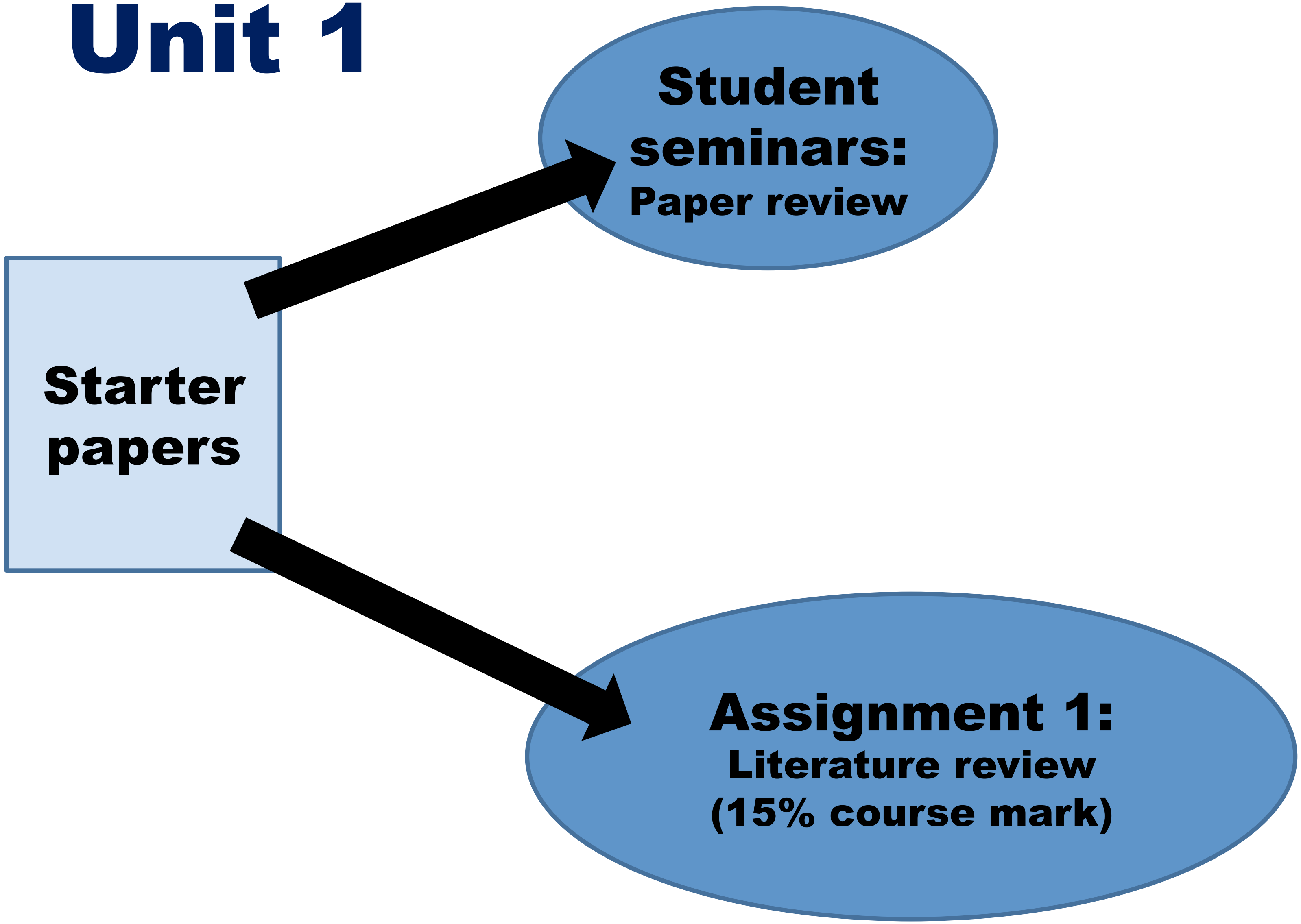
ADAPTIVE LEARNING ENVIRONMENTS:

Unit 1 Intro

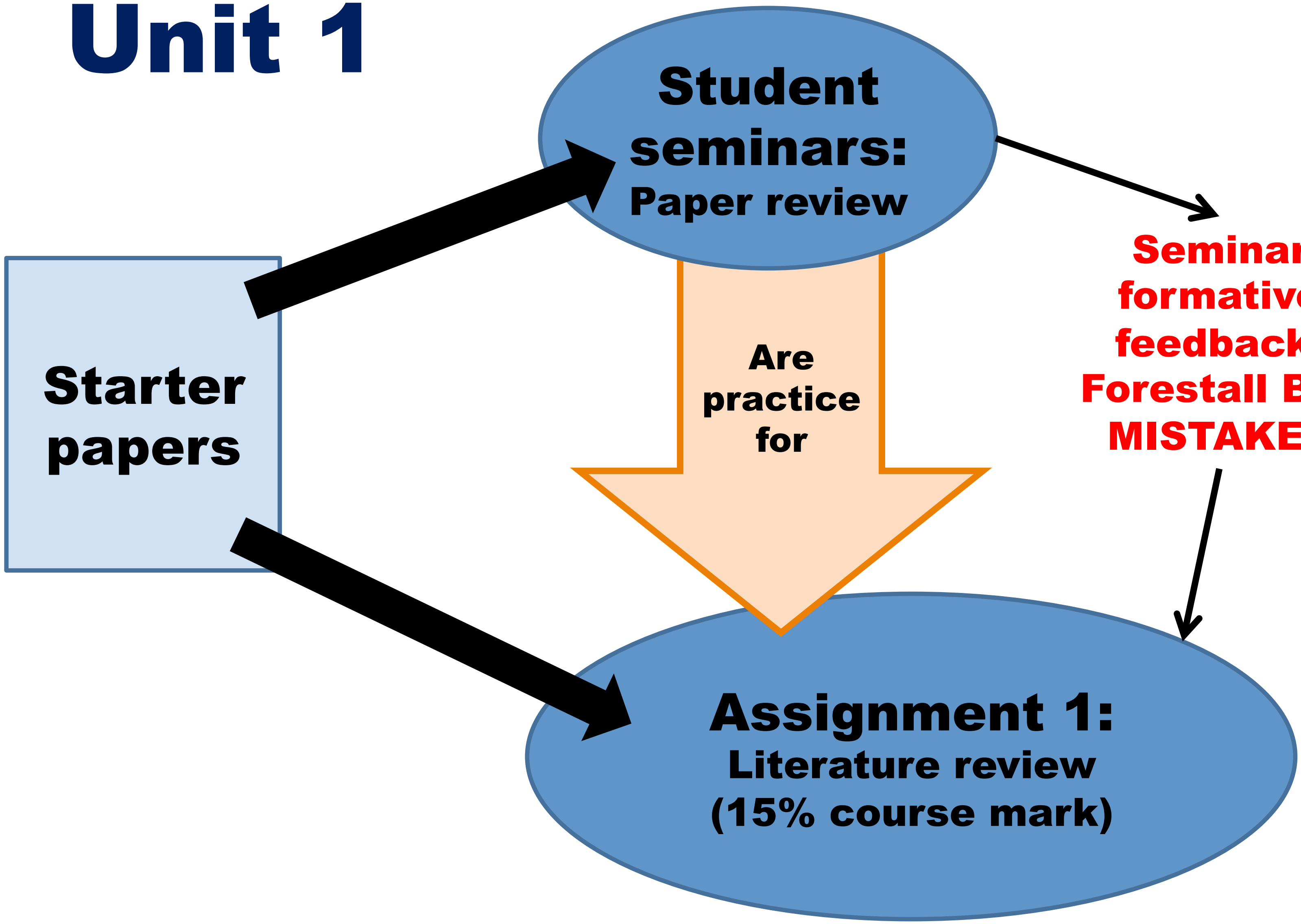
L4: Knowledge Representation

Unit 1: Reviewing

Unit 1


Student seminars:
Paper review
Starter papers
Assignment 1:
Literature review
(15% course mark)

