4 Geschichte der Lernmaschinen

4.1 Vorgeschichte

4.2 Behaviorismus: Programmierte Unterweisung

4.3 Kognitivismus: Instruktionsdesign, Intelligente Tutorielle Systeme

4.4 Konstruktivismus: Mikrowelten, situiertes Lernen

4.5 Hypermediales Lernen und Web-Based Training

Literatur:

A. Holzinger: Basiswissen Multimedia Band 2, p. 176-182

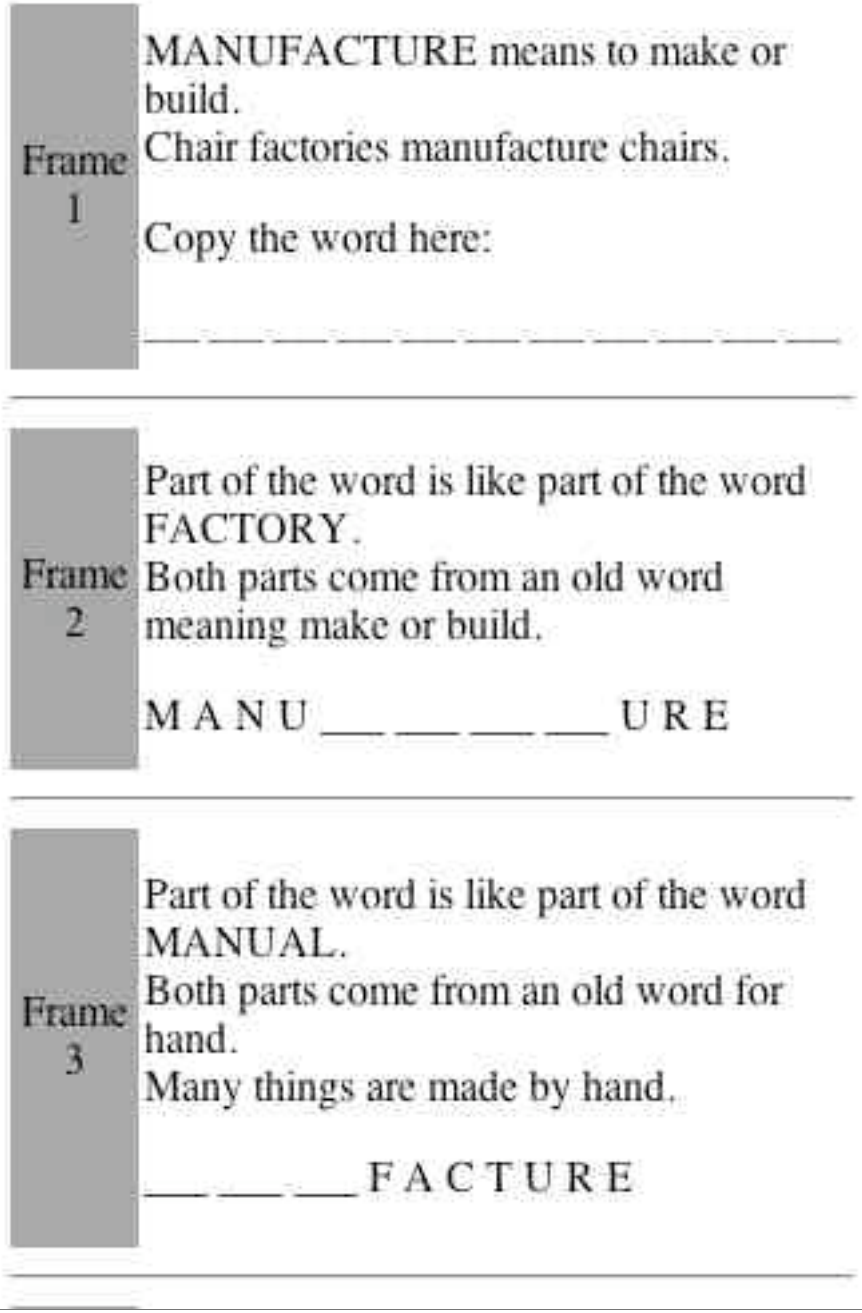
J. Hasebrook: Multimedia-Psychologie, Kapitel 7 und 8

H. Niegemann et al.: Kompendium E-Learning, Kapitel 1

Burrhus Skinner: Programmierte Unterweisung

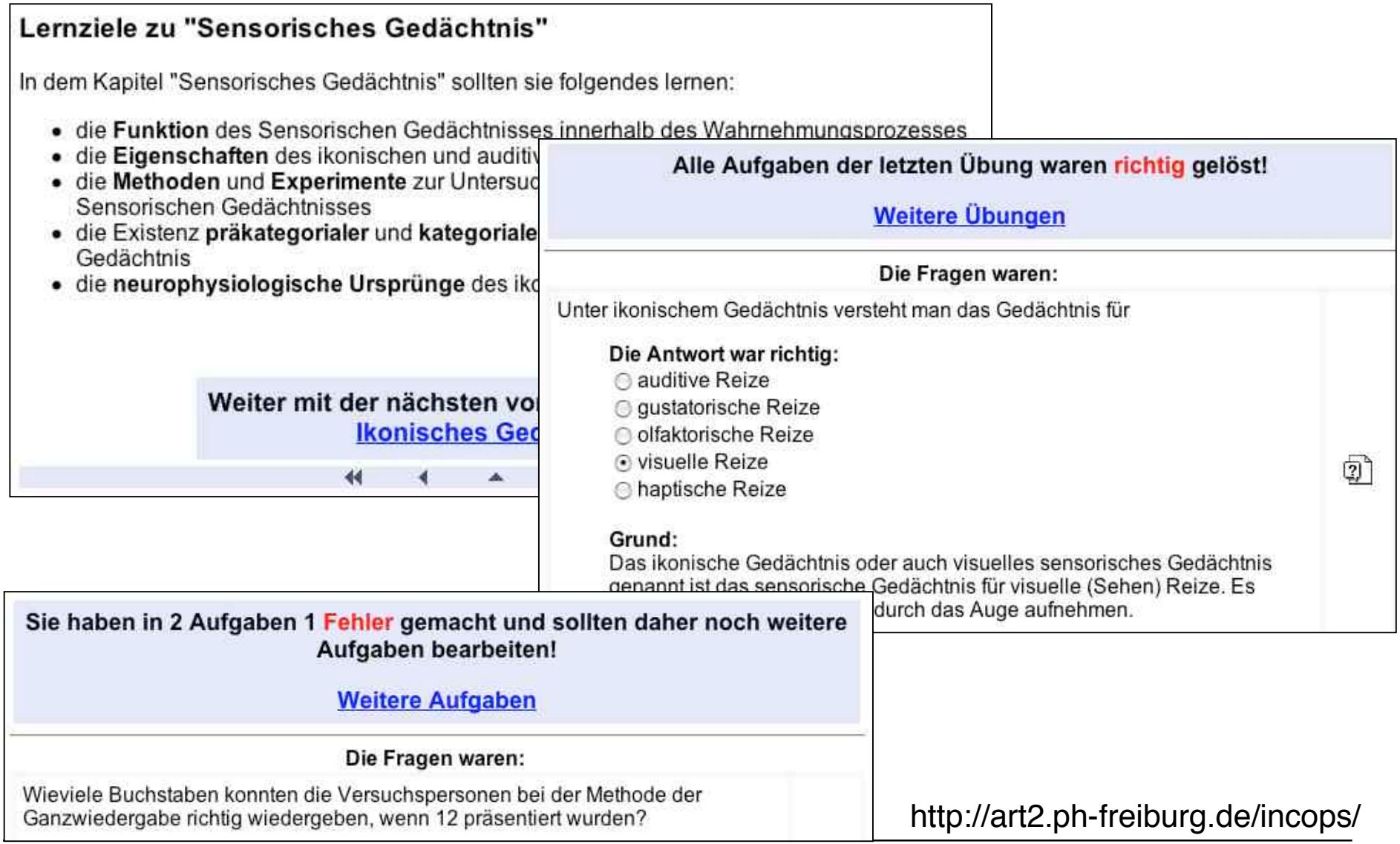
- Rezession lähmt auch Anwendung von Lernmaschinen
- Nach dem 2. Weltkrieg: „Babyboom“, „Sputnik-Schock“, …
- Programmiertes Lernen nach Skinner
  (ca. 1958, angeblich aufgrund von Beobachtungen in Grundschule):
  - Jede Antwort bekommt eine sofortige Rückmeldung.
  - Jeder Schüler arbeitet in seinem individuellen Tempo.
  - Lernziele sind klar und objektiv formuliert.
  - Aufgaben sind so gestellt, dass sie mit hoher Wahrscheinlichkeit richtig gelöst werden.
  - Unterrichtsstoff zerlegt in „Frames“ (Frage- und Antwortkombinationen) mit langsam ansteigender Schwierigkeit und der Präsentation des Stoffs aus verschiedenen Perspektiven
  - Lernende werden zur Aktivität angeleitet.
  - Ausdauerndes und gutes Arbeiten führt zu Zusatzbelohnungen.
- Basis vieler (der meisten?) Lernprogramme bis heute!

