Computer-based and computer-assisted tests to assess procedural and conceptual knowledge

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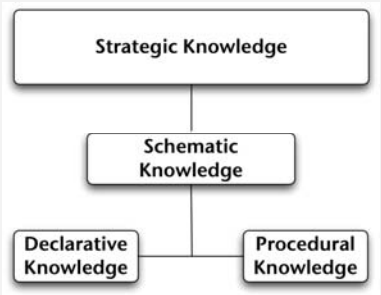
Presented at the 8th International Computer Assisted Assessment Conference in Loughborough, UK. July 6 & 7, 2004. See: http://www.caaconference.com/

Pedagogical Problem...

- Biosciences are essentially practical and experimental subjects
- Biosciences undergraduates therefore must develop abilities to:
  - acquire and apply procedural knowledge
  - demonstrate understanding of concepts that underpin procedures
  - use procedural knowledge in appropriate contexts; i.e. to develop strategic knowledge within the domain

Knowledge framework

c.f. Shavelson et al. (2002) EARLI/Northumbria Conference keynote address



Declarative knowledge...

- "Knowing *that*..."
  - a fact-base, or knowledge store

Procedural knowledge...

- "Knowing *how to do* something"
- Consists of...
  - if/then rules
  - sequence of steps
- Calls upon...
  - declarative knowledge

Schematic knowledge...

- Having a scientifically justifiable conception, i.e. "knowing why"
- May be used to...
  - interpret problems
  - troubleshoot
  - explain an outcome
  - predict an outcome
- Depends on...
  - having an understanding of principles
    - "conceptual knowledge" = combination of declarative and procedural knowledge

Strategic knowledge…

- Knowing when, where and how to use certain types of knowledge in a new situation
  - conditional knowledge, strategies
    - *what schematic knowledge is applicable here?*
  - essential for solving new problems

"Conceptual knowledge"…*

- a subset of *schematic knowledge*
  - taken to equate to "understanding the basis for a particular procedure"

* as I have used in the abstract

Knowledge framework

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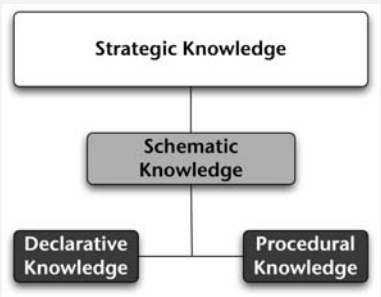

A key aim…

- Exploit the strengths of CBA to promote development of procedural and conceptual knowledge in biosciences students
- Context…
  - first-year module: *Molecular Cell Biology*
  - using "case-based" approaches in different forms

Two Approaches

- TRIADS CBA focusing on a "classic experiment"
  - Meselson-Stahl experiment: outcome simple, but to appreciate its power requires understanding of several sophisticated principles
- CaseIT! simulation software
  - to teach and assess procedural and conceptual knowledge of key molecular biology techniques
  - http://www.uwrf.edu/caseit/caseit.html

CaseIT!

- Virtual molecular biology lab
  - "apparatus" for performing separation of DNA fragments and for identification of specific DNA sequences
  - apply molecular biology techniques in the context of a case study of human genetic disease
    - must perform a Southern blot…

Southern Blot Procedure

- **Component tasks**
  - obtain DNA sample and select enzyme
  - perform reaction to digest the DNA
  - load sample onto electrophoresis gel
  - run gel; stain and destain
  - transfer DNA from gel to a membrane
  - select radioactive hybridisation probe and apply to membrane
  - reveal specific DNA sequences by exposing membrane to X-ray film

Movie

- CaseIT in action

Computer-Assisted Test

- **t0 = Introduction to techniques and to CaseIT! (demonstrated in lecture)**
- **t+1 = Classroom session, hands-on (3 h)**
  - students work on cases involving Southern blotting as the key technique
- **t+5= Test session**
  - paper-based test with unseen case
  - must use CaseIT to obtain results
  - test items (short answer responses) depend on correctly performing Southern blot

Why did we do it?

- **History**
  - In 2002, only 4 of 40 students correctly answered an item on a TRIADS exam which required understanding of the Southern blot procedure
  - For 2003, we devised and used the CaseIT test; it was used again in 2004
- **CaseIT! Test Results**
  - 2003 & 2004: extremely poor on the whole
    - 2004 mean = 42%
    - 30 of 66 got <35%!
  - *but* 61 of 66 (in 2004) were able to perform the Southern blot procedure correctly
- **TRIADS Item, 2004**
  - 18 of 57 scored 100%

Southern blot TRIADS item

Summary

- **CaseIT! provides a reasonably realistic analogue of "real" lab techniques**
  - helps build understanding of rationale/ approach in "fail-safe" environment
- **The CaseIT! test "forced" students to learn blot procedure!**
  - have to learn a logical sequence of procedures that mimics the learning required in the "real" situation
- **CAA/CBA need not be a "test given on a computer"**

Acknowledgements

- **Funding:**
  - Birkbeck College Development Fund
  - Higher Education Funding Council of England (HEFCE) through FDTL4
- **People at Birkbeck:**
  - Authorware Programmers: Dijana Maric, Ellen McCarthy, Caroline Pellet-Many
- **People elsewhere:**
  - Don Mackenzie and his team at the Centre for Interactive Assessment Development, University of Derby
  - Mark Bergland, author of CaseIT!, University of Wisconsin-River Falls

References

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