Advances in Cognition and Exploratory Learning in the Digital Age

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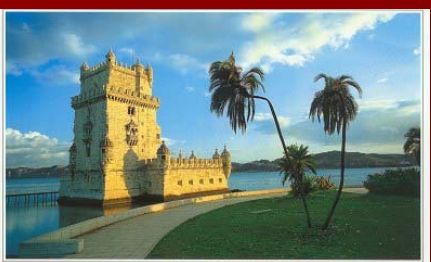

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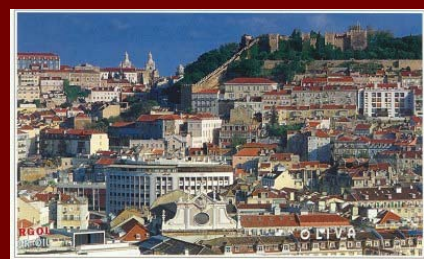

Portuguese Lesson

Obrigado = thank you

Gosto muito = I like it a lot


I ♥ NY
SORRY

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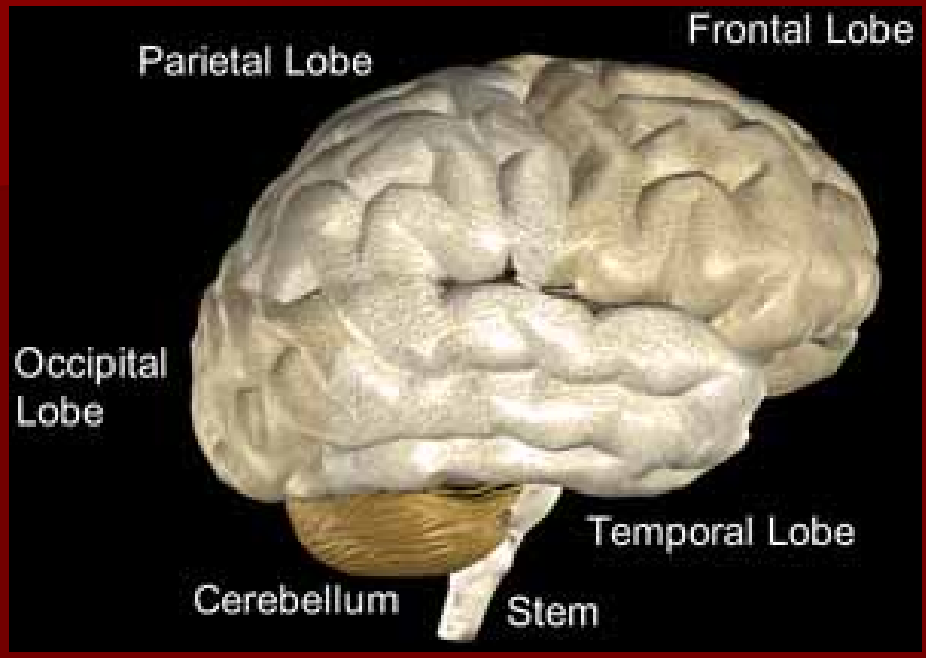
Introduction

- Where have we been and what have we seen?
  - Who?
  - What?
- Where are we going and what are we doing?
  - Where?
  - Why?