Example of Original Skinner Frames



- From Skinner, B.F. (1958). Teaching machines. *Science, 128* (3330), 969-977.

Ein aktuelles Lernprogramm (incops)

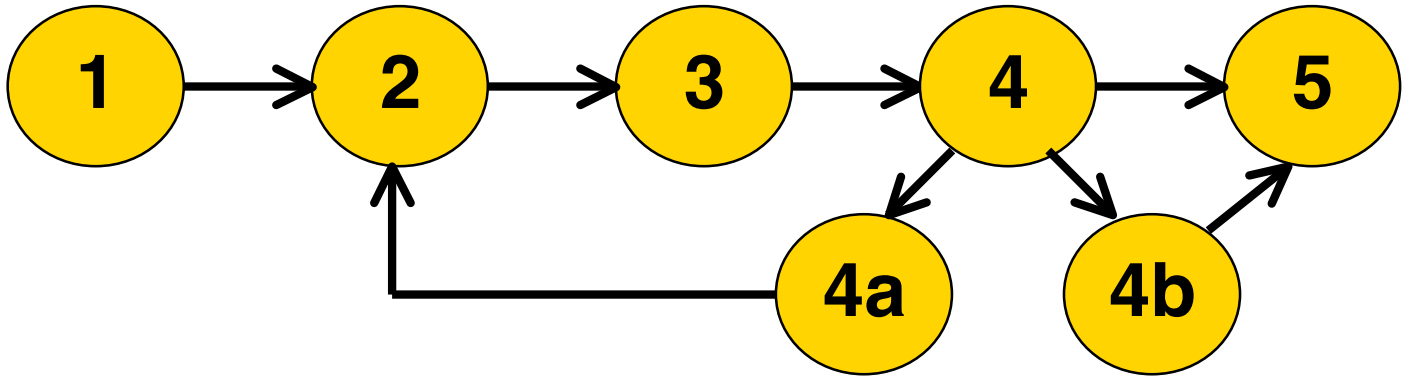


http://art2.ph-freiburg.de/incops/

Lineare und verzweigte Programme

- Reaktionszentrierter Ansatz von Skinner/Holland:
  - Lineare Abfolge des Lehrmaterials durch Lehrenden festgelegt
  - Feedback nur bei korrekten Antworten

- Reizzentrierter Ansatz von Norman Crowder (1959):
  - Rückkopplung, um festzustellen, ob Kommunikationsprozess erfolgreich war
  - Feedback bei negativen Antworten
    (abweichend von operanter Konditionierung)



Zwei Großprojekte

- Ziel: Klärung der Effektivität computergestützter Instruktion durch Feldversuche
- National Science Foundation (NSF), USA, 1971
  - Zwei Großprojekte über jeweils 5 Jahre
  - Insgesamt 60 Mio $
- TICCIT
  - Mitre Corp. und Brigham Young University
  - Minicomputer für je 128 Terminals
- PLATO
  - Control Data Corporation und University of Illinois, Urbana-Champaign
  - Ein Großrechner für 950 Terminals

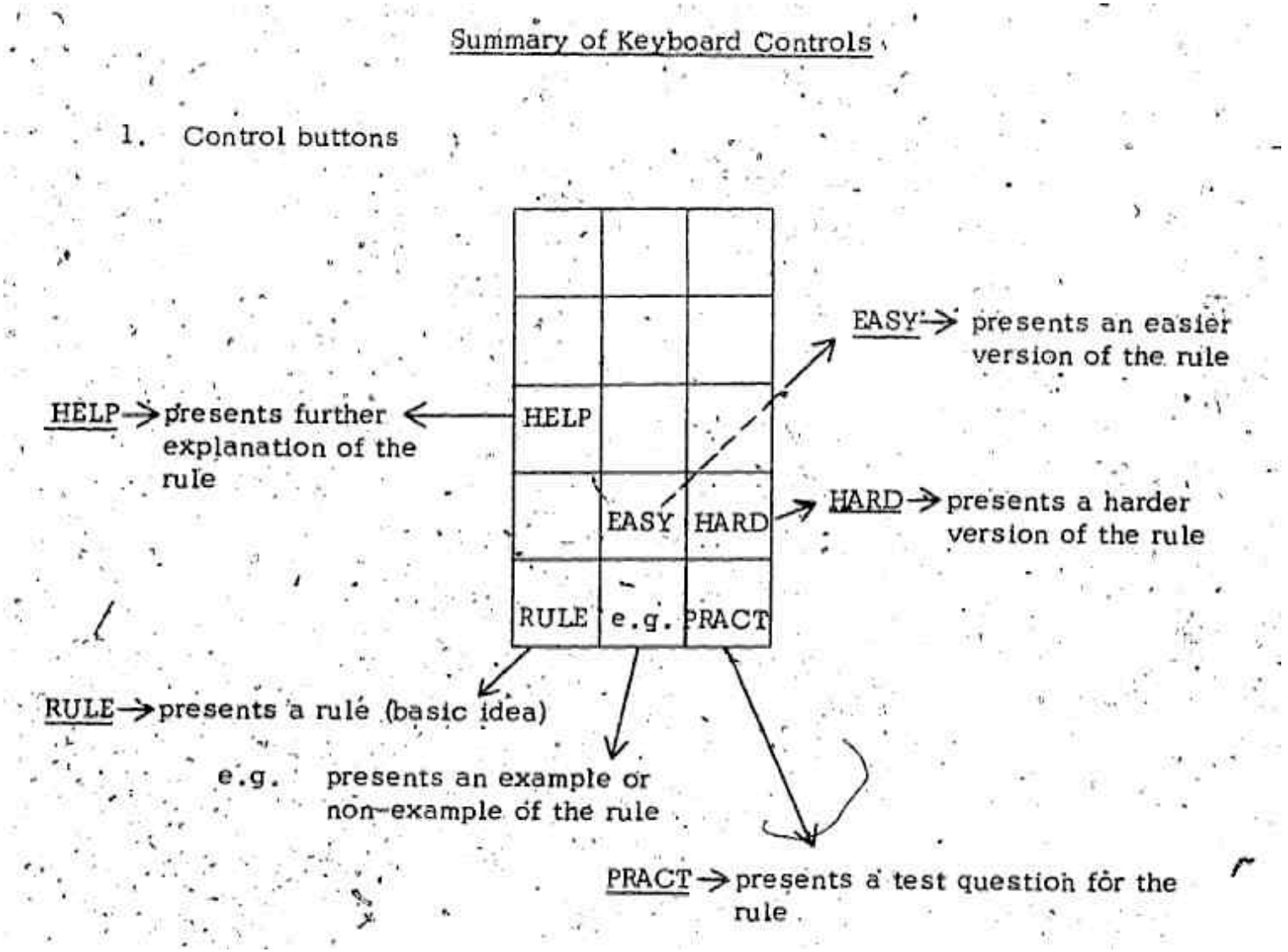
Project TICCIT

- TICCIT (1971 – 1977)
  - (Time-Shared Interactive Computer Controlled Information Television)
  - Developed at the University of Texas and Brigham Young University
  - Together with PLATO 60 mio $ funding
  - Audience: adult learners, but later version for elementary schools

