

## Development of Expertise

### General Empirical Results:

#### Stages of skill learning (Fitts & Posner '67)

cognitive

declarative, verbal

slow

associative

errors detected & eliminated

connections strengthened

autonomous

automated and rapid

#### Power Law of Practice

## Aspects of Development of Expertise

### 1. Proceduralization

compiling declarative knowledge into specific rules

### 2. Tactical Learning

sequences as chunks  
computation -> retrieval

### 3. Strategic Learning

#### Physics

backward -> forward search  
(also seen in geometry)

problem categorization by deeper principles  
(seen also in math, programming, and medicine)

#### Programming

no change to working forward  
depth first -> breadth first  
deeper representation  
language independence

### 4. Problem Perception

#### Physics (see above)

problem categorization by deeper principles  
(seen also in math, programming,  
and medicine)

#### Chi, Feltovich & Glaser 1981

classification

"angular speed" -> conservation of energy

#### Medicine

Lesgold et al. 1988

x-rays

## 5. Pattern Learning and Memory

de Groot 1965, 1966 memory for chess  
(seen in other domains since)

Chase & Simon, 1973

chunking

more patterns, larger patterns

Simon & Gilmartin 1973 ~50k chunks

Newell & Simon 1972

Human Problem Solving

chunks = productions

~50K productions for expertise

## 6. Long Term Memory and Expertise

(patterns are basis for memory recording)

Chase & Simon, 1973

chunk define by 2 sec. pause

master:	3.8 pieces
	7.7 patterns / board
	= 29.26 total (ceiling?)
beginner:	2.4 pieces
	5.3 patterns / board
	= 12.72 total

Charness 1976

chess patterns after 30 sec.

interference task

Chase & Ericson 1982

digit spans

## Learning and Implications

Ericsson et al. 1993 Deliberate Practise

Transfer of Skill

Doctrines of formal discipline  
cross cultural evidence  
role of practice!  
Theory of Identical Elements  
No negative transfer?  
language

protocol analysis

componential analysis  
mastery learning

intelligent tutoring systems