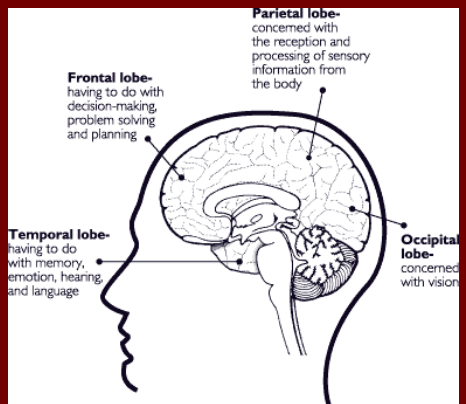
Advances in Cognition

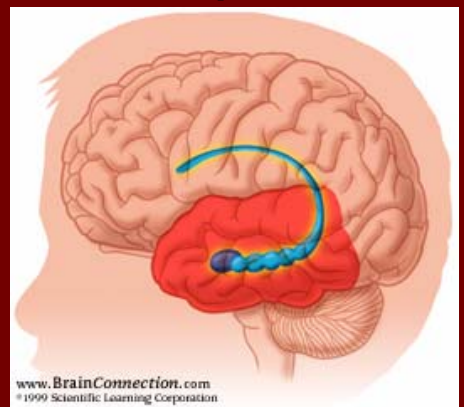
- I used to be able to remember all sorts of things ... now I can only remember things that never happened ... but
- Some memories are vivid ... some fade ... some say that memories ripen ... and
- The hippocampus is central to memory and learning ... but
- The mechanisms of mental storage and retrieval remain somewhat elusive.

What About the Brain?



- http://www.pbs.org/wnet/brain/3d/
- http://www.med.harvard.edu/AANLIB/cases/caseNA/pb9.htm





Brain Research → Cognitive Science

- The linkages between brain research and cognitive science are obvious in many university research centers, including:
  - University of North Carolina at Chapel Hill's Language Cognition and Brain Research Group http://lcb.unc.edu/research.htm
  - Carnegie Mellon University's Center for the Neural Basis for Cognition http://lcb.unc.edu/research.htm
  - Chinese University of Hong Kong's Centre for Cognition and Brain Studies http://www.psy.cuhk.edu.hk/research/cogcenter.html
  - University of Cambridge's Cognition and Brain Sciences Unit http://www.mrc-cbu.cam.ac.uk/

Knowledge Advances

- fMRI studies
  - See, for example, http://www.fmri.org/ and http://redwood.ucdavis.edu/scott/research/fmri/
- Memory studies
  - See http://www.brightsurf.com/EDU_news_092002.html
- Cognitive load studies
  - http://education.arts.unsw.edu.au/CLT_NET_Aug_97.HTML
- Expert performance studies
  - http://www.psy.fsu.edu/

Fundamental Questions Persist

- Why are some things remembered/learned more easily than others?
- Why are some things difficult to remember/learn? Difficult to forget/unlearn?
- Why do some memories and skills fade?
- Why are early memories in some elderly people so vivid? Why don't we forget how to ride a bicycle after not riding for many, many years?
- See Visser's *Book of Problems* http://www.learndev.org/

The Varieties of Learning Experience

- From early childhood to adult learning
- Both individual and group learning
- Planned and unplanned
- Role of language and images
- Role of the environment and culture
- Motivation and self-regulation

Technology Transformations

- Technology changes
  - It changes what we do
  - Also what we can do and want to do
- Bloom's two sigma effect
  - Not quite realized in intelligent tutoring systems
  - Significant improvements in selected domains
  - The potential for personalized instruction remains
  - The promise of powerful virtual collaboration remains
- AIDA: "The History of an Error?"
  - What have we learned from attempts to automate instructional design, development and delivery?

First Principles
(Merrill, 2002)

- Problem centering and focusing learning
- Activating and motivating learners
- Demonstrating knowledge and skills in action
- Applying new knowledge to solve meaningful problems
- Integrating knowledge and skills into life

Spector's Principles

- Learning is fundamentally about change
- Change begins with and is based on experience
- Meaningful experience is determined by context
- Meaningful integration of knowledge and skills involves multi-faceted and multi-dimensional contexts
- We know less than we are inclined to believe

Difficult Questions

- What will come from we are now doing and may do tomorrow?
  - We have privileged positions as teachers, researchers, developers, and such – what are we contributing that will last and be of value?
- What can be done to address serious problems confronting society?
  - Are we training people who will generate responsible and sustainable environmental policies?
  - Create manageable and humane medical conditions?
  - Resolve serious social and political conflicts?