Interactive Television system : TICCIT

- Goal: Compare class-room and computer-based instruction
- Hardware:
  - Color monitor with loudspeaker (TV)
  - Special keyboard
  - Lightpen (Lichtgriffel)
  - Video tape player

TICCIT Keyboard



More:

- Attention
- Exit
- Repeat
- Go
- Skip
- Back
- Objective
- Map
- Advice

http://eric.ed.gov, document ED16006

TICCIT Evaluation

- Evaluation by ETS (Eduational Testing Service) was mixed:
  - TICCIT mathematics and English course students reported "significant achievement" over the traditional classroom formats
    - » For those students who completed the TICCIT courses!
  - Drop-out rate around 50%, 84% for math courses!
  - More students favored lecture classes over TICCIT math courses
  - Acceptance by teachers quite low

Project PLATO

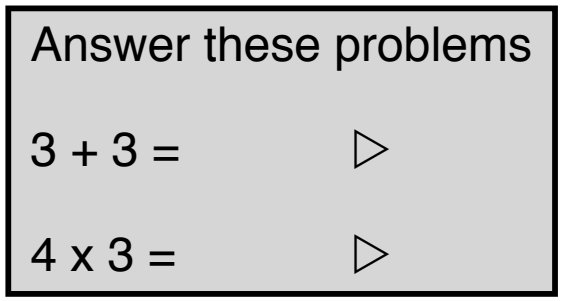
- PLATO (from 1960)
  - (Programmed Logic for Automated Teaching Operation)
  - University of Illinois, Donald Bitzer
  - PLATO I – III (until 1966)
- PLATO IV (1972), Computer-based Education Laboratory (CERL)
  - Plasma display (partially with back-projected slides)
  - Touch screen
  - TUTOR language for session design
  - Graphics, animations
  - Message exchange among users, message boards (notes), chat rooms
  - Flight simulator, multiplayer games
- Commercial product until 1986
- See www.cyber1.org

Example for TUTOR Script

```
unit    math
at      205
write   Answer these problems

        3 + 3 =

        4 x 3 =
arrow   413
answer  6
arrow   613
answer  12
```



http://en.wikipedia.org/wiki/TUTOR_(programming_language)

PLATO Evaluation

- No significant difference between learning with the system and traditional learning
- Drop-out quote not higher than in traditional learning
- Reasonable acceptance
- 70% of students used the system outside course times
- 88% of teachers planned to work with the system again
- However:
  83% of students stated that a full course taught only by PLATO is unsatisfactory.

O‘Shea and Self 1986

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R. Schulmeister: Grundlagen hypermedialer Lernsysteme, Kap. 5 + 6

D.H. Jonassen (ed): Handbook of Research on Educational Communications and Technology, 2nd ed. 2004.

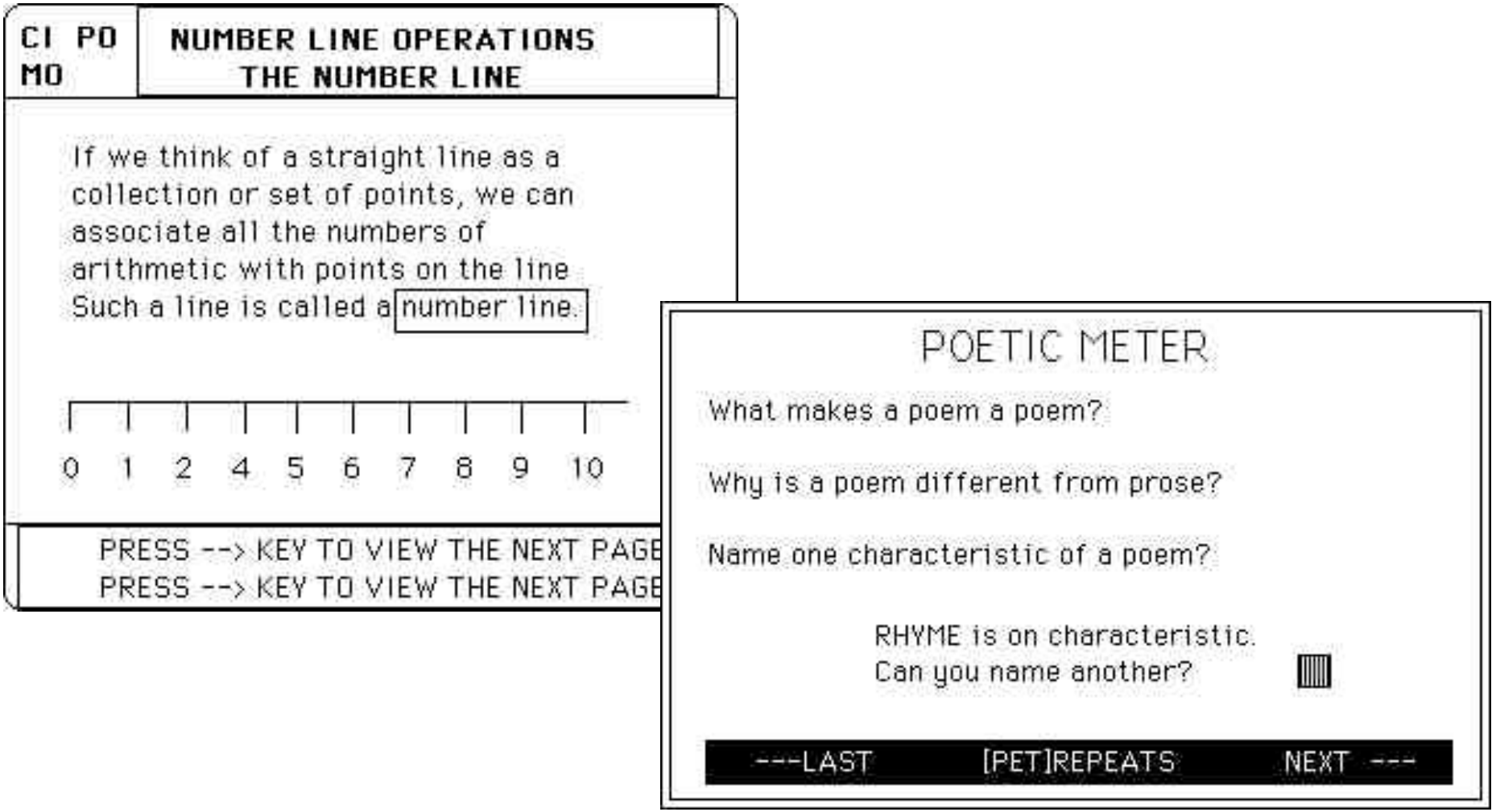
CAI, CBT, CUU, …

- Akronyme:
  - CAI = Computer-Aided Instruction
  - CBT = Computer-Based Training
  - CUU = Computer-unterstützter Unterricht
- Unterscheidung CAI/CBT:
  - In Teilen der Literatur:
    - » CAI = Behavioristische "Drill"-Programme
    - » CBT = Programme mit kognitivistischen Elementen
  - Häufig keine wirkliche Unterscheidung im Gebrauch der Begriffe!

