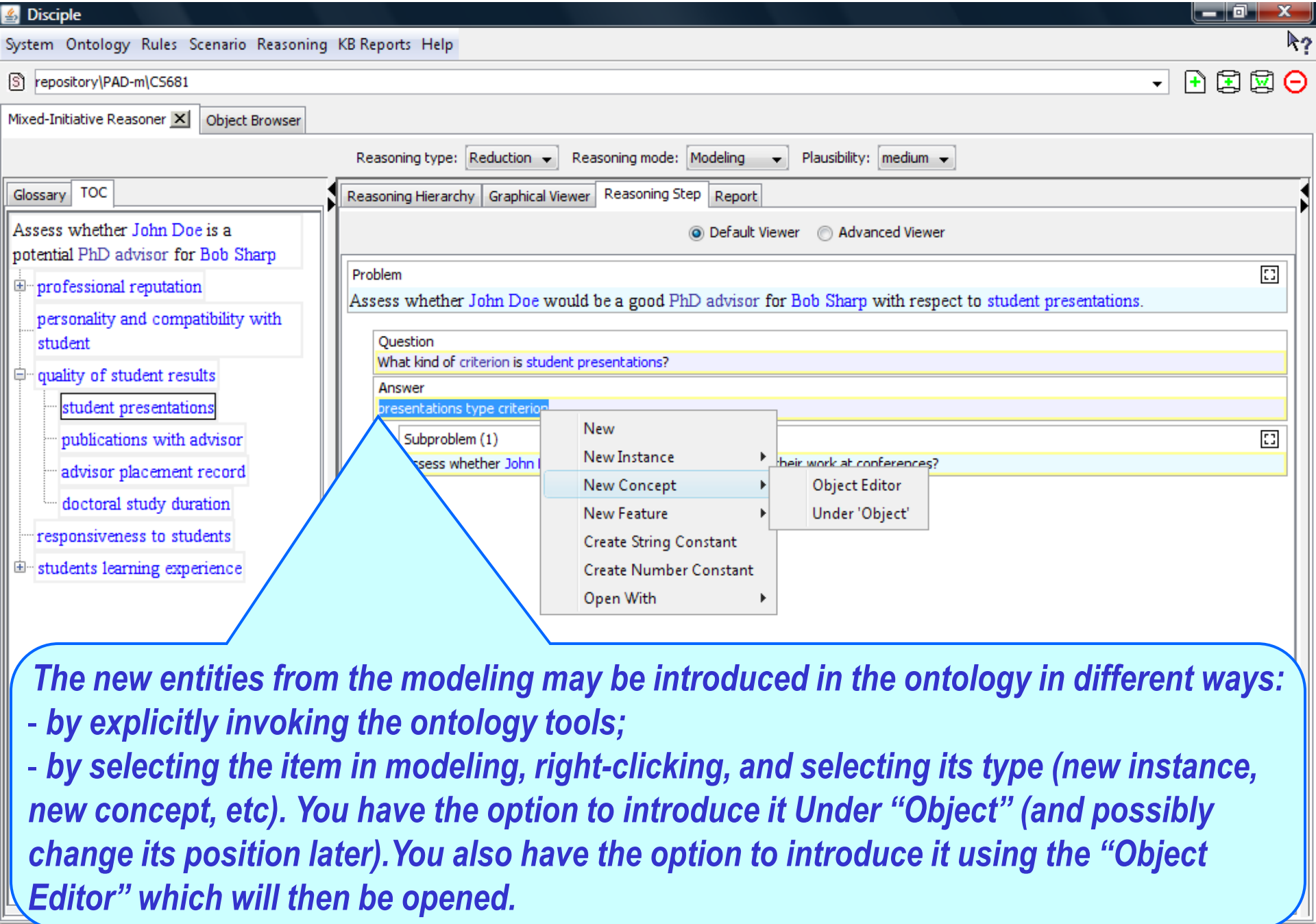
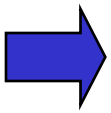
Reasoning Step
Report
Assess whether John Doe would be a good PhD advisor for Bob Sharp with respect to student presentations.
What kind of criterion is student presentations?
presentations type criterion
Assess whether John Doe's students make presentations of their work at conferences?
The Reasoning Hierarchy tool was shows the newly defined reduction step.
Q/A
Ontology Specs
Explanations
Default Explanations Viewer