A Research Agenda

- Focus on technology-enhanced learning in complex domains
- Develop a methodology to determine that and how technology contributes to the development of understanding and expert performance
- Implement innovative technologies that can be demonstrated to improve understanding and performance

Problem Focus

- Support for learning in and about complex subject matter
  - Complexities: computational, relational, dynamic, uncertainties
- Which approach is appropriate for a particular type of complex problem-solving situation
  - Evidence of improved learning outcomes
- Problems in these domains are often ill-structured
  - Lack single, or correct or standard solutions

How to Assess Progress of Learning

- Model the problem solving behaviors of recognized experts
  - Do experts in a domain exhibit a common pattern of approaching problems?
- Develop metrics to assess progress towards expert-like problem solving behavior
  - Multiple levels of assessment
    - **surface analysis**
    - **structural analysis**
    - **semantic analysis**

Relevant Research

- Expert Performance
  - Anders Ericsson: high performers attaining excellence through deliberate practice (2001)
- Concept Mapping Analysis
  - Harry O'Neil: machine scoring of concept maps (1999)
- Levels of Analysis
  - Research initiated at the University of Bergen (2000)
  - Seel's research at the University of Freiburg (2001)
  - Jonassen's problem-solving taxonomy (2002)

Differences in Domains

- Differences in complex problem solving arise in different domains?
  - Delayed effects, non-linear relationships, fuzziness, internal feedback, dynamic changes, etc.
  - In terms of van Merriënboer's 4C/ID: prominence and dominance of non-recurring problems, reliance on heuristic methods, etc.
- Can one method of representing complex problem-solving performance capture such differences?

Purpose of Representations

- To detect changes in student understanding
  - Seel's research shows simple causal concept maps are adequate
- To detect improved understanding
  - Requires a target (e.g., a family of expert representations in addition to individual change)
- To determine optimal instructional approach
  - Requires many subjects in many domains

Dynamic Enhanced Evaluation of Problem Solving (DEEP)

- Three domains
  - engineering design, biology, and medical diagnosis
- Recognized experts and beginners
  - 5 experts and 15 inexperienced respondents per domain
- Two problems in each domain
  - To explore differences in problems as well as responses
- Annotated causal maps
  - Similar to Seel's work and that of Milrad *et alii*

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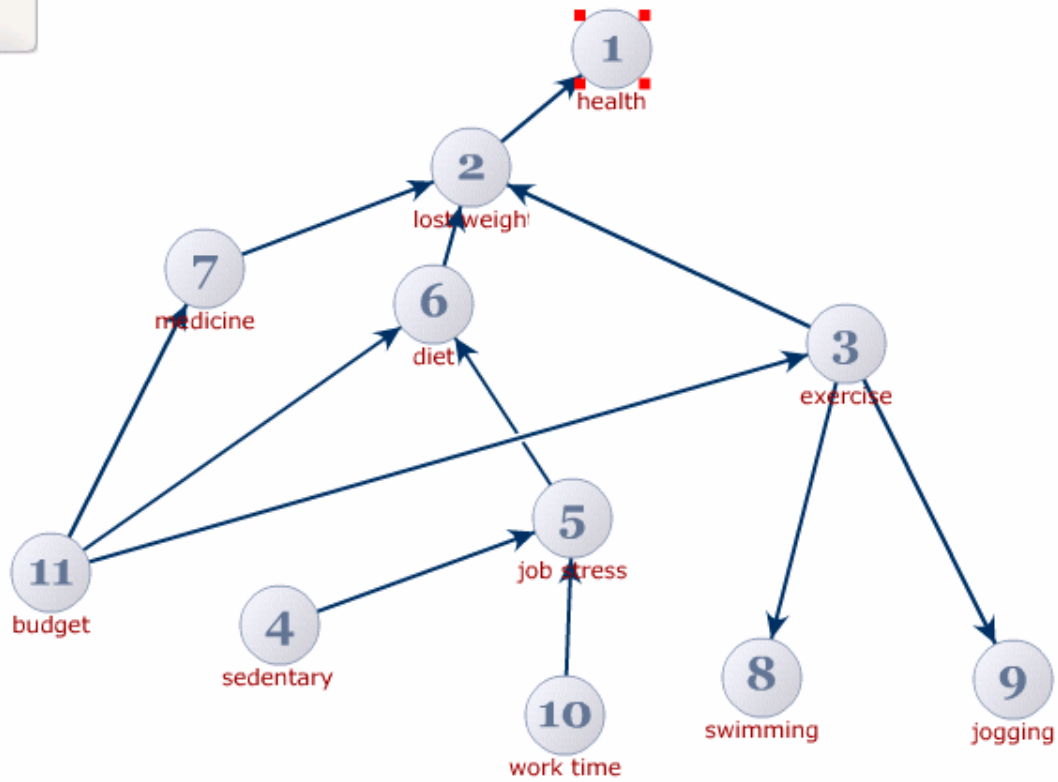
Conceptualizing the Problem Space