Unit 1



Student seminars:
Paper review
Starter papers
Are practice for
Seminar formative feedback: Forestall BIG MISTAKES
Assignment 1:
Literature review
(15% course mark)

SSS1: Before presentation

Individually:

1. Read the paper
2. Write individual review - consider “starter questions”

As a group:

3. Discuss paper and individual reviews.
   - Agree on the contents of “meta-review”
   - Agree on an overall decision:
     - Accept (good paper for communicating to non-experts)
     - Weak accept
     - Neutral (neither good nor bad)
     - Weak reject
     - Reject (dreadful for communicating to non-experts).
4. Write the Meta-review

SSS1: In presentation

5. Prepare a presentation with **1 slide each for:**
   1. Key paper content - extra slides for images ONLY
   2. Overall decision (accept/reject) and why
   3. Comments to authors: what done well/ what needs improvement

6. When presents to class, explain enough about work to understand your comments or criticisms.

BUT spend most time on your *review of the paper (why you evaluated it the way you did).*

7. Turn in individual reviews, meta-reviews, and slides for formative feedback.

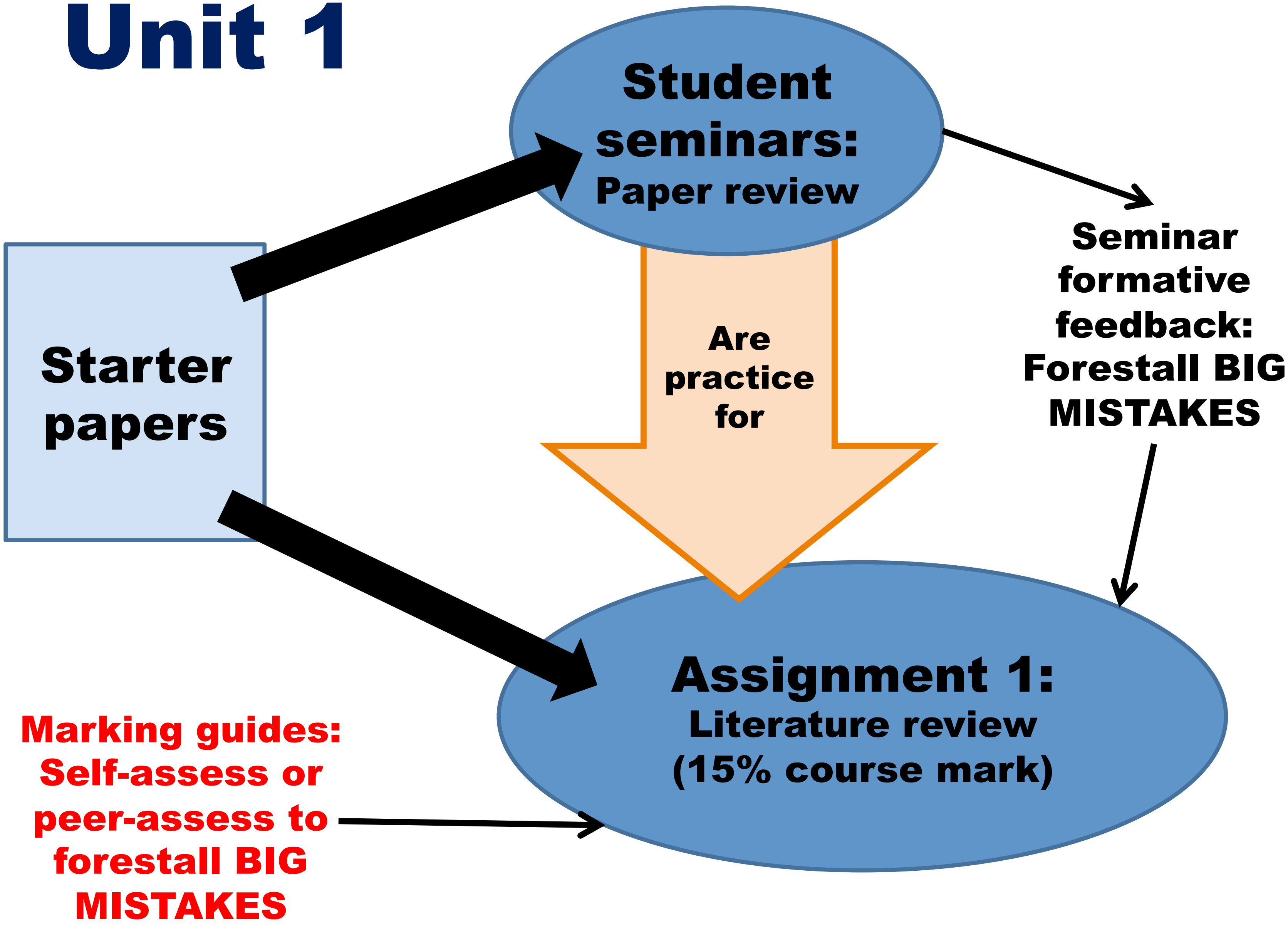
SSS1: Goals

1. **What it means to review a paper**
2. **More depth on core systems**
3. **Learn how peer reviewing works**

Allows you to:

- Getting ahead on the Assignment 1 reading
- Practicing the key skills for Assignment 1 *and this whole course*, helped by classmates
- Get formative feedback on how you are doing with the reviewing

Unit 1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Marking guides:
Self-assess or peer-assess to forestall BIG MISTAKES

SSS1: Assignment 1

Write a small-scale review of related literature:

- discuss 3 to 5 papers in some depth;
- in order to answer a particular question, e.g.

"What is the evidence that Autotutor-emotions impacts learners' interactive knowledge construction?"

Your review should include:

- at least 1 paper from the SSS1 papers list
- at least one non-seminar paper.

Not required to use the paper presented in your seminar
May use more than 5 papers if you wish, but not required

See handouts online

Marking guide (rubric)

Your chance to try some metacognition

Use as a **checklist**--make sure you didn't forget anything

Definitions of poor/good in each category: e.g.

Referencing and citation use:

"A **top score** in this category would mean that in-text references (appropriately formatted) are used throughout the assignment to support descriptions of key concepts and information about systems. All in-text references appear on the end references list (and vice versa). The end references provide complete information about each referenced item, and they are appropriately formatted."

"A **low score would mean that some of the following are in evidence:** key claims and information are consistently not supported by citations; In-text citations and reference list do not match up with one another; lots of missing references or missing information from listed references. "

→ This is a tool. Assess yourself, assess each other.

