Problem Solving
Expert and Novices

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Today: Expert vs. Novice Problem Solving

1. Who counts as an expert?
2. Expert characteristics
3. Novice characteristics

Today: Expert vs. Novice Problem Solving

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Who counts as an expert?

- Those who have extensive knowledge of a particular area or 'domain'
  - e.g. Piano, Chinese History, Soccer
  - Better problem solving in that domain
  - Is problem solving itself domain specific?
- Debated
- Possible transfer with practice across domains and metacognitive redulation
- Estimated to take 10,000 hours of study

(e.g. Ericsson, 1996; Hayes, 1988; Simon, 1995)

  - i.e. 5 to 10 years!

Expertise continuum

- Prior knowledge can be thought of as a <u>continuum</u>

- Novice  Expert

Expert Characteristics: Domain-specific Knowledge

- Domain or Domain-specific knowledge is knowledge about a particular field of study
- We know that expert have a large store of domain-specific knowledge
  - i.e. large number of schemas available for problem solving
- Elaborated and well practiced
- Automated
- Easier to retrieve from LTM (Anderson, 1993)
- Use to organize new information
- Domain knowledge influences new learning in that domain. The more you know, the easier it is to learn new connected information.
- Experts (high prior knowledge) solve problems very differently to novices (low prior knowledge)

General Knowledge and problem solving

- Both domain specific and general knowledge is required for problem solving

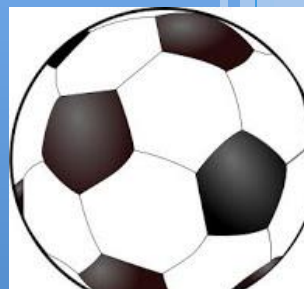
General knowledge

- is broad knowledge- how to function in society- how to find different types of information etc.
- Can be applied to a number of tasks and is not linked specifically to a domain

Expert Characteristics: Domain-specific Knowledge

Example 1: Schneider & Bjorklund (1992)

- Participants:
  - Year 4 students
  - Soccer experts and novices were identified
- Method: students were given a passage about soccer to read
- Results: Experts recalled many more new soccer terms than novices, *despite* no greater academic ability

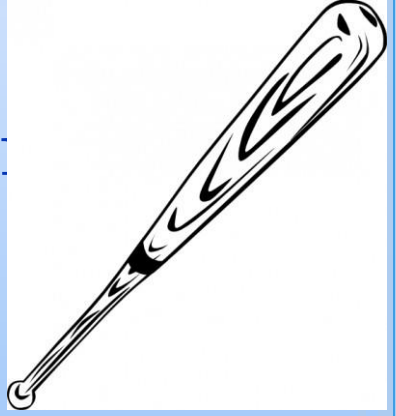


Expert Characteristics: Domain-specific Knowledge

Example 2: Recht & Bjorklund (1988)

- Participants:
  - Junior High School Students
  - Good and bad readers were identified
- Method:
  - Step 1: students were tested on baseball knowledge
  - Stage 2: students read about half an inning between a local and rival term
  - Step 3: students were asked to (1) re-enact the inning, (2) summarize the passage, and (3) sort sentence according to how important they were

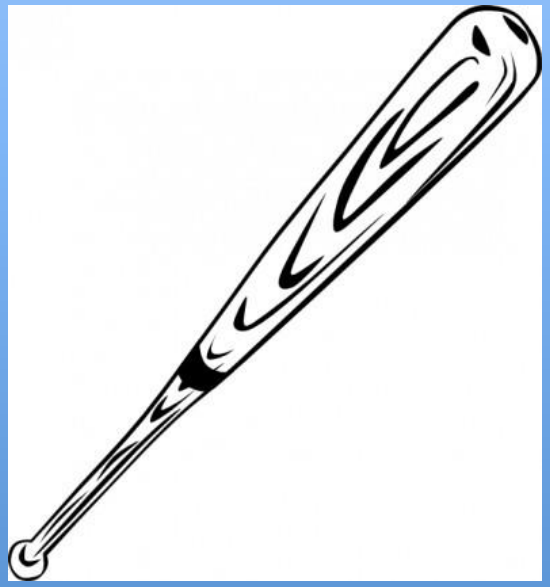
Expert Characteristics: Domain-spec Knowledge



- Results:
  - Poor readers/expert baseballs performed almost as well as good reader/expert baseballers
    - Across re-enactment, recall, and sentence-sort
  - Poor readers/expert baseballers recalled much more than good readers/novice baseballers
  - Poor readers/novice baseballers performed worst

Expert Characteristics: Domain-specific Knowledge

- Implications: Soccer/Baseball experts used domain knowledge to organize new information for better learning and retrieval



Expert Characteristics: Domain-specific Knowledge

- Implications for problem solving: Better problem identification, deep representation, and strategy selection
- Effective categorization of problems
- Links to similar problems and solutions
- Focus on deep problem characteristics rather than surface features
- e.g. most effective solution solution strategy vs. objects included in problem

Expert Characteristics: Treatment of Problem

- We also know that experts spend more time organizing, planning and monitoring learning activities

- So, for problem solving, experts spend time…
  - Analyzing the problem
  - Drawing diagrams
  - Breaking the problem into sub-problems
  - Making plans

Expert Characteristics: Example

e.g. Swanson, O'Connor & Cooney

- Participants: Expert and novice teachers
- Method: Examined how teachers would 'solve' classroom management problems

Expert Characteristics: Example

- Findings:

1. Time spent analyzing problem

- Experts prioritized defining and representing the problem

2. Depth of problem analysis and categorization

- Experts analyzed the type and severity of problem
- Novices categorized problems according to solution

3. Strategy/solution selection

- Experts considered different solution and evaluated each
- Novices typically chose just one solution

Expert Characteristics: Example

4. Focus of solution

- Experts chose internal interventions such as counseling students
- Novices chose external interventions such as removing students

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Novice Characteristics: Misconceptions

- Novices may misunderstanding information in a particular domain
  - e.g. Physics
- May children believe turning on a light 'brightens' a dark area around objects
- In actual fact, light is reflected off objects into the eye
- These misunderstandings are variously called:
  - Misconceptions
  - Naïve conceptions/models
  - Intuitive conceptions/models

Novice Characteristics: Misconceptions

- Research shows it is important to challenge misconceptions directly
- Not just present correct information

- e.g. Eaton, Anderson and Smith (1984)
  - Participants: Year 5 students
  - Method: Two groups
- Group 1: students completed a Science unit on light and vision, including reflection
- Group 2: As for group 1, but students ALSO had their misconception about light directly challenged

Novice Characteristics: Misconceptions

- Results:
  - 78 % of Group 1 students retained their original misconceptions
  - Only 20% of Group 2 retained their original misconceptions

Novice Characteristics: Misconceptions

- What causes a student to abandon an incorrect conception?
  - Requires motivation to do so
- According to Pintrich, Marx and Boyle (1993), four conditions must be met:
  - Students must be dissatisfied with the new current concept
  - Students must understand the new concept
  - The new concept must be plausible
  - The new concept must be useful

Novice Characteristics: Misconceptions

- How do novice misconceptions affect problem solving?
  - Inadequate/misleading problem Identification and representation
  - Effective problem solving can therefore require ‘unlearning’

Novice Characteristics: Summary (Burning et al., p.175)

Experts:

1. Excel only in their specific domain
2. Perceive large, meaningful patterns in information
   - Experts process information in larger units compared with novices (chunks, schemas)- Research of de Groot (1965), Chase & Simon (1973) on chess-masters
3. Perform tasks quickly and with few errors
   - Have experienced a vast number of problems compared with novices (example of Chess-masters). Can remember solutions rather than problem solving

Deeper learning

- Tasks "Categorize the following into 3 groups

soldier, 1492, discovery, kings & queens, 1914, revolution, sailors, war, 1789

- Surface structure grouping

(Dates) 1492, 1914, 1789

(People) Kings & Queens, sailors, soldiers

(Concepts) Discovery, war, revolution

- Deep structure grouping

(French Revolution) 1789, Kings & Queens, revolution

(WW1) 1914, Soldiers, war

("Discovery" of the new world) 1492, sailors

Expert Characteristics

5. Hold more information in WM and LTM
- *Automated* schemas allows information to move into WM with few demands on cognitive load. Allows more higher order functions to be considered such as monitoring, evaluating etc.
6. Take time to analyze a problem
- Once more the problem is clarified them strategy selection is faster than novcies
- Often a complex problem is divided into key sub-problems (Vost and Post, 1988)
7. Are better at monitoring performance
- Generating and rejecting alternative solutions before starting. Are able to understand the

Experts work forwards rather than backwards

Problem: get to lecture in Ruang PPG 2

Relative expert:

- Use transport option to get to UNY
- Upon arrival at UNY, go to R.PPG2

Relative novice:

- Look in street directory to locate UNY
- Decide on public or private transport
- Examine public transport options and decide which option
- Obtain transport information on routes, timetables, costs
- Upon arrival at UNY, find R.PPG2 on map or ask
- Use map or directions to find R.PPG2.

Improving problem solving

1. **Facilitate the acquisition of expert knowledge**

- *Extensive domain knowledge essential*
- Teachers identify what knowledge is needed to become ‘expert’
- This care body of knowledge becomes the focus of instruction
- No substitute for extended engagement in the domain to become an expert.

2. Develop an awareness of a general PS strategy

- Exposes learners to the five steps model of problem solving previously described and/or Polya's model-particularly younger students.
- Last step in Polya's model crucial-meta-cognitive activity

3. Focus on discovering and identifying problems

- Problem discovery a crucial stage
- A key aspect is to spend time analyzing the problem

4. Use external representations whenever possible

- Graphs, diagrams, re-writing etc. reduce working memory load

5. Mimic expert strategies?

- With caution! Lack of expertise may interfere with successful implementation. However, emphasizing higher-order skills, concepts like categorization may be beneficial.
- Study exerts solutions

Is problem solving a good way to learn?

- *Difference between problem solving and learning through PS*
- Dependent upon prior knowledge: Research by Sweller and colleagues at UNSW has shown that novices learn better by "direct" instruction (e.g. worked examples) rather than by a more unstructured (discovery) problem solving approach (working memory explanation).
- In contrast, learners with more expertise can learn effectively from a problem solving approach (schemas)
- Pure discovery learning has not been shown to work (Mayer, 2004), but guided discovery does.
- Research by Kayulga, Ayres, Chandler & Sweller (2003) document the *expertise reversal effect*- "one size doesn't fit all"- effective strategies become ineffective for the "wrong" learners.

Summary

- Expertise is domain specific
- Many expert-novice difference
  - Qualitative and quantitative (type of schemas and automation)
- Methods to improve problem solving
- Problem solving as an effective learning strategy is moderated by prior knowledge