Properties

Node 1

health

good health is the goal or outcome desired

Save

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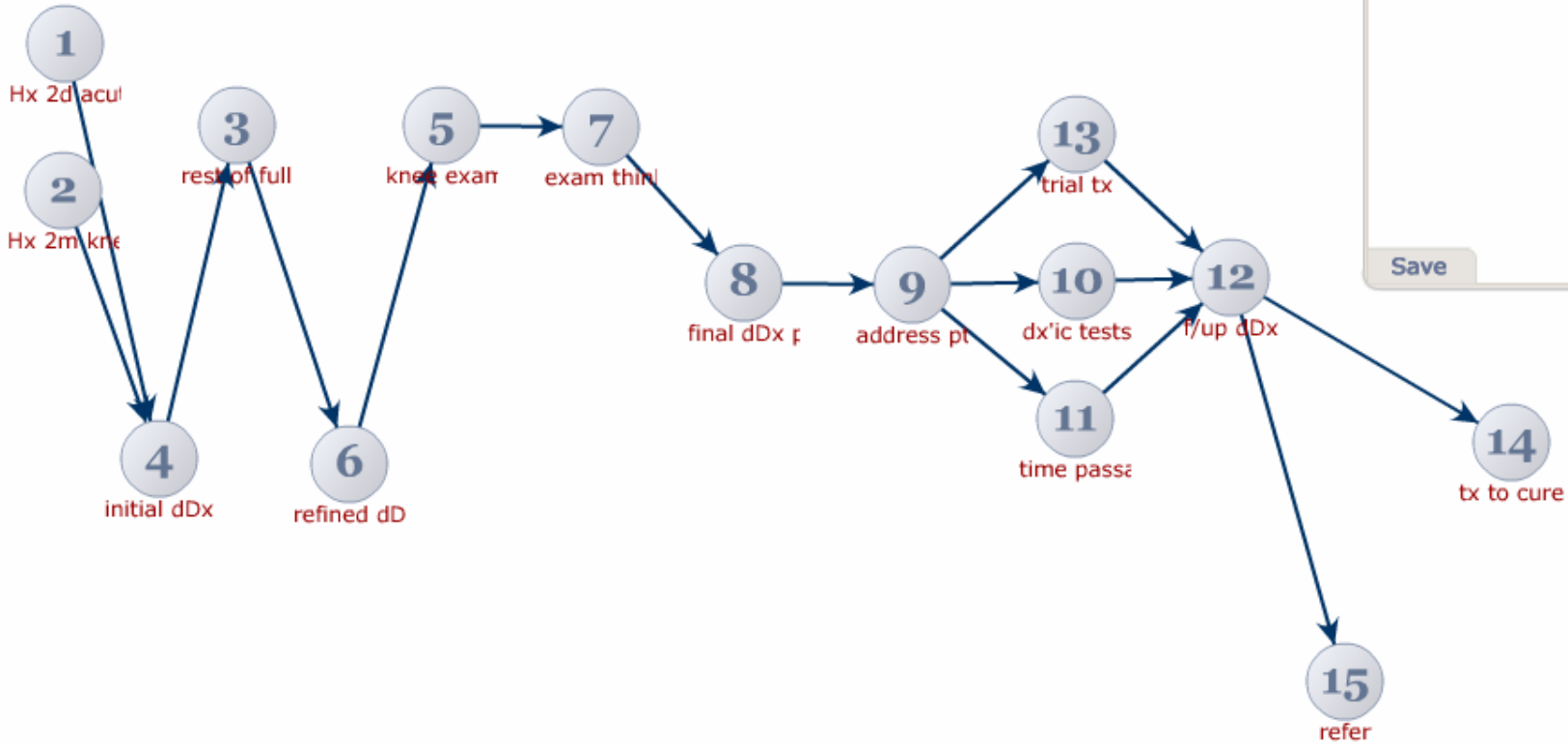
Problem Space - Microsoft Internet Explorer