The new entities from the modeling may be introduced in the ontology in different ways:
- by explicitly invoking the ontology tools;
- by selecting the item in modeling, right-clicking, and selecting its type (new instance, new concept, etc). You have the option to introduce it Under "Object" (and possibly change its position later).You also have the option to introduce it using the "Object Editor" which will then be opened.

Overview



- Modeling Methodology
- Modeling and Ontology Specification
- Demo: Modeling Editor
- **Hands On: Modeling for the PhD Advisor**
- Research Problem: Modeling Assistant
- Reading

Modeling for "Quality of student results"

- Necessary conditions
- Professional reputation
- Personality and compatibility with student
- Students' learning experience
- Responsiveness to students
- Support for students
- Quality of student results

7. How long do students take to complete their degrees with this director?
9. What is the placement record of this director's students? Where do they get jobs?
12. Does the director publish with students?
13. How many publications does the typical student accumulate with this director?
20. Do the director's students make presentations of their work at conferences?
24. What is the quality of the dissertation produced with this director?

Quality of Student Results: Criteria

7. How long do students take to complete their degrees with this director?

Doctoral study duration

9. What is the placement record of this director's students? Where do they get jobs?

Advisor placement record

12. Does the director publish with students? Covered by “13”

13. How many publications does the typical student accumulate with this director?

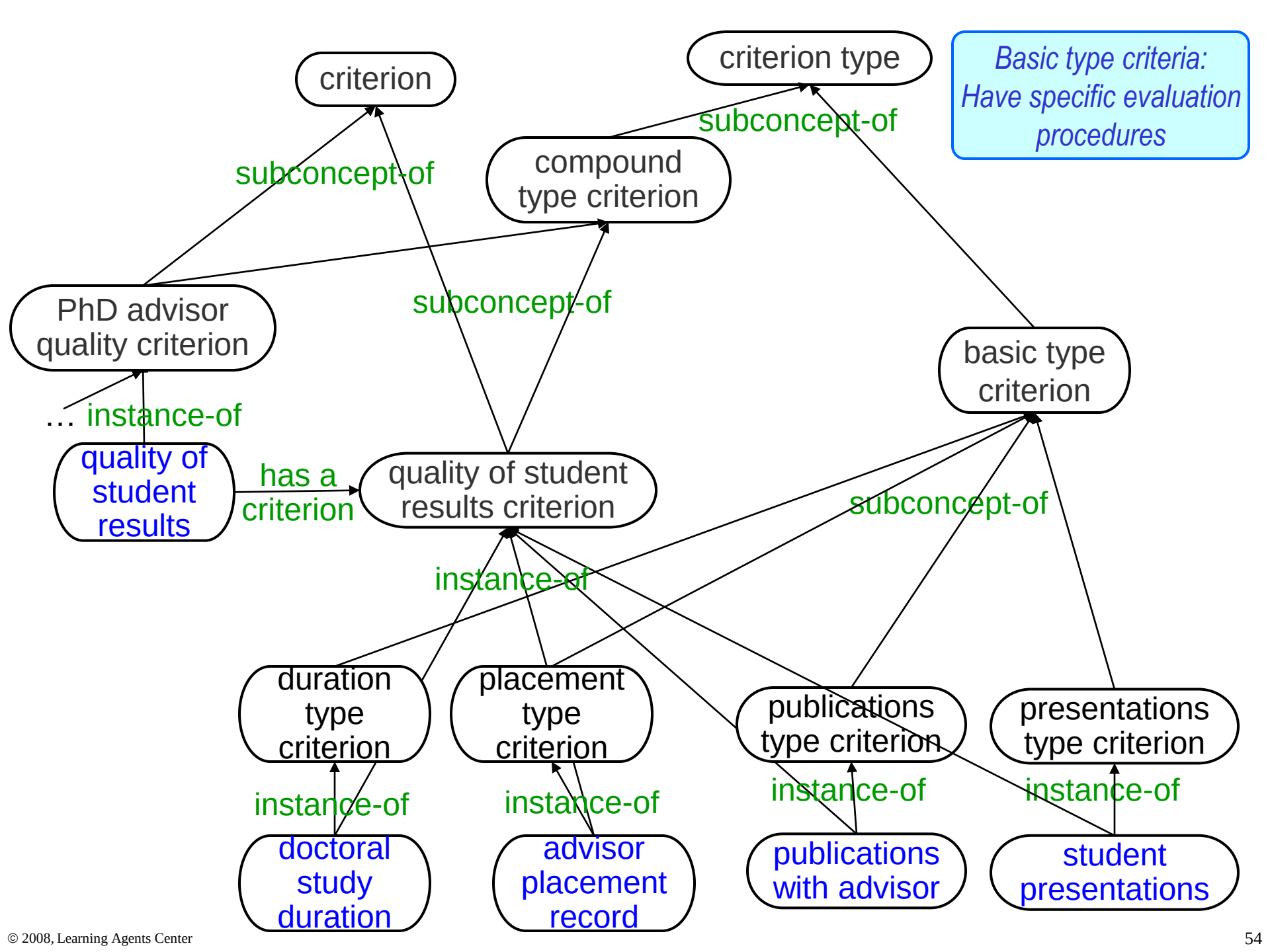
Publications with advisor

20. Do the director's students make presentations of their work at conferences?

Student presentations