Topic unit A: Knowledge representation & User modelling

Today:

Knowledge representation, domain models

The plan: 3-level discussion

1. HIGHEST LEVEL: What types of things are out there that we could represent? *Domains level*

2. MIDDLE LEVEL: What could we/should we represent within our target domain? *Domain level*

3. LOW LEVEL: How could we/should we represent that knowledge? *"Implementation" level*

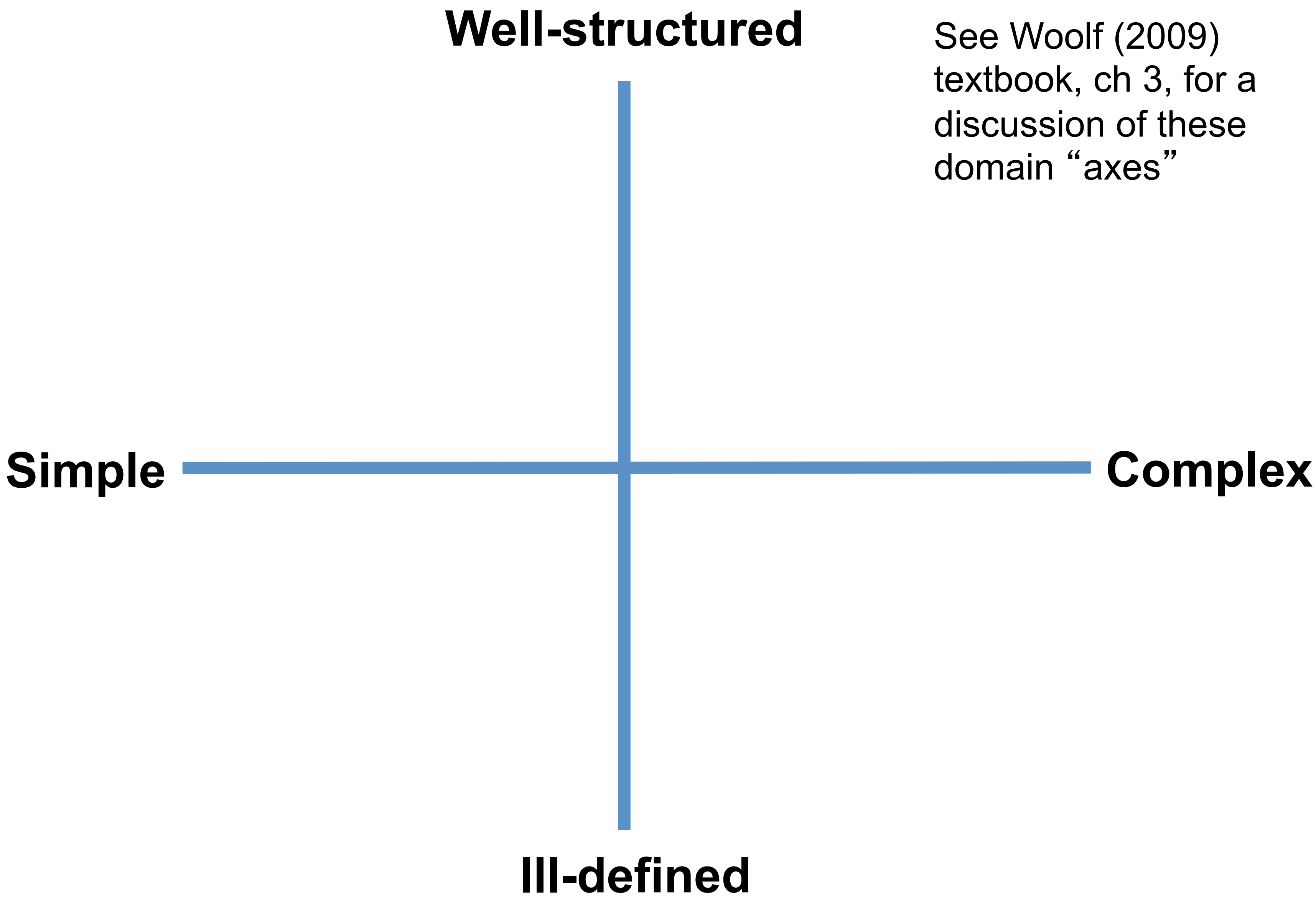
1: Types of domains

Well-defined versus ill-defined (defined == structured)

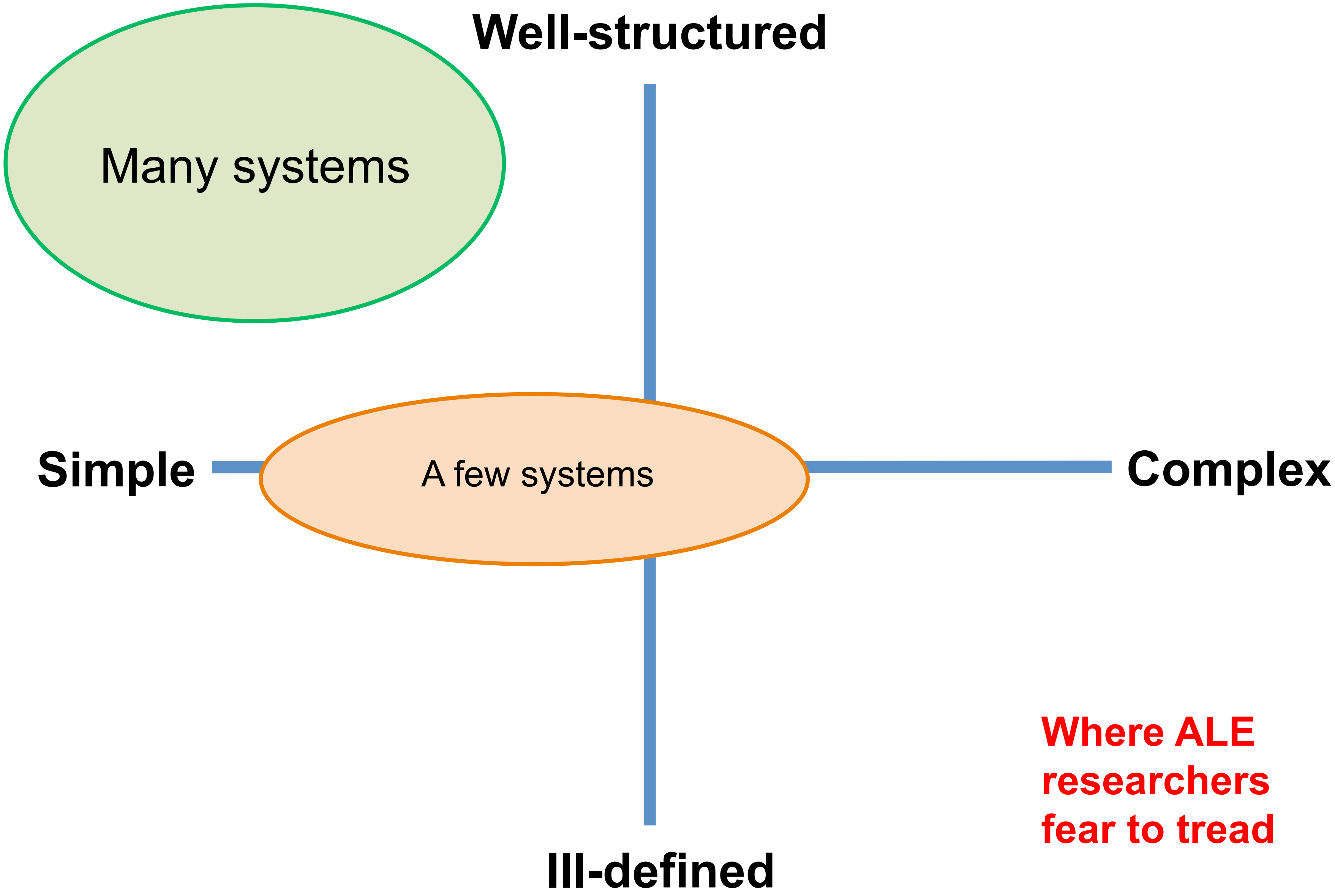
Structured domains have right answers. They have theories and rules. Ill-defined domains are the opposite.

- "Domains are **ill-defined** when essential concepts, relations, or criteria are un- or underspecified, open-textured, or intractable requiring a solver to recharacterize them." (Lynch, Ashley, Pinkwart, & Aleven, 2009)
- May lack (widely accepted) theories about concepts and relationships in the domain

Problems where "no amount of expertise can provide the indisputable answer." (Lynch et al p. 261).