User ID : med-05 | Problem ID : acd | Solution ID : 23

Conceptualizing the Problem Space



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Slide 1 of 1 | Default Design

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Level 1 Analysis – Scenario 1

Scenario #	Domain	Group	Avg. # nodes	Avg. one-way links	Avg. two-way links	Avg. words-node	Avg. word-node-name	Avg, words-link
Scenario 1	Medical							
		Novices	13.07	16	6.86	15.86	1.83	11.57
		Experts	10.6	17.6	4	26.6	2.24	21.2
	Engineering							
		Novices	9	12	2	22.9	2.6	7.25
		Experts	8	8	1.5	11.15	2.55	16
	Biology							
		Novices	7.36	10.29	1.14	39	2	24.86
		Experts	16	20.6	0.6	12.8	1.8	8.8

Level 1 Analysis – Scenario 2

Scenario #	Domain	Group	Avg. # nodes	Avg. one-way links	Avg. two-way links	Avg. words-node	Avg. word-node-name	Avg, words-link
Scenario 2	Medical							
		Novices	12.21	16.36	5	21.5	2.06	15.36
		Experts	12.25	15.5	1.5	31.75	2.35	14.63
	Engineering							
		Novices	8.5	8.5	1.5	27.5	3.05	18.05
		Experts	10.5	15.5	2	16.4	2.6	11.75
	Biology							
		Novices	7.13	24.5	1.13	10	4.25	23.94
		Experts	16.8	25.8	1.4	12.2	1.6	12

Level 1 Analysis – Medical Domain

Domain	Scenario	Group	Avg. # nodes	Avg. one-way links	Avg. two-way links	Avg words-node	Avg. word-node-name	Avg, words-link
Medical	*Scenario 1*							
		Novices	13.07	16	6.86	15.86	1.83	11.57
		Experts	10.6	17.6	4	26.6	2.24	21.2
	Scenario 2							
		Novices	12.21	16.36	5	21.5	2.06	15.36
		Experts	12.25	15.5	1.5	31.75	2.35	14.63

Level 1 Analysis - Biology

Domain	Scenario	Group	Avg. # nodes	Avg. one-way links	Avg. two-way links	Avg words-node	Avg. word-node-name	Avg, words-link
Biology	*Scenario 1*							
		Novices	7.36	10.29	1.14	39	2	24.86
		Experts	16	20.6	0.6	12.8	1.8	8.8
	Scenario 2							
		Novices	7.13	24.5	1.13	10	4.25	23.94
		Experts	16.8	25.8	1.4	12.2	1.6	12

Level 1 Analysis - Engineering

Domain	Scenario	Group	Avg. # nodes	Avg. one-way links	Avg. two-way links	Avg words-node	Avg. word-node-name	Avg, words-link
Engineering	*Scenario 1*							
		Novices	9	12	2	22.9	2.6	7.25
		Experts	8	8	1.5	11.15	2.55	16
	Scenario 2							
		Novices	8.5	8.5	1.5	27.5	3.05	18.05
		Experts	10.5	15.5	2	16.4	2.6	11.75

Structural & Semantic Analysis

- Intertwined due to resolving names of nodes and links
- Protocols based on expert analysis of the problem scenarios and a selected set of responses
- Individual responses coded based on protocols
- Similarities and differences among and between experts and novices ...