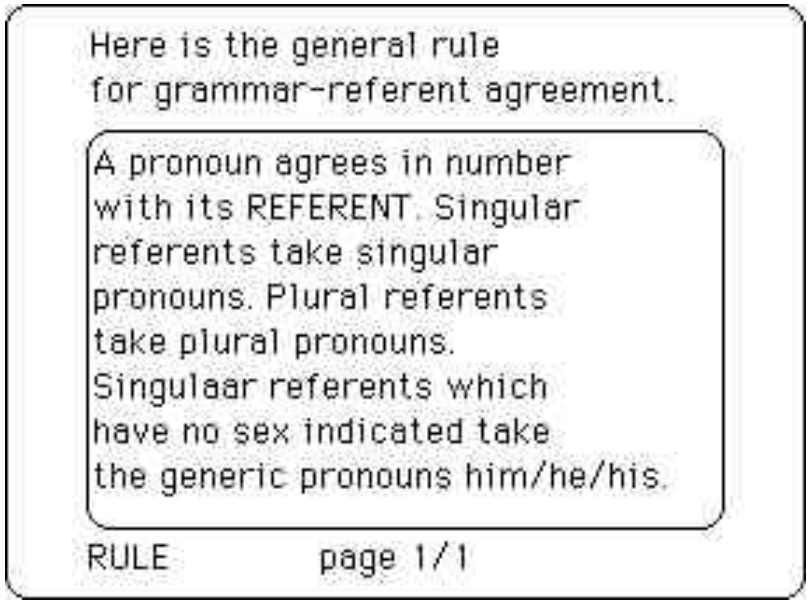
Grundidee kognitivistisch orientierter Systeme

- Feedback:
  - Lerner erhält individuell abgestimmte Rückmeldung
  - "Assistenz"-Funktionen zum Erkennen von Fehlern
- Adaptivität:
  - System versucht Informationsangebot an aktuelle Situation (Wissensstand, Abarbeitungsstand) anzupassen
- Die Grenze zu rein behavioristischen Systemen ist fließend.
  - Grundlegendes Interaktionsprinzip ("Frames", Frage-Antwort-Dialoge) gleich

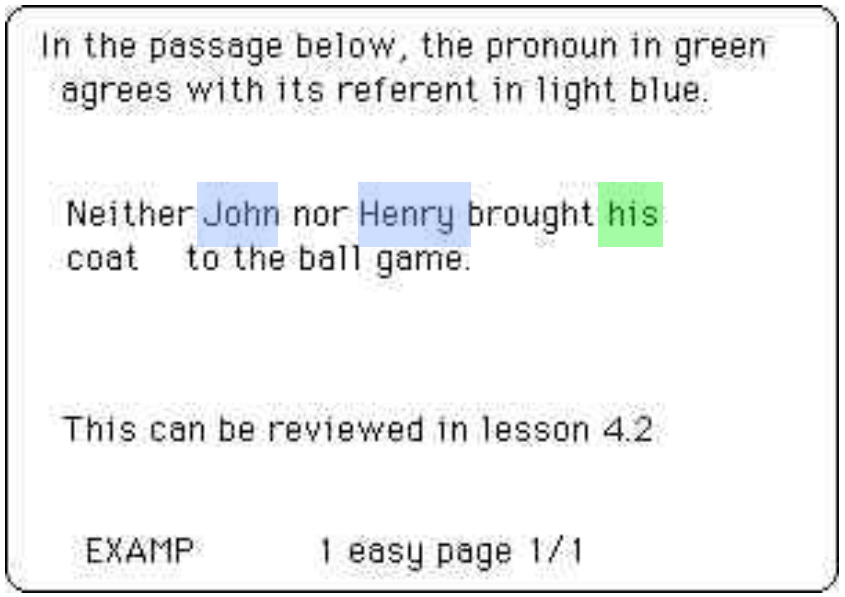
Examples from TICCIT (1)

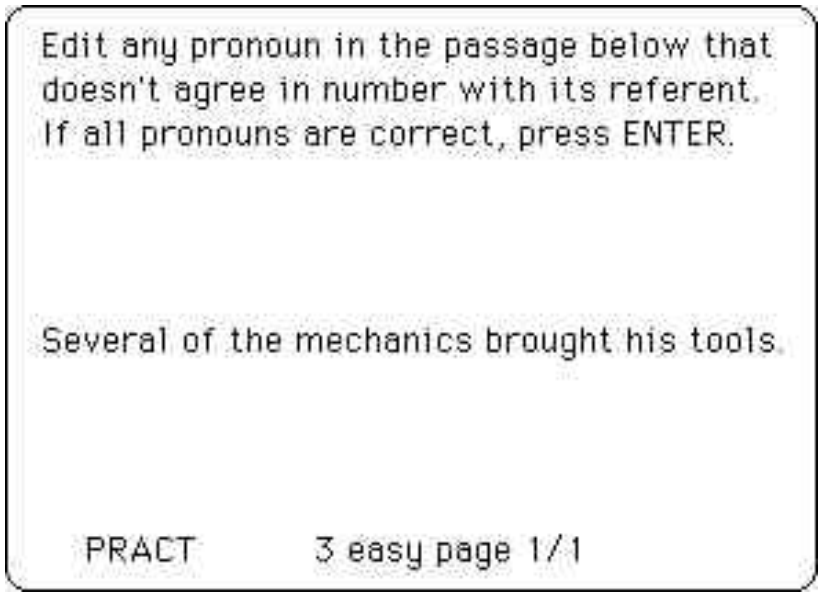


Examples from TICCIT (2)



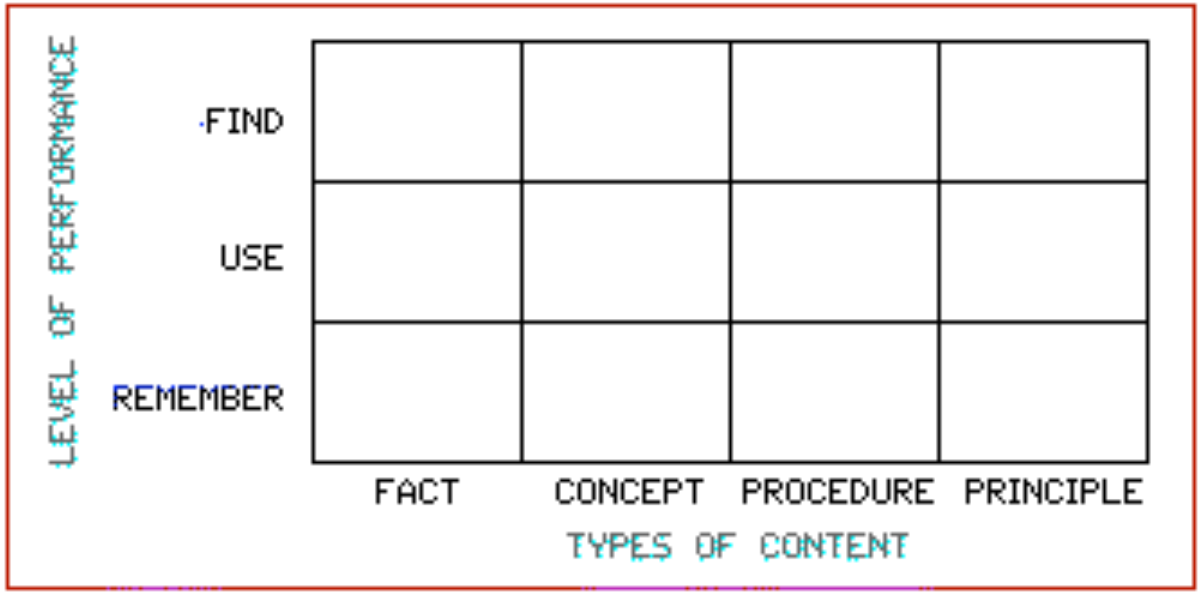
- TICCIT lessons were designed according to Merrill's CDT