See Woolf (2009) textbook, ch 3, for a discussion of these domain "axes"


Well-structured
Many systems
Simple
A few systems
Complex
Where ALE researchers fear to tread
Ill-defined

2: What to represent

We will focus on well-structured "problem-solving" domains for now, as they are a majority of current systems...

Domain model ≠ Domain encyclopaedia

- Generally mixture of declarative domain knowledge ("what") and procedural domain rules/heuristics ("how")
- May include *general* (domain independent) problem-solving strategies and heuristics
- May include *incorrect* declarative or procedural knowledge (e.g. Common learner mistakes)

2: What to represent

End goal IS NOT to have an amazing, perfect representation of the domain.

End goal IS to have domain knowledge in a form that we can use to help system **reason about** what *students* know or do not know, help inform system tutorial actions, etc.

Domain model = knowledge to <u>reason with</u>

Example: ANDES

Background:

- **Elementary** physics=law-based
- Problem-solving as induction; answers=**proofs**

What does it represent?

- Major "textbook" physics principles
- What authors call "minor principles" required to justify key inferences in many problems BUT may not be explicitly taught [by a textbook]
- Mathematical or "common sense" info to justify problem steps.

ANDES

"...to an AI program, all these pieces of [minor] knowledge act just like the major principles—they justify inferences about physical situations"

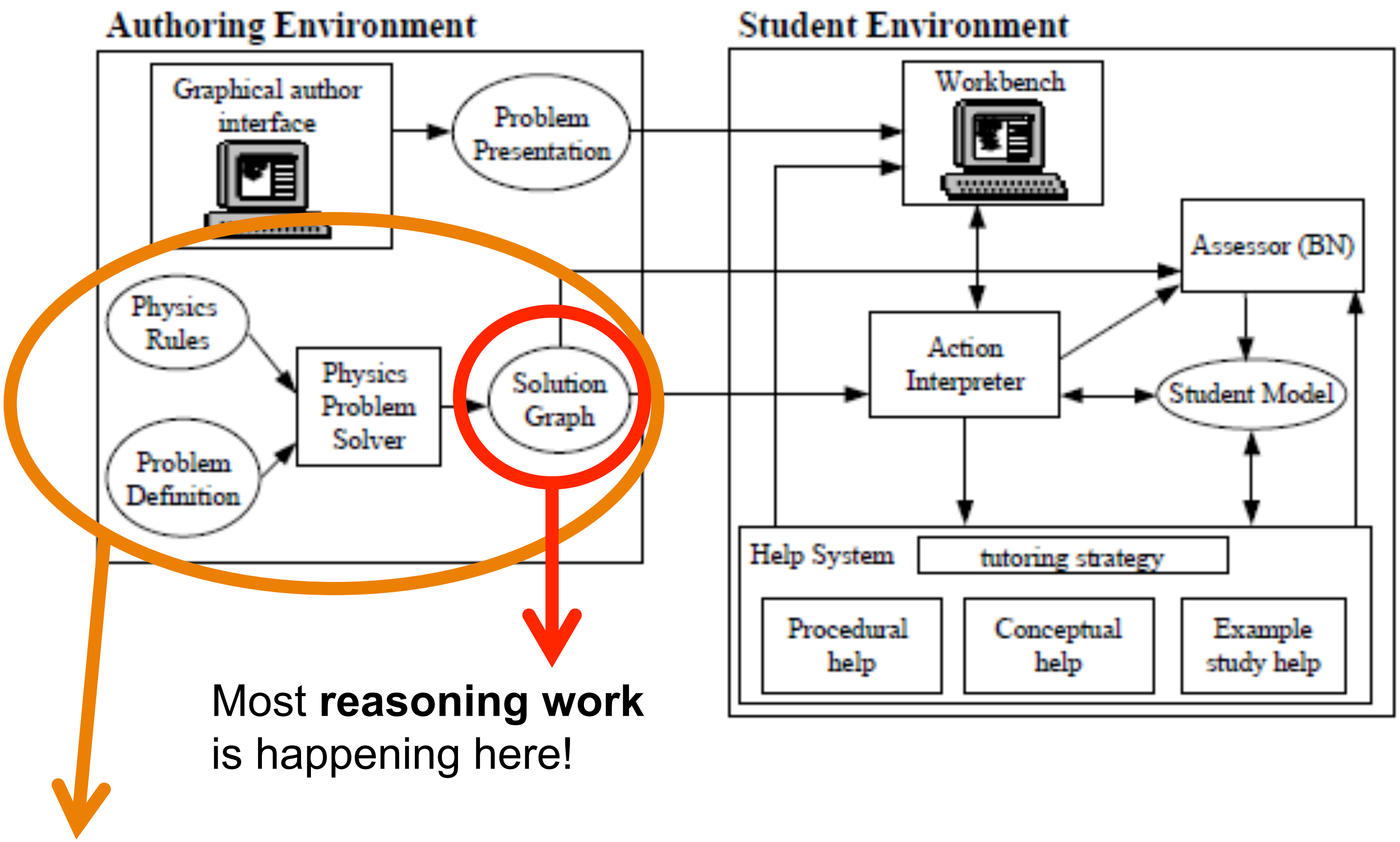
VanLehn et al (2005) Andes "lessons learned" paper

And thus they must be explicitly represented!

BUT Andes authors point out that a system representing principles alone will not do it– **experts have OTHER knowledge to constrain their reasoning.**

How to do it here?

(Long story short, they do not– after much research, no consensus about how physics experts do it in practice.)



Also must represent **problem-level information** to be able to reason about the correct solution path (and what the student is doing relative to that path)

3: How to represent it

This is the “implementation” level, where systems differ most

Our task: We have some nice facts and rules– how do we record them in ‘reason-aboutable’ form suitable for domain, pedagogic goals?

Often have multiple layers here: domain-level model, individual problem-level

Many options, will mention a few examples today.

Example: Production rules

Remember: Basic function of a production system is choosing and applying rules from its database

- Rules are domain-specific IF/THEN rules relating conditions to consequent actions

Example systems: The Cognitive Tutors, based on ACT-R cognitive architecture (discussed earlier)

- Geometry tutor
- LISP tutor
- Pump algebra tutor (PAT)

!!! Many domains simply not reducible to this format.

Pump Algebra Tutor (PAT)

Background:

- Teaches basic algebra problem-solving
- Is one of the Cognitive Tutors: about *doing* and about acquiring *goal-related knowledge*

What does it represent?

"It is important to note that the rules of mathematics (theorems, procedures, algorithms) are not the same as the **rules of mathematical thinking**, which are represented in PAT by production rules." *(Woolf 2009, ch 3, p 61)*

PAT Production rules

Rules of mathematical thinking: This is the issue of constraining, navigating problem space to DO algebra effectively

Right: Two alternate "correct" rule examples, plus *incorrect* one (a common novice mistake).

From Woolf (2009) p. 62

(1) *Correct:*
IF the goal is to solve $a(bx + c) = d$
THEN rewrite this equation as $bx + c = d/a$

(2) *Correct:*
IF the goal is to solve $a(bx + c) = d$
THEN rewrite this equation as $abx + ac = d$

(3) *Incorrect*
IF the goal is to solve $a(bx + c) = d$
THEN rewrite this equation as $abx + c = d$

Learning through Model Building

Assumes learner is active and seeking stimulation

Making knowledge explicit:

- get learner to communicate beliefs
- get learner to model theories and test them
- get learner to reflect on learning

Learning through confrontation:

- student has belief of what happens in environment
- tests belief -> consequences in environment
- if consequences don't match belief, then (hope)
- cause student to review belief (=learn)

But are all confrontations beneficial?

Using Multiple Representations

Users with a repertoire of representational skills can ***describe, reason with*** and ***build*** models of information.