Biology Summary Data

Scenario 1

	5 Experts		14 Novices	
		Percent		Percent
cause/effect	32	31.4%	2	1.4%
example	0	0.0%	0	0.0%
correlation	65	63.7%	138	98.6%
process	5	4.9%	0	0.0%
Total Links	102	100%	140	100%

Scenario 2

	5 Experts		14 Novices	
		Percent		Percent
cause/effect	65	50.8%	40	27.2%
example	0	0.0%	0	0.0%
correlation	58	45.3%	101	68.7%
process	5	3.9%	6	4.1%
Total Links	128	100%	147	100%

Engineering Summary Data

Scenario 1

	5 Experts		18 Novices	
		Percent		Percent
cause effect	0	0.0%	cause effect	14	6.1%
example	0	0.0%	example	0	0.0%
correlation	54	85.7%	correlation	179	78.2%
process	1	1.6%	process	23	10.0%
mathematical	8	12.7%	mathematical	13	5.7%
TOTAL Links	63	100%	TOTAL Links	229	100%

Scenario 2

	5 Experts		18 Novices	
		Percent		Percent
cause effect	**9**	**11.54%**	cause effect	**42**	**20.49%**
example	**61**	**76.92%**	example	**158**	**77.07%**
correlation	**0**	**0%**	correlation	**0**	**0%**
process	**0**	**0%**	process	**2**	**0.98%**
mathematical	**9**	**11.54%**	mathematical	**3**	**1.46%**
TOTAL Links	**79**	**100%**	TOTAL Links	**205**	**100%**