Component Display Theory

- M. David Merrill (1983):
  CDT (Component Display Theory)
  - Basic ideas already used in the TICCIT-System!
- Performance/content matrix:
  - Level of learner performance
  - Types of content
- Presentation forms:
  - Rules
  - Examples
  - Repetition
  - Practice
  - …



- Revised and extended theory by M.D. Merrill:
  - Instructional Transaction Theory (ITT)

Non-Computerized CDT Example

There are several important events in the invention of the microscope. You will be required to remember each of these events.
Learning Tip: Use the following cards for drill. Look at the front and say the information on the back. Shuffle the cards and try again. Repeat until you make no mistakes and your answers are immediate.

Front	Back
First magnifying glass What?	Glass globe filled with water
First magnifying glass Who?	Used by engravers
First solid glass lens When?	Late 1200's A.D.
First compound microscope Who?	Zacharias Janssen
First compound microscope When?	About 1590 A.D.

Adaptive Instruction

- Macrolevel adaptation:
  - Selecting a few main components such as instructional goals, depth of curriculum, delivery system
- Aptitude Treatment Interaction (ATI) approach:
  - Adapt learning methods and procedures according to learner characteristics (aptitudes)
  - Cronbach & Snow (1977): Aptitude = individual characteristic of the learner that increases or impairs probability of success
  - How to measure aptitude variables?
    (intelligence, prior knowledge, cognitive styles, motivation)
- Microlevel adaptation:
  - Adapt to learner's needs during instruction session
  - Feedback not only based on answer but on derivation path to answer
  - Example: "Minnesota Adaptive Instructional System" (MAIS)
    - » Stochastic model to compute level of competence after each learner interaction

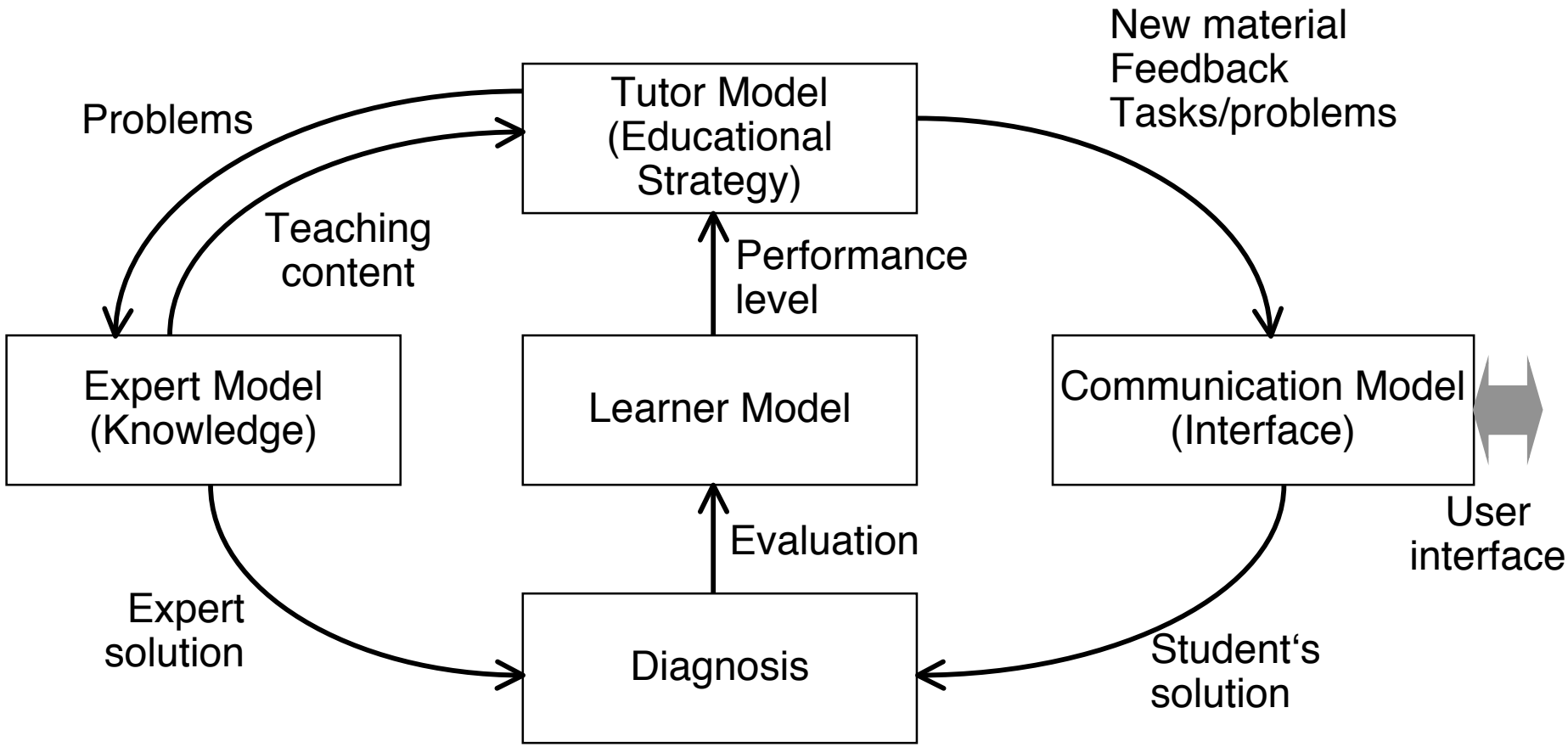
Intelligent Tutoring Systems (ITS)

- Combining Artificial Intelligence (AI) and education methods
  - Ideas from the 1960s, implementation in the 1980s
- Key characteristics:
  - Representation of domain knowledge, modeling of student + adaptation
  - Mixed initiative: Student can ask questions
- Typical interaction techniques:
  - Socratic dialogue: System guides learner by (adaptive) questions
  - Coaching: Assistance function in background until requested
  - Learning by doing: System closely guides learner through activities
  - Learning while doing: System passively observes learner and gives occasional hints
- Knowledge representation:
  - E.g. Semantic network (see SCHOLAR)
  - E.g. Expert system (see GUIDON)

History of Intelligent Tutoring Systems

- SCHOLAR (Carbonell, Collins et al. 1979): Geography
  - Socratic dialogue (asking the learner)
  - Mixed initiative
- SOPHIE (Burton, Brown et al. 1982): Electronic Circuits
  - Computer simulation of faulty hardware, strategies to find errors
- BUGGIE (Suppes 1981): Mathematics
  - Identification of misconceptions using wrong (buggy) problems
- GUIDON (Clancey 1983): Medicine
  - Based on expert system MYCIN
  - Diagnose of diseases by natural language dialog
- MAIS (Tennison, Park 1987)
- Geometry Tutor (Koedinger, Anderson 1993)
- ISIS (Meyer, Miller et al 1999)
  - Ecology, simulation-based

Architecture of an ITS



Learner Models

- Main approaches:
  - Subset model (or overlay model): Which subset of the expert knowledge has been mastered?
  - Difference model: Which are the differences between expert solution and learner solution?
- Functions of learner models
  - Corrective function
  - Elaborative function
  - Strategic function
  - Diagnostic function
  - Predictive function
  - Evaluative function

Example: GeoTutor, 1992

Sample Dialogue:

** Let's talk about Western Canada

Fine. What is the capital of British-Columbia?