'Constructivist' learning theory stresses relationship between building ***internal mental models*** and building ***external information models*** (Cox & Brna 1995).

When reaching an impasse (become 'stuck') while solving a problem, ***reformulating it using a different representation*** can be effective in making progress (Cox & Brna).

By making thinking visible, the process of constructing an information map can help to understand, refine and communicate ideas.

Information Maps as Classroom Tools (Conlon, 2000)

Used by teachers to communicate information

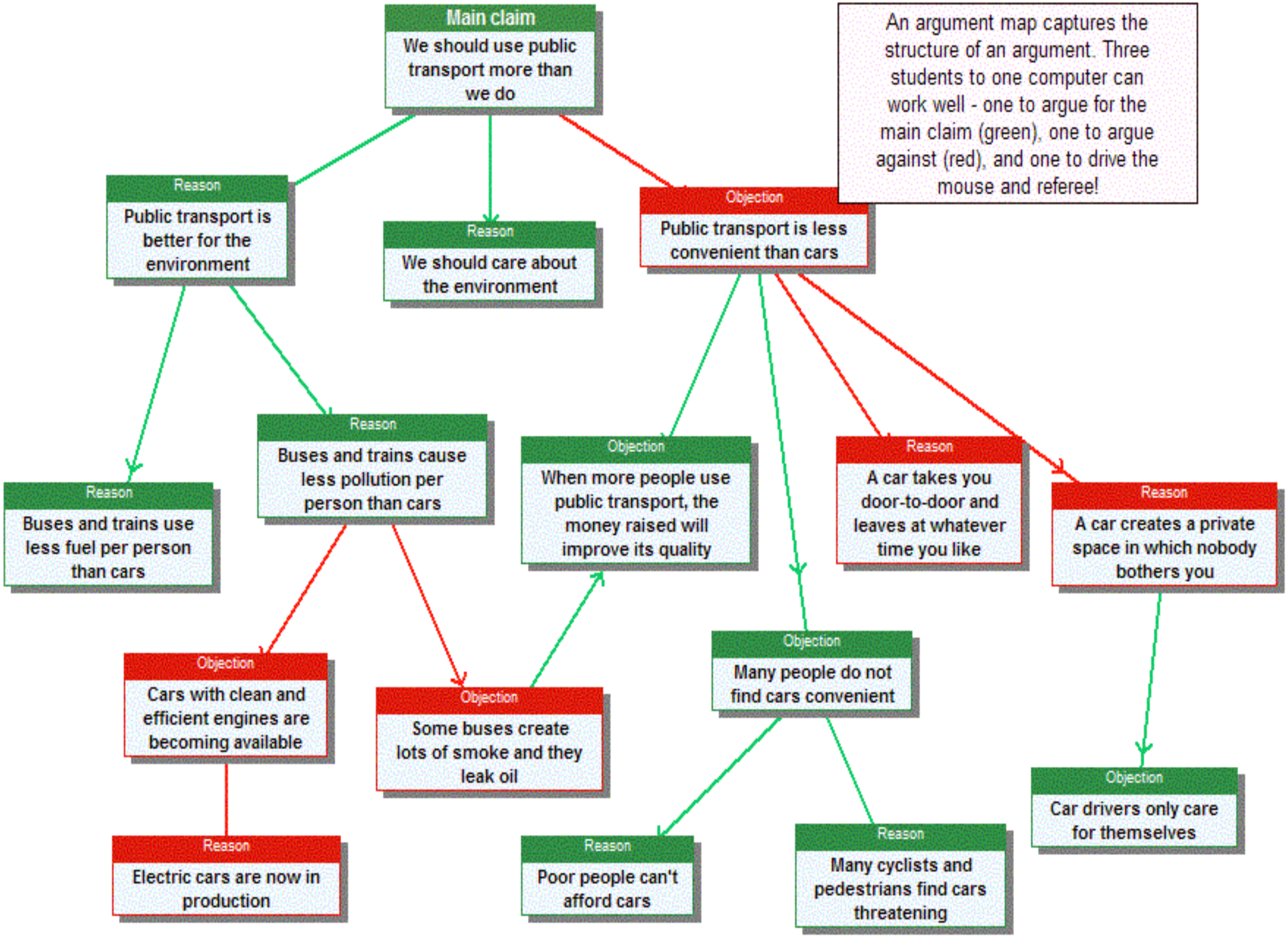
Used by pupils to learn subject matter.

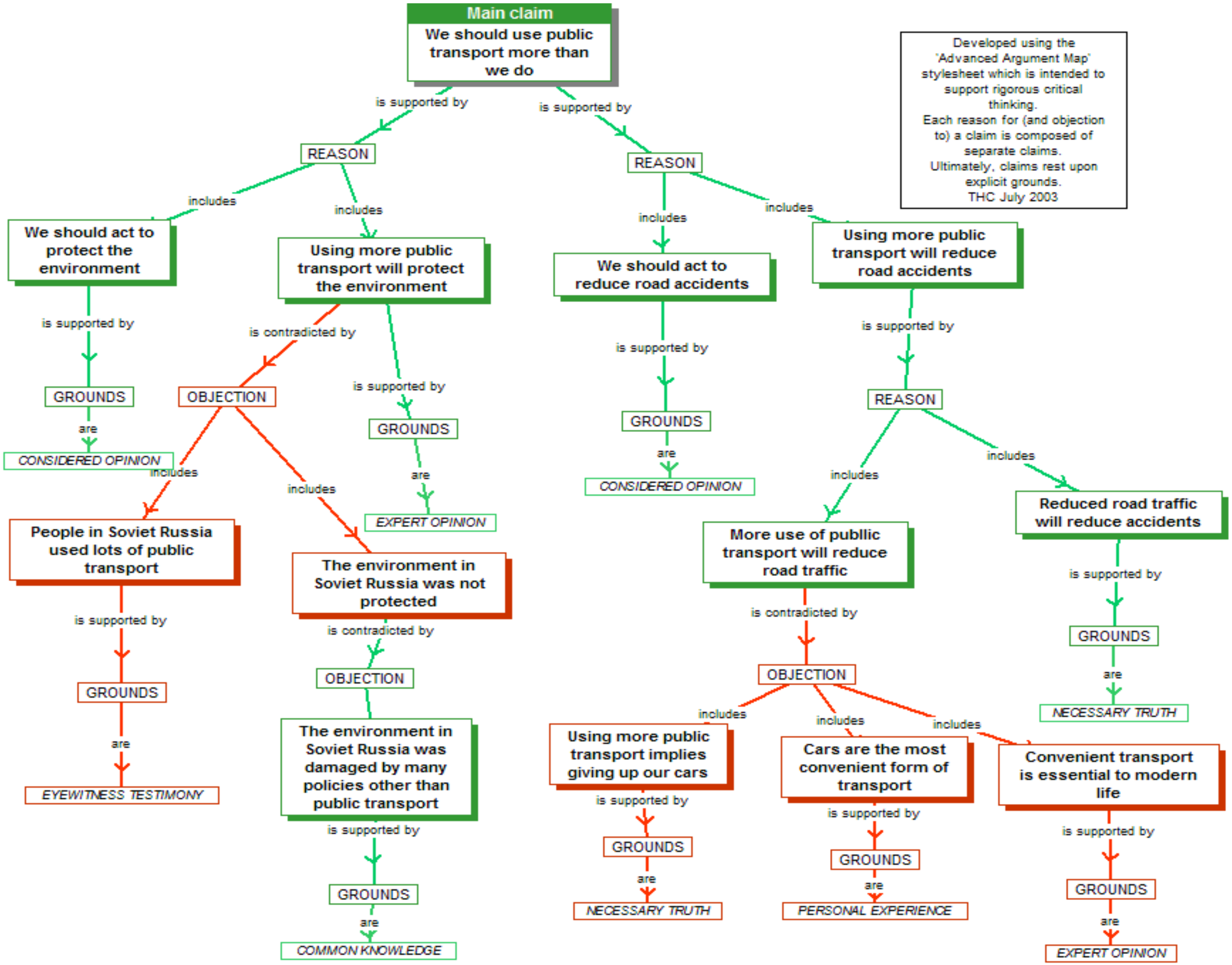
Building information maps improves generic representational techniques and transferable thinking skills.

eg.1 **creating an argument map** about transport policy – ***learn: argument can be understood as hierarchical structure of claims, justifications and objections.***

eg.2 **creating a decision map** about the budget – ***learn: decision-making process can be understood in terms of options, factors and evaluations***.

