The Role of Understanding in Medical Student Learning:

Insights from Cognitive Psychology

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A starting assumption:

Thorough understanding of basic mechanisms is essential for medical students to become competent physicians

(Basic science is important)

Why is it important?
(some conjectures)

- All physicians need to know basic science as part of clinical reasoning
  (all docs need it some of the time)
- Some physicians (anesthesiologists, intensivists, nephrologists) use it a lot
  (some docs need it all of the time)

"All docs need to know basic science…"

The "two worlds" Hypothesis

-Expert clinicians reasoning about a case rarely mention basic science
(Patel, 1989; Custers, 1998; Patel, 1995)

"Basic science knowledge and clinical knowledge are incongruous, and information used in solving a case is organized independently of basic science information". (Schmidt, 2003)

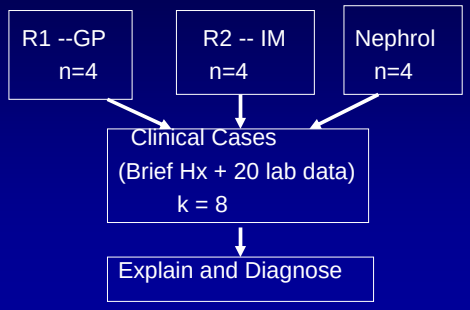
But not always…..

"In difficult cases, basic science can provide coherence in explanation of clinical phenomena" Schmidt, 2003

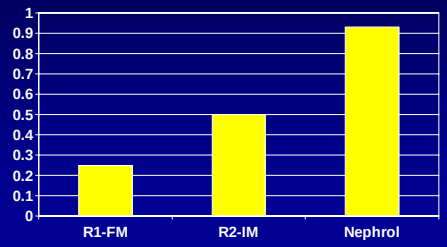
Basic Science and Difficult Cases

(Norman, Brooks, Trott, 1991)

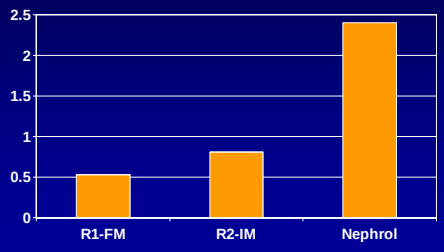
Experimental Design



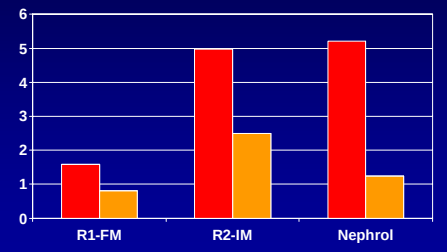
Diagnostic Accuracy



Causal Explanations



No of Diagnoses / Investigations



Conclusions - Use of Basic Science

- In difficult diagnostic situations, clinicians use causal physiological knowledge
- Expertise associated with more coherent explanations, better diagnosis

But is this all there is???

Three assertions about the role of basic science in learning

- Expertise is based on knowledge, not skills
- Knowledge can be more easily acquired and remembered when it has meaning
- Basic science provides meaning and coherence

Assertion #1

Expertise is based on knowledge, not skills

The Cognitive Perspective

"The essence of intelligence is less a matter of reasoning and more a matter of knowing a lot about the world"

H.A.Simon, 1989

"The problem-solving difficulties of novices can be attributed largely to the inadequacies of their knowledge base and not to limitations in their problem-solving capabilities"

R. Glaser, 1984

How do you get to be a chess master?

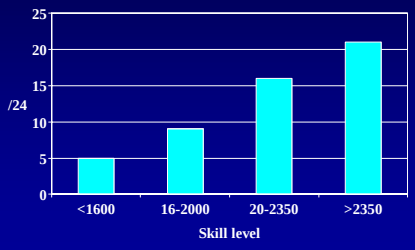
Is it:

- learning the rules?
- learning to think of more moves and deeper strategy? (process)
- learning to think *better* moves? (knowledge)

Recall of Chess Positions

- 4 levels of chess player
- mid-game positions
- 5-7 sec exposure

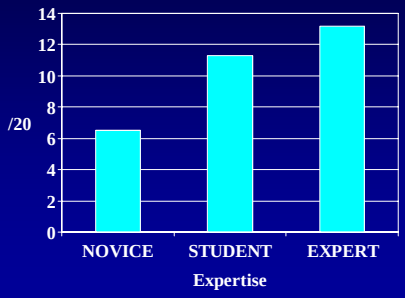
Recall after 5 sec. exposure



How do you get to be a nephrologist?