** Vancouver.

No, the capital of British-Columbia is Victoria.Where is Victoria situated?

** Let's discuss Banff.

I do not know Banff. Is Banff the name of a place?

** Yes. It is a town.

Where is Banff located?

** In the Rocky Mountains.

Is Banff in British-Columbia or in Alberta?

** In B.C.

What is the population of Banff?

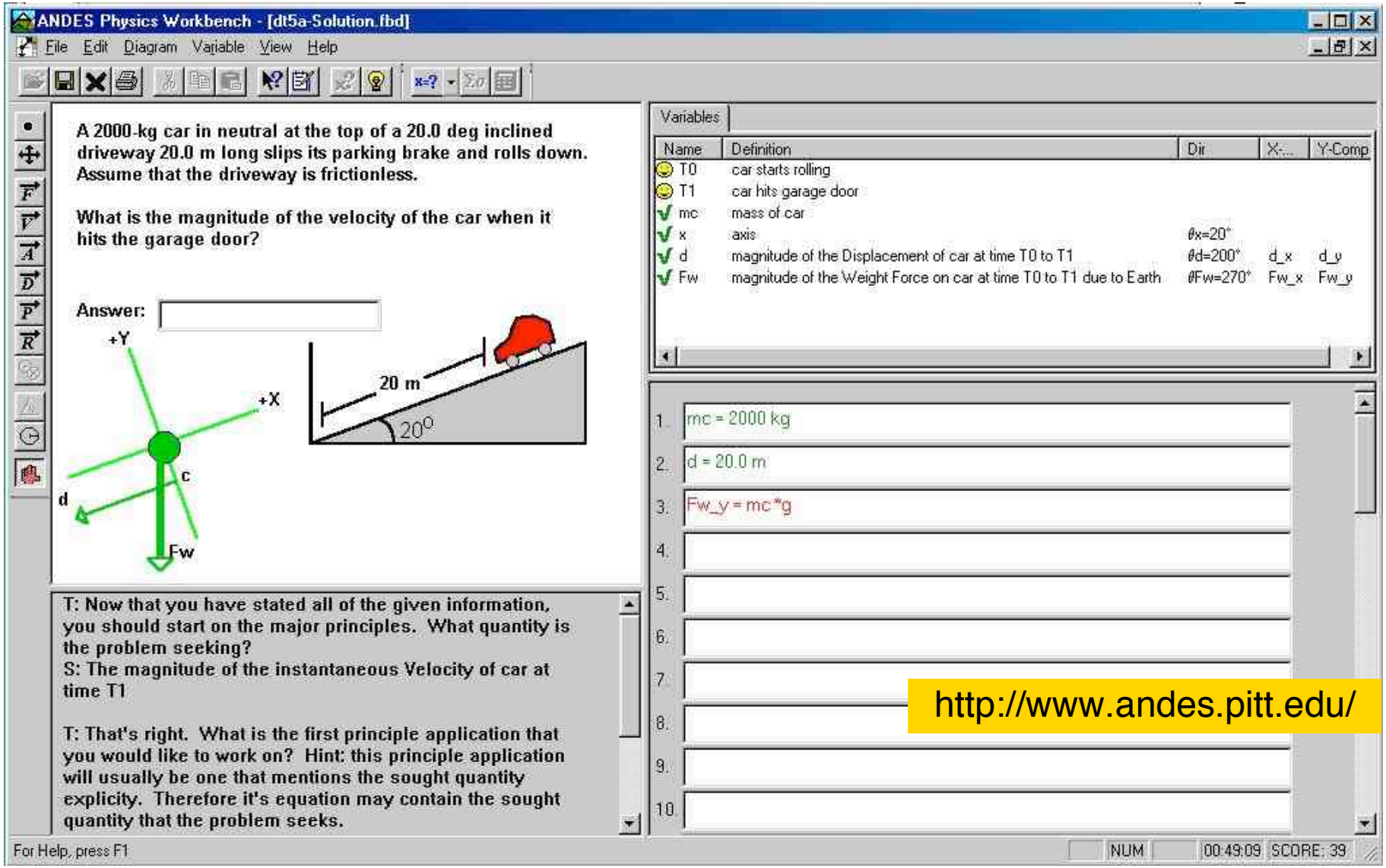
** 5000.

What other towns are near Banff?

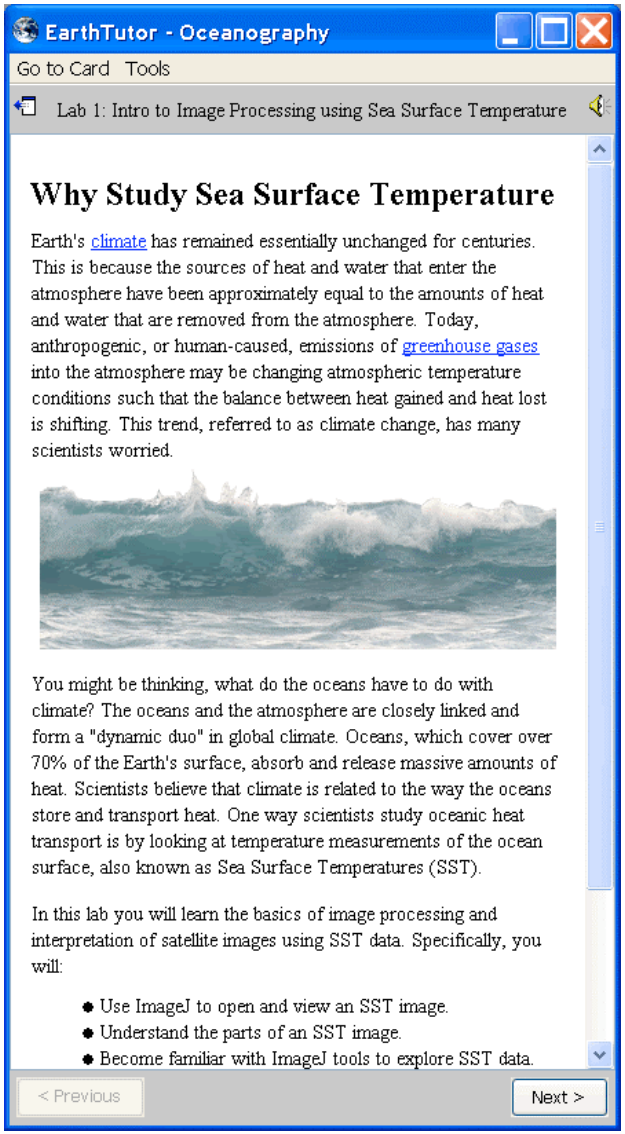
** Tell me about Victoria.