24. What is the quality of the dissertation produced with this director?

Covered by a separate criterion.



Discussion

Assess whether John Doe's students make presentations of their work at conferences?

Assess how many publications does the typical student accumulate with John Doe.

Assess how long do students take to complete their degrees with John Doe.

Assess the student placement record of John Doe.

http://129.174.113.212/wba/jdisciplesetup-v2008.10a-PAD.exe

Hands On

Install the system from:

http://129.174.113.212/wba/jdisciplesetup-v2008.10a-PAD.exe

Model the solving of the discussed problem.

Overview

- Modeling Methodology
- Modeling and Ontology Specification
- Demo: Modeling Editor
- Hands On: Modeling for the PhD Advisor
- Research Problem: Modeling Assistant
- Reading

Research Problem: Modeling Assistant

Research the development of an intelligent assistant that helps the user to express his/her reasoning in solving a new problem.

Reference:
Mihai Boicu, Gheorghe Tecuci, Dorin Marcu, Mixed-Initiative Assistant for Modeling Expert's Reasoning, *In Proceedings of the AAAI-05 Fall Symposium on Mixed-Initiative Problem-Solving Assistants, Arlington, Virginia,* November 4-6, 2005.

Reading

Tecuci G., Lecture Notes on Modeling Expert's Reasoning, 2008 (required).

Tecuci G., Boicu M., Cox M.T., Seven Aspects of Mixed-Initiative Reasoning: An Introduction to the Special Issue on Mixed-Initiative Assistants, *AI Magazine*, Volume 28, Number 2, pp. 11-18, Summer 2007. http://lac.gmu.edu/publications/2007/BoicuM_AIMagazine_Intro.pdf (required).

Mihai Boicu, Gheorghe Tecuci, Dorin Marcu, Mixed-Initiative Assistant for Modeling Expert's Reasoning, *In Proceedings of the AAAI-05 Fall Symposium on Mixed-Initiative Problem-Solving Assistants, Arlington, Virginia,* November 4-6, 2005. http://lac.gmu.edu/publications/2008/Disciple-LTA08.pdf (required).