An argument map captures the structure of an argument. Three students to one computer can work well - one to argue for the main claim (green), one to argue against (red), and one to drive the mouse and referee!




Main claim
We should use public transport more than we do
is supported by
is supported by
REASON
REASON
includes
includes
includes
includes
We should act to protect the environment
Using more public transport will protect the environment
We should act to reduce road accidents
Using more public transport will reduce road accidents
is supported by
is contradicted by
is supported by
is supported by
is supported by
GROUNDS
OBJECTION
GROUNDS
GROUNDS
REASON
are
CONSIDERED OPINION
includes
includes
are
EXPERT OPINION
are
CONSIDERED OPINION
includes
includes
People in Soviet Russia used lots of public transport
The environment in Soviet Russia was not protected
More use of publlic transport will reduce road traffic
Reduced road traffic will reduce accidents
is supported by
is contradicted by
is contradicted by
is supported by
GROUNDS
OBJECTION
OBJECTION
GROUNDS
are
EYEWITNESS TESTIMONY
The environment in Soviet Russia was damaged by many policies other than public transport
is supported by
GROUNDS
are
COMMON KNOWLEDGE
includes
includes
includes
are
NECESSARY TRUTH
Using more public transport implies giving up our cars
Cars are the most convenient form of transport
Convenient transport is essential to modern life
is supported by
is supported by
is supported by
GROUNDS
GROUNDS
GROUNDS
are
are
are
NECESSARY TRUTH
PERSONAL EXPERIENCE
EXPERT OPINION
Developed using the 'Advanced Argument Map' stylesheet which is intended to support rigorous critical thinking.
Each reason for (and objection to) a claim is composed of separate claims.
Ultimately, claims rest upon explicit grounds.
THC July 2003

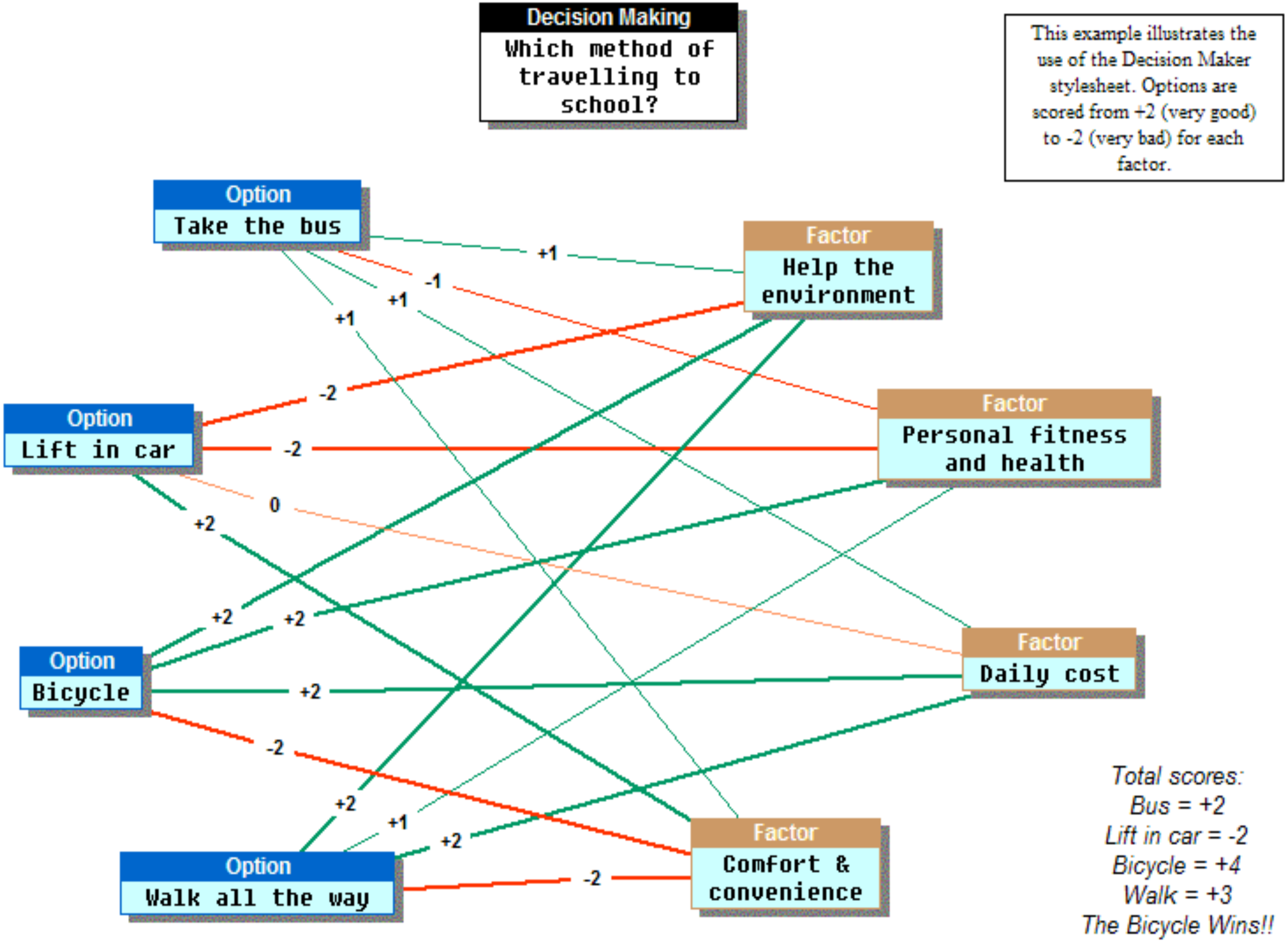
Argument mapping

Involves:

- informal discussion
- this involves learners working in twos or threes around a computer,
- debating a main claim while simultaneously constructing an argument map.

Preparation for:

- Formal classroom debates
- Planning an essay
- Reporting on research


Decision Making
Which method of travelling to school?
This example illustrates the use of the Decision Maker stylesheet. Options are scored from +2 (very good) to -2 (very bad) for each factor.
Option
Take the bus
Option
Lift in car
Option
Bicycle
Option
Walk all the way
Factor
Help the environment
Factor
Personal fitness and health
Factor
Daily cost
Factor
Comfort & convenience
+1
-1
+1
+1
-2
-2
0
+2
+2
+2
+2
-2
+2
+1
+2
-2
Total scores:
Bus = +2
Lift in car = -2
Bicycle = +4
Walk = +3
The Bicycle Wins!!

Map types and applications

Map Type	**Represents …**	**Applications for learners**:
Concept map	**A concept framework.** Symbols represent concepts, links represent relationships	Creating, completing and correcting summaries of syllabus material and texts — scope for peer critiquing and other forms of collaborative work .
Web map	**As for a concept map**, but **some** or all **symbols are hyperlinked** to web sites.	Creating a record of internet-based research — organising web findings into a coherent conceptual framework.
Argument map	**An argument framework.** Top-level symbol represents a main claim. Lower level symbols represent justifications or objections.	Supporting live informal discussion between two or three pupils seated around a computer. Preparation for formal classroom debate.