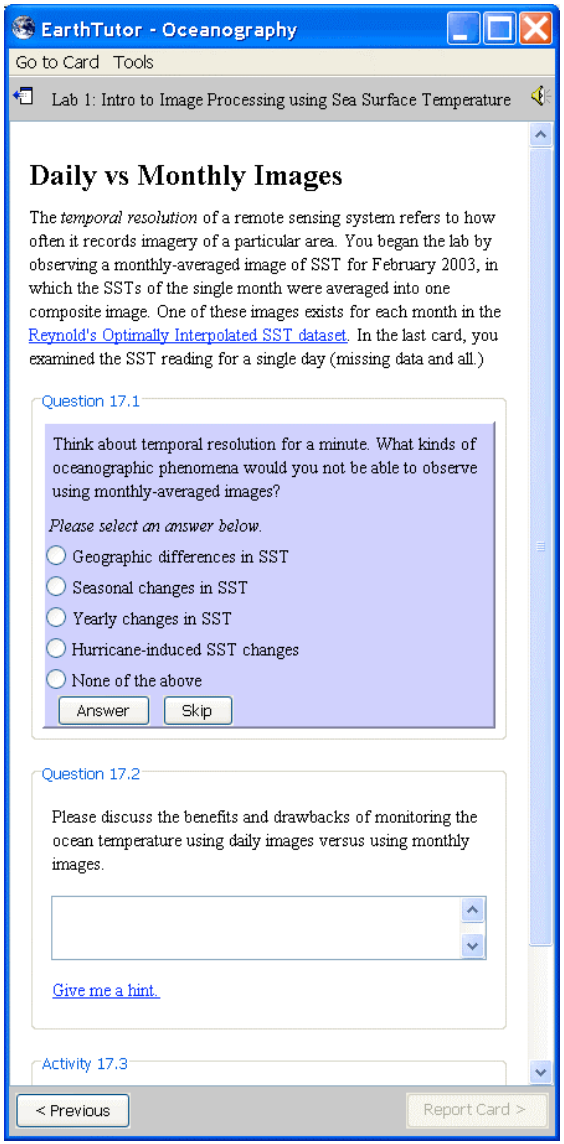
Victoria is situated on Vancouver Island. It is the second largest city in British-Columbia. What else would you like to know?

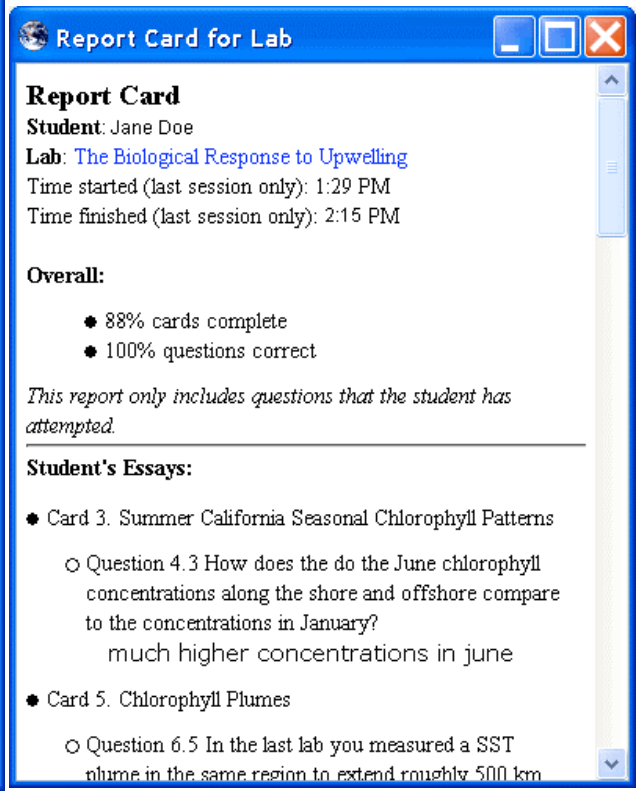
Example: ANDES Physics Workbench, 2001



Example: EarthTutor, 2005 (1)