- Lab data, nephrology problems
- 5 research associates
- 6 students
- 5 experts

Recall of Nephrology Data



Conclusion

- Expertise in chess and nephrology (and medicine) related to available knowledge (both cases and formal rules)
- No evidence for generalizable skills

Assertion #2

Meaningful knowledge is more easily learned and remembered

- If we can understand what we are learning in terms of pre-existing knowledge, better learning and retention results
- Meaning is a consequence of the interaction between learner and 'to be learned'

Tomorrow and tomorrow and tomorrow creeps in this petty pace from day to day.
And all our yesterdays have lighted fools the way to dusty death.
Out, out brief candle.
Life's but a walking shadow, a poor player that struts and frets his hour upon the stage and then is heard no more.
It is a tale told by an idiot
Full of sound and fury
Signifying nothing

W. Shakespeare, MacBeth

Sound is walking, stage struts and a tale is heard. No more a poor candle, frets life. A brief idiot, fury and shadow, is in a dusty fool.

drswa gtrus hdrkl opono rluta
sflta dnaro lensa bfdoa radit
sogfv sonap vfhoe qpofs cpoas

- Meaning is idiosyncratic

The procedure is quite simple. First you arrange things into different groups. Of course, one pile may be sufficient. If you have to go somewhere else due to lack of facilities, this is the next step. It is better to do too few things at once than too many. At first it seems complicated, but soon it just becomes a fact of life. After it's over, you arrange the materials in groups again, then put them in the right place.

Washing Clothes

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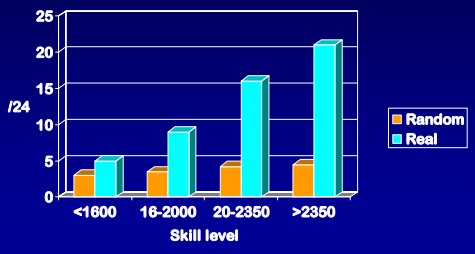
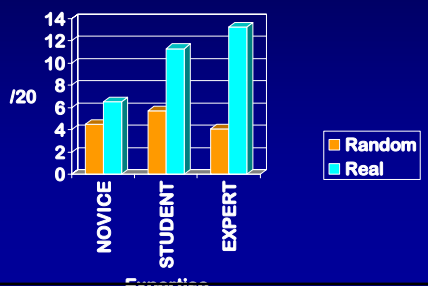
Recall of Chess Data



Recall of Nephrology Data



Conclusions

- Remembering for meaningful material is enhanced.

Assertion #3

Basic science provides meaning and enhances learning

(Woods, Brooks, Norman, 2003)

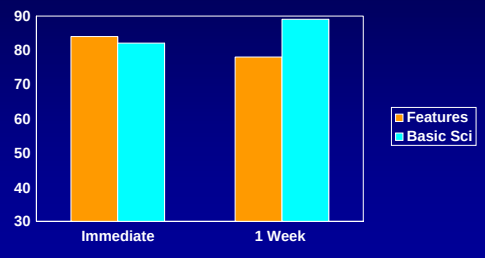
- Four neurological diseases
  - Muscle Disorders
  - Neuromuscular Junction Disorders
  - Upper Motor Neuron Lesions
  - Lower Motor Neuron Lesion
- 18 features / category
- 36 undergrad psych students
- Basic Science or Sympt x Disease probability

- Basic Science condition
  - Overview of neuroanatomy
  - Specific disease process description
  - Features “always” or “sometimes” associated with disease
- Feature list condition
  - List of signs/symptoms that usually occur with condition