Medical Summary Data

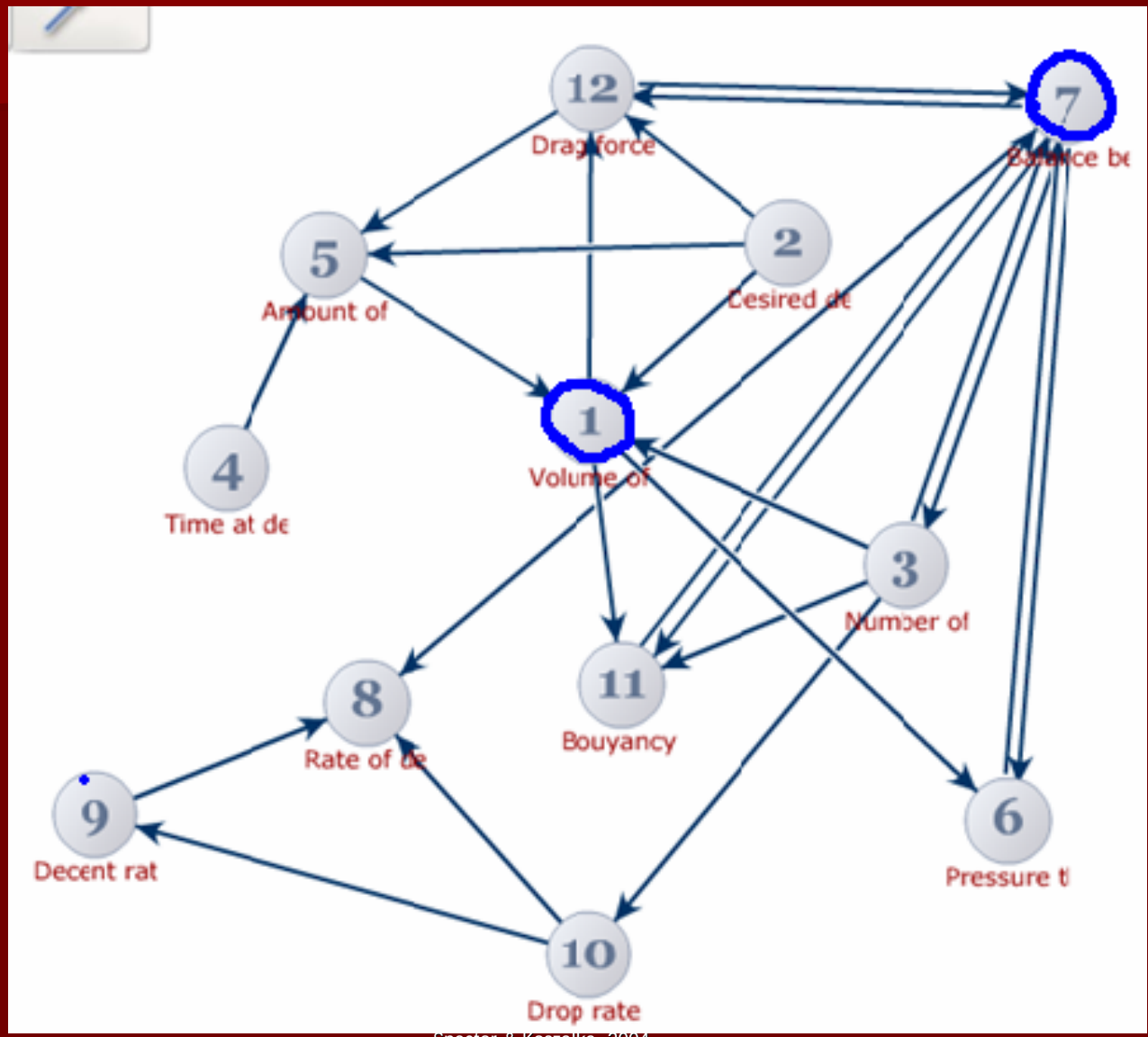
Scenario 1

	5 Experts	Percent		14 Novices	Percent
cause/effect	73	68.9%	cause/effect	185	58.2%
example	0	0.0%	example	24	7.5%
correlation	8	7.5%	correlation	84	26.4%
process	25	23.6%	process	25	7.9%
TOTAL Links	106	100%	TOTAL Links	318	100%

Scenario 2

	5 Experts	Percent		14 Novices	Percent
cause/effect	28	41.2%	cause/effect	137	46.6%
example	0	0.0%	example	27	9.2%
correlation	10	14.7%	correlation	123	41.8%
process	30	44.1%	process	7	2.4%
TOTAL Links	68	100%	TOTAL Links	294	100%

Node-Link Clusters



Comparing Experts & Novices

Biology Experts – Scenario 2 (N = 5; Links = 128).

	Nodes	*Links*	*From / To*	*Percentage*
1	Analyze the mercury concentrations	16	9 / 7	12.5%
2	Possible solutions	14	7 / 7	10.93%
3	Food chain	12	7 / 5	9.37%
3	Source of mercury contamination	12	8 / 4	9.37%
4	Limit consumption	11	7 / 4	8.59%

Biology Novices – Scenario 2 (N = 16; Links = 147).

	Nodes	*Links*	*From / To*	*Percentage*
1	Biological effects of mercury on fish	41	21 / 20	27.89%
1	Source of mercury contamination	41	24 / 17	27.89%
2	Human interaction	29	12 / 17	19.72%
3	Social awareness	28	13 / 15	19.04%
4	Analyze the mercury concentrations	24	17 / 7	16.32%

Links

- DEEP Data Collection Software:
  - http://soe-dl.syr.edu:8080/DMVS/jsp/index.htm
- DEEP Project Website:
  - http://idde.syr.edu/NSF-DEEP/
- Cyber Playground – How the Brain Works:
  - http://www.edu-cyberpg.com/Teachers/brain.html

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Feliz Natal

Feliz Ano Novo

Gosto muito