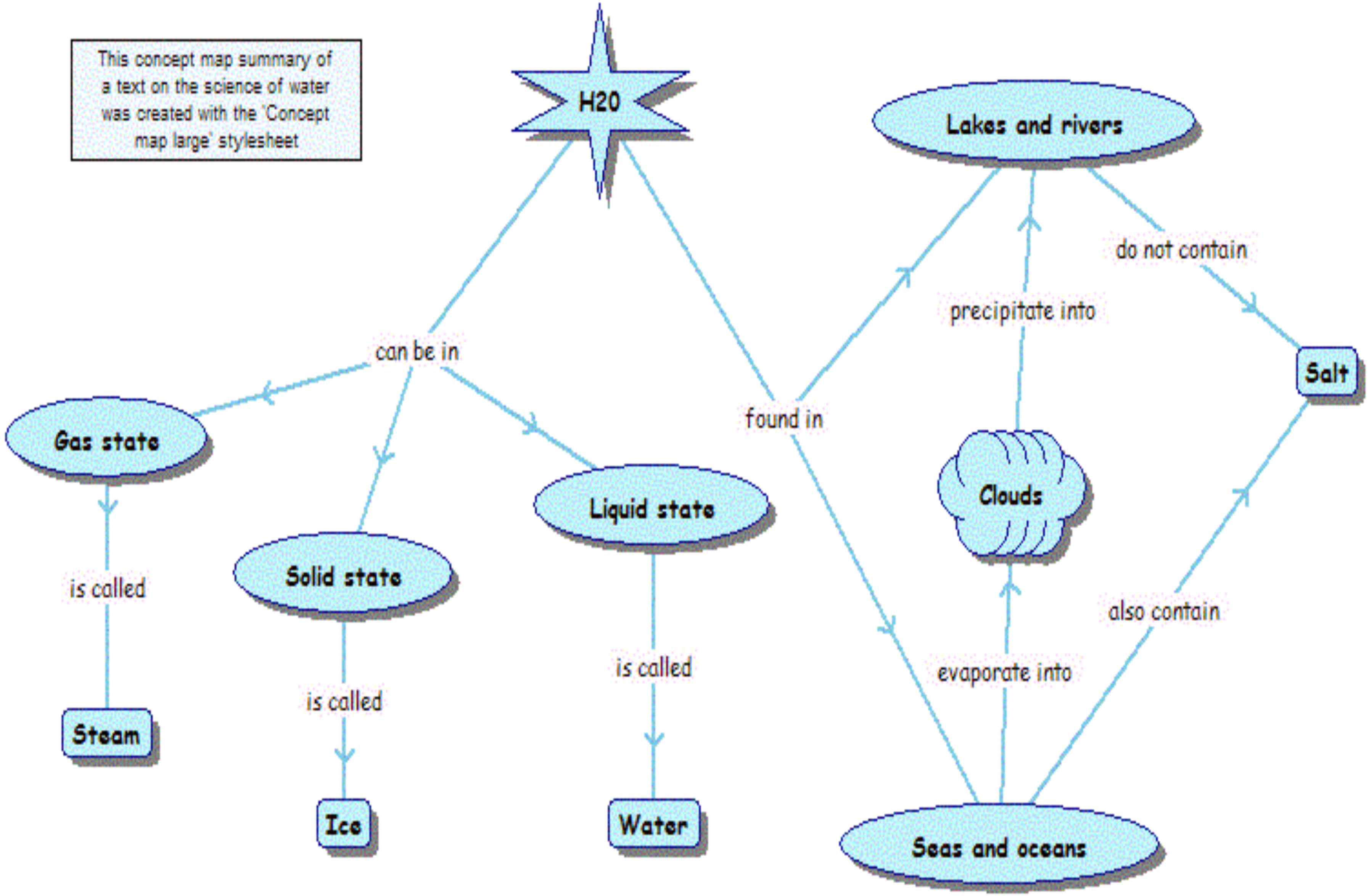
Map types and applications

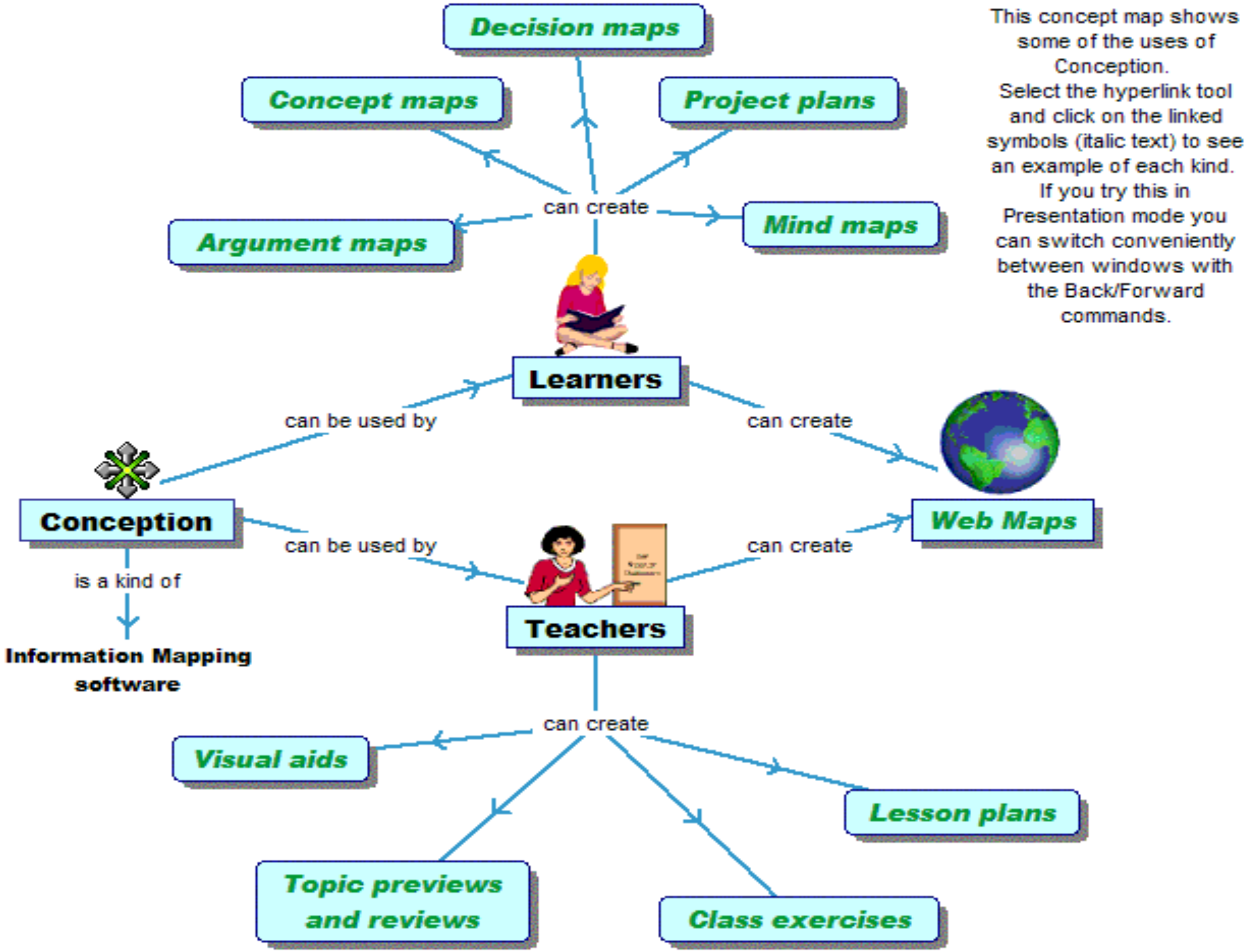
Map Typ e	Represents …	Applications for learners :
Decision map	**A decision-making framework**. Symbols represent options or factors. Links represent the evaluation of the options against the factors .	Creating a model of the decision-making process for some aspect of the curriculum — scope for peer critiquing and other forms of collaborative work.
Mind map	**An ideas framework.** The central symbol represents the main idea. Ideas that are considered to be associated are linked to the main idea in a star-like network.	Fast and loose' information gathering tasks such as note-taking and brainstorming .