Measurement

- Diagnostic Test
  - 15 cases, 4-6 features
- Administered at 0, 7 days

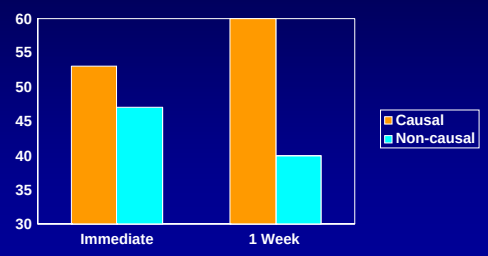
Score on Dx Test



Woods et al., Exp 2

- 4 conditions; 6 features / condition
  - 3/6 features have a causal (A>B>C) story
  - 3/6 features no causal story
- 15 graduate students
- Test with 50/50 cases
  - 2 causal, 2 non-causal features
- Test at 0, 7 days

Score on Dx Test



Conclusion

- Basic science knowledge provides meaning and coherence
- Enables reconstruction of category after learning

What can we do to enhance meaningfulness of basic science?

Traditional Instruction

- Basic science is taught / learned in "courses" with coherent and progressive development

Advantage

- Coherent, meaningful accrual of knowledge

Disadvantage

- No linkage across discipline domains
- No clinical (problem) associations

Problem Based Learning

- Knowledge is learned around clinical problems

Advantage

- Association between the clinical features and the concepts / processes

Disadvantages

- No progression development of concepts
- Superficial learning of concepts
- Concept may be "bound" to the problem, not available for new problems

- The Traditional Learner
  - A student who “knows the stuff but can’t problem – solve”
- The PBL Learner
  - A student who “can problem-solve but doesn’t know the stuff”

What does it take for the knowledge to be learned and used?

TRANSFER

using old knowledge to solve new problems

- A general wishes to capture a fortress located in the centre of a country. There are many roads radiating from the fortress. All have been mined so that, while small groups of men can pass over the roads safely, a large force will detonate the mines. A full-scale direct attack is therefore impossible. The general’s solution is to divide the army into small groups, send each down a different road, and have the groups converge simultaneously on the fortress.

You are a doctor faced with a patient who has a malignant tumour in his stomach. It is impossible to operate on the tumour. X-rays can be used to destroy the tumour. If sufficient rays reach the tumour all at once, the cancer cells will be killed, but surrounding tissue will be damaged as well. How can you arrange the procedure to destroy the tumour cells without severely damaging the surrounding tissue.

Gick & Holyoak, 1980

Transfer and Context Specificity

- The initial solution (multiple simultaneous paths) was learned in, and stored with the problem context (fortress and army).
- To solve the new problem, must recognize that the old problem was analogous to the new, despite different contexts
- To recognize analogy, we must recognize similarity in deep structure

this rarely happens…..

- Why not just teach them the principle?
  - Teach the principle, then give them an example of the principle

Using Examples in Teaching to Enhance Transfer

The *Example – Analogy* model (Ross, 1987)

"…during early learning, the principle is only understood in terms of the earlier example… the principle and example are bound together. Even if learners are given the principle or formula, they would use the details of the earlier problem in figuring out how to apply that principle to the current problem"

- Multiple examples vs. "Principle + Example"
  - Active Compare and Contrast vs. Separate (Gentner, 2003)
- Active solution vs. Memorization
  - (Needham & Begg, 1991)
- Multiple learning examples vs. Single Example
  - Compare and Contrast (Catrambone & Holyoak, 1989)

Multiple Examples vs. Principle + Example

- MBA Students , negotiation problem

Factor 1

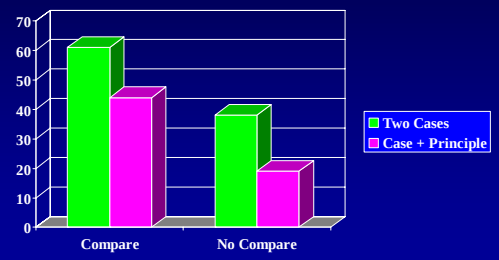
- Two cases, implicit principle vs.Principle + Case

Factor 2

- Read case and principle (on successive pages) vs. Compare Case and Principle

Loewenstein& Gentner, 2003

Effect of Examples and Comparisons



Gentner, 2003

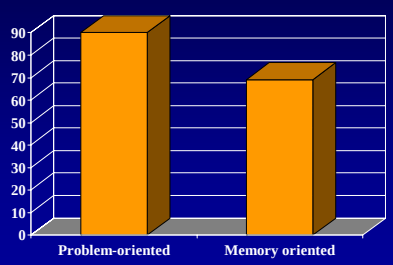
Effect of active, problem-oriented processing

- Intro psychology students, 5 classic problems
- "Try to solve these difficult problems"
  (27% successful)

  vs.