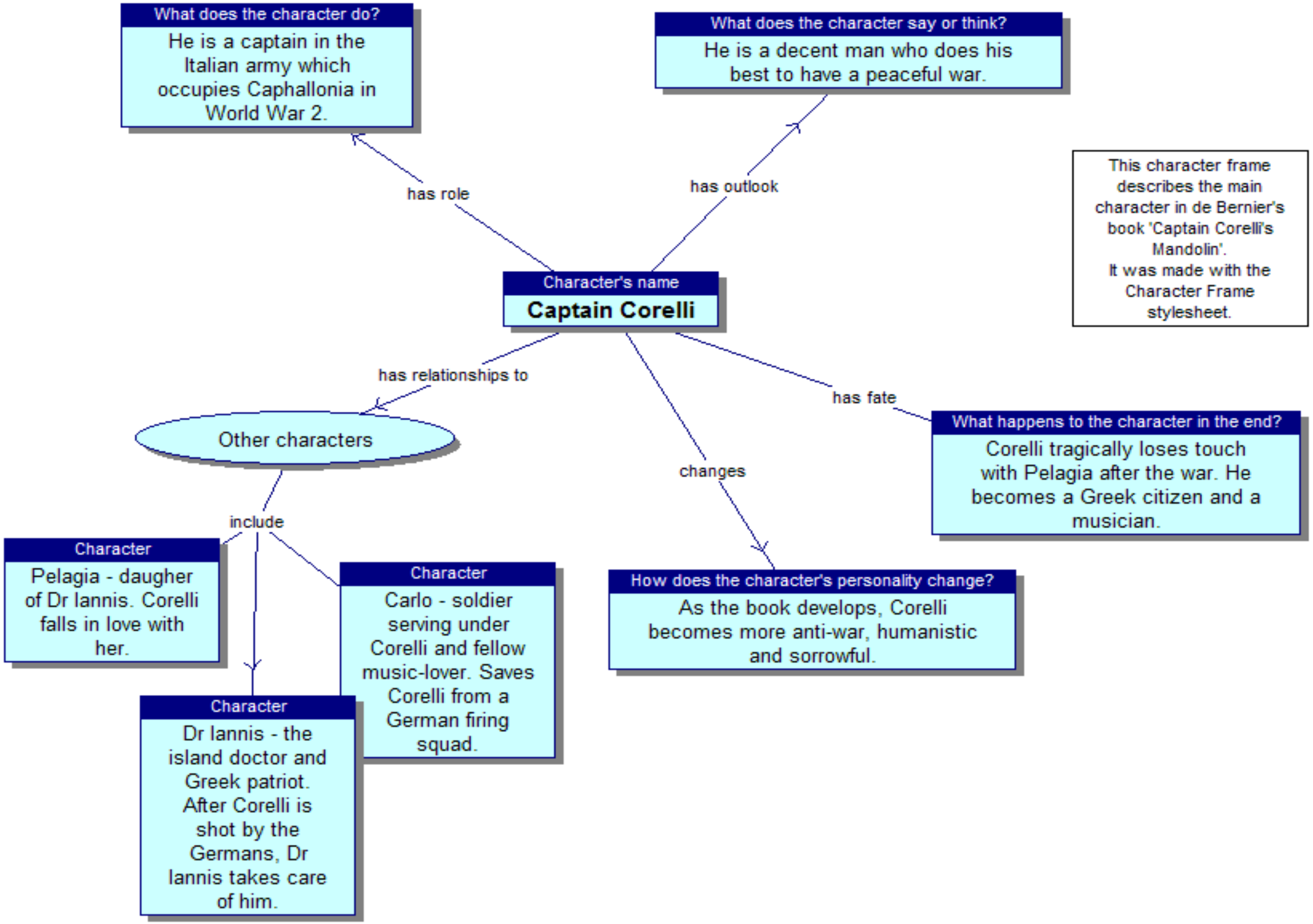
Concept mapping by learners

Concept mapping activities by learners can be placed into three categories:

1. **Tabula rasa ('blank slate') mapping** involves the creation of a map from scratch
2. **Scaffolded mapping tasks**: elements of the map are provided by the teacher, leaving the learner to supply the rest.
3. **Buggy map correction tasks** present learners with concept maps containing deliberately introduced bugs (errors). Learners task is to locate and correct them.


This concept map summary of a text on the science of water was created with the 'Concept map large' stylesheet
H20
can be in
Gas state
Solid state
Liquid state
is called
Steam
Ice
Water
found in
Lakes and rivers
Seas and oceans
Clouds
precipitate into
evaporate into
do not contain
also contain
Salt


Decision maps
Concept maps
Project plans
can create
Argument maps
Mind maps
Learners
can be used by
can create
Conception
can be used by
can create
Web Maps
is a kind of
Information Mapping software
Teachers
can create
Visual aids
Lesson plans
Topic previews and reviews
Class exercises
This concept map shows some of the uses of Conception.
Select the hyperlink tool and click on the linked symbols (italic text) to see an example of each kind.
If you try this in Presentation mode you can switch conveniently between windows with the Back/Forward commands.


What does the character do?
He is a captain in the Italian army which occupies Caphallonia in World War 2.
What does the character say or think?
He is a decent man who does his best to have a peaceful war.
has role
has outlook
This character frame describes the main character in de Bernier's book 'Captain Corelli's Mandolin'.
It was made with the Character Frame stylesheet.
Character's name
Captain Corelli
has relationships to
Other characters
has fate
What happens to the character in the end?
Corelli tragically loses touch with Pelagia after the war. He becomes a Greek citizen and a musician.
changes
include
Character
Pelagia - daugher of Dr Iannis. Corelli falls in love with her.
Character
Carlo - soldier serving under Corelli and fellow music-lover. Saves Corelli from a German firing squad.
How does the character's personality change?
As the book develops, Corelli becomes more anti-war, humanistic and sorrowful.
Character
Dr Iannis - the island doctor and Greek patriot. After Corelli is shot by the Germans, Dr Iannis takes care of him.

Looking ahead

Talking about domain models is only half the picture.

Next time: From domain models to student models
- Often, domain model representation type also used in student model, to reason about student's knowledge and competencies *(ex. Betty's Brain)*
- Generally will be separate modules of system

BUT sometimes student model represents totally independent information *(i.e. affect)*

PS: Do your readings

References

Conlon, T. (2000). A Cognitive Tool for Classification Learning. Revised version of paper presented at the *Ninth International Peg Conference (PEG99) on Intelligent Computer and Communications Technology*, Exeter, UK, July 1999. Also available at http://www.parlog.com/impaper/index.html

Conlon, T. and Gregory, S. (2007) Representations of Conception: Towards a Repertoire for Thinking and Learning draft paper) available from:

http://www.parlog.com/shared/roc.pdf

Conception software available from http://www.parlog.com/en/conception.html

Cox, R. and Brna, P. (1995). Supporting the use of external representations in problem solving: the need for flexible learning environments. *Journal of Artificial Intelligence in Education*, 6(2/3).