  "Remember the problem and solution so you can solve some additional problems"
  (21% successful)

Effect of Active Problem-solving

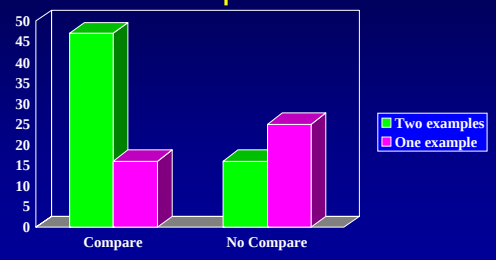


Needham & Begg, 1991

Effect of examples
(Catrambone & Holyoak, 1989)

- Undergraduate psychology students,
- Two related examples vs. one example and control
- "Summarize the two stories"
  vs.
  "Describe the ways the two situations are similar"

Effect of Examples, Comparisons



Catrambone & Holyoak, 1989

Implications for Teaching

- Transfer can be facilitated by use of examples during initial learning
  - multiple examples > principle + example
  - compare and contrast
  - active seeking for deep structure

Transfer, examples and practice

- Critical to learning, transfer is the opportunity to see the concept arise in multiple contexts
- This can only arise with multiple practical exercises

What can we do to enhance the value of practice?

What do you need to do stats?

An Observation:

With the availability of sophisticated statistical software, the central issue facing the statistics student is " What test do I use?"

To learn this, students have to see data sets, think of possible strategies, and get feedback

What do you get in stats courses?

- Instructional time occupied by equation proving, formula remembering

SPSS knows the formulas

- Practice at end of chapter of the form:
  "Do a t test on these data"

SPSS knows the formulas

Strategies to Optimize Practice

- Mixed vs. Blocked Practice
  (Hatala, 2002)
- Optimal sequencing in learn & practice
  (Avrahami, 1997)

Mixed vs. Blocked Practice

Hatala, 2000

- ECG Diagnosis -- 3 categories
- 6 examples / category

Blocked

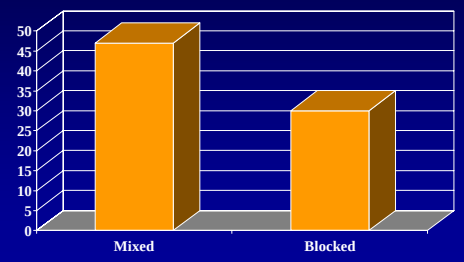
Review, then 6 examples/category

Mixed

Review, 2/category, 12 (4 x 3) practice

TEST6 new ECGs

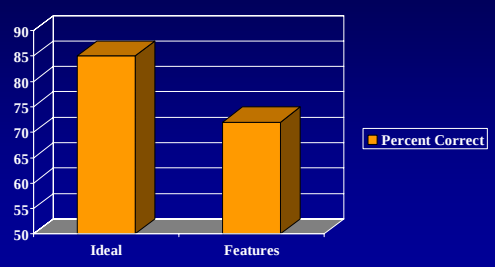
Accuracy -- %



Optimizing the Sequence (Avrahami, 1997)

- Sequence selected spontaneously
  - Ideal positive cases
  - Ideal negative cases
  - Borderline cases

Percent Correct with Different Strategies



Implications for Teaching

- Practice is critical for learning and transfer (being able to use basic science)
  - Mixed >> blocked
  - Sequence from typical to atypical with confusables
  - Distributed >> massed

Conclusion

1) Basic science has a developmental role in providing meaning to clinical material
2) But teaching basic science to facilitate this role is not straightforward
3) Evidence from psychology of transfer provides strategies for teaching
   - Active problem exploration before solution
   - Seeking deep structure
   - Multiple examples