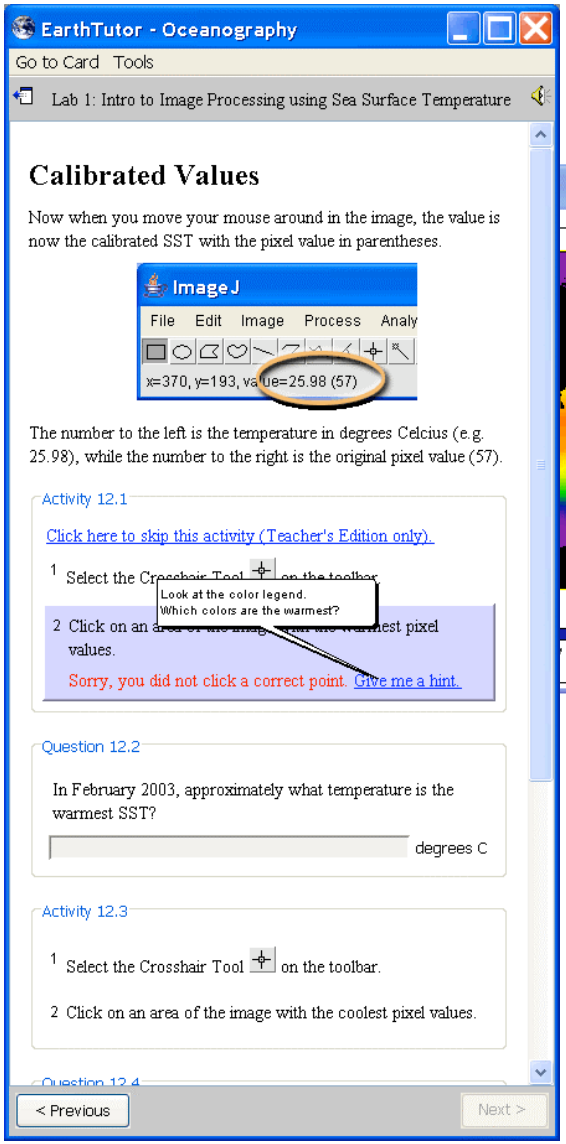


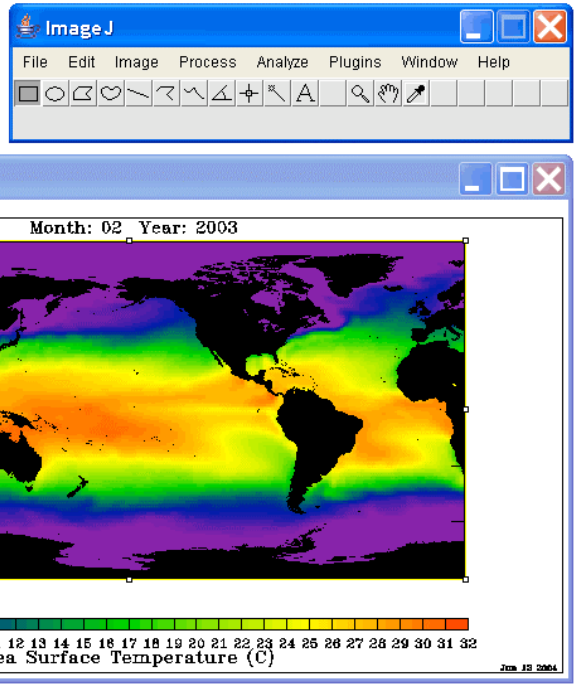


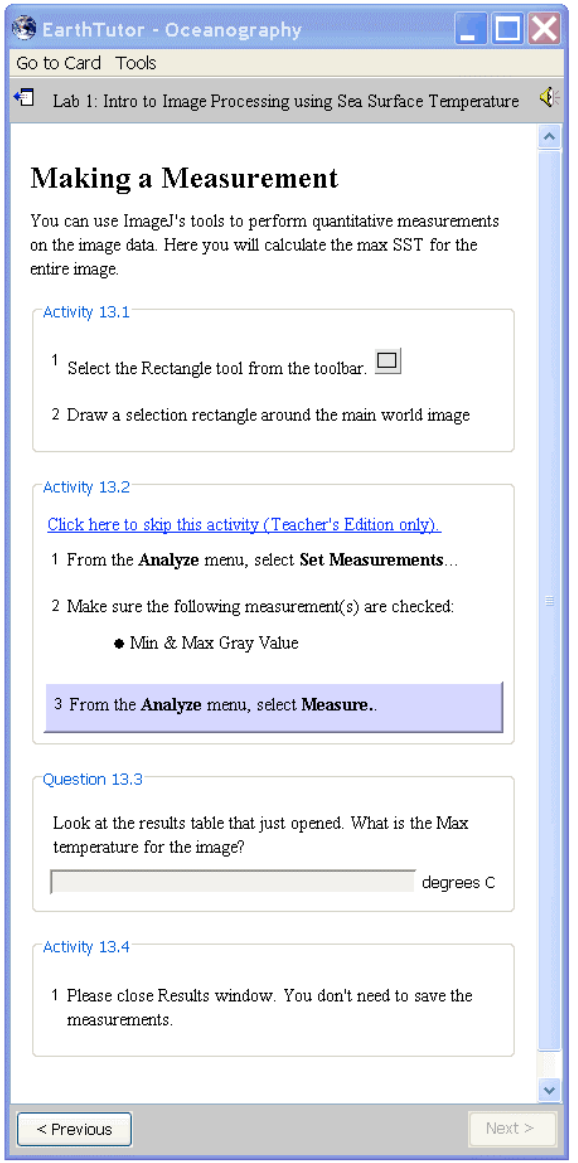


Earth science (remote sensing), in particular usage of image processing software from NASA and NIH

Example: EarthTutor, 2005 (2)







http://www.stottlerhenke.com/earthtutor/

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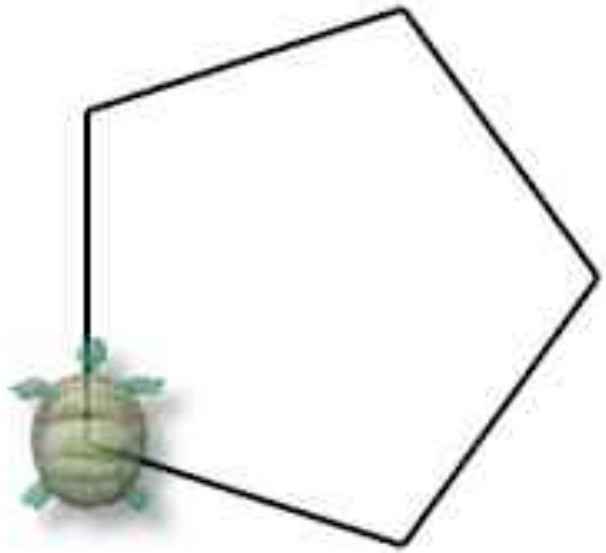
Handbook of Research on Educational Communications and Technology (D.H. Jonassen (ed), 2nd ed. 2004), Chapter 22

(http://aect-members.org/m/research_handbook)

Logo (S. Papert): Physical and Virtual Turtles

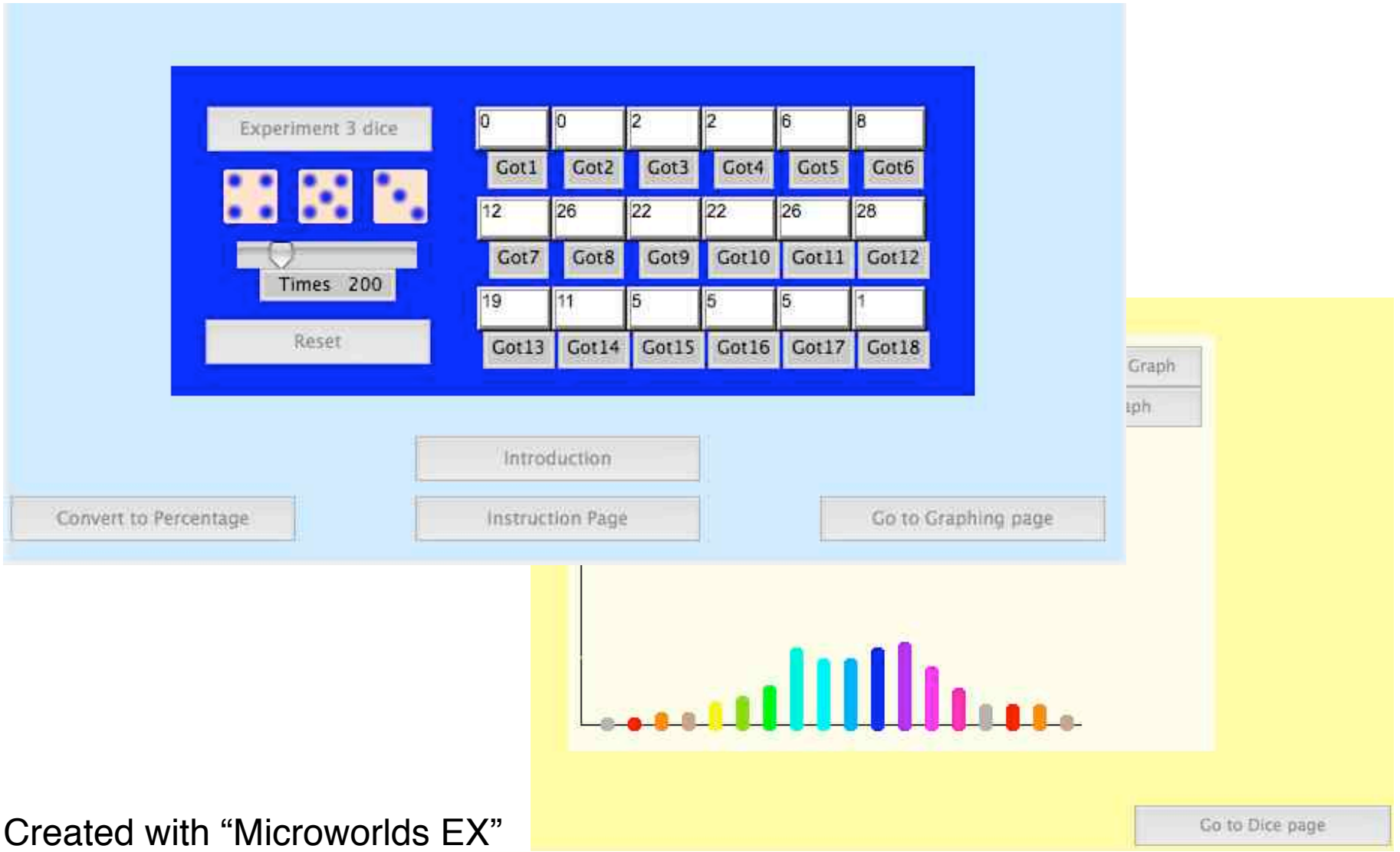


```
to polygon
repeat :sides
       [ forward :size
         right 360/:sides ]
polygon 5 100
```

Microworlds

- “Learning by exploration”
- Microworld consists of:
  - Set of computational objects that model the mathematical or physical properties of the microworld’s domain
  - Links to multiple representations of the underlying properties of the model
  - Ability to combine objects or operations in complex ways
  - Set of activities or challenges
- History:
  - Key idea introduced with “LOGO” (Seymour Papert)
  - ThinkerTools (White 1990): Physics activities realized in Logo
  - Boxer (diSessa 1991): Logo-style programming with direct graphic manipulation (objects as boxes)
  - GenScope (1993), SimCalc (2000): Evaluations

Example: “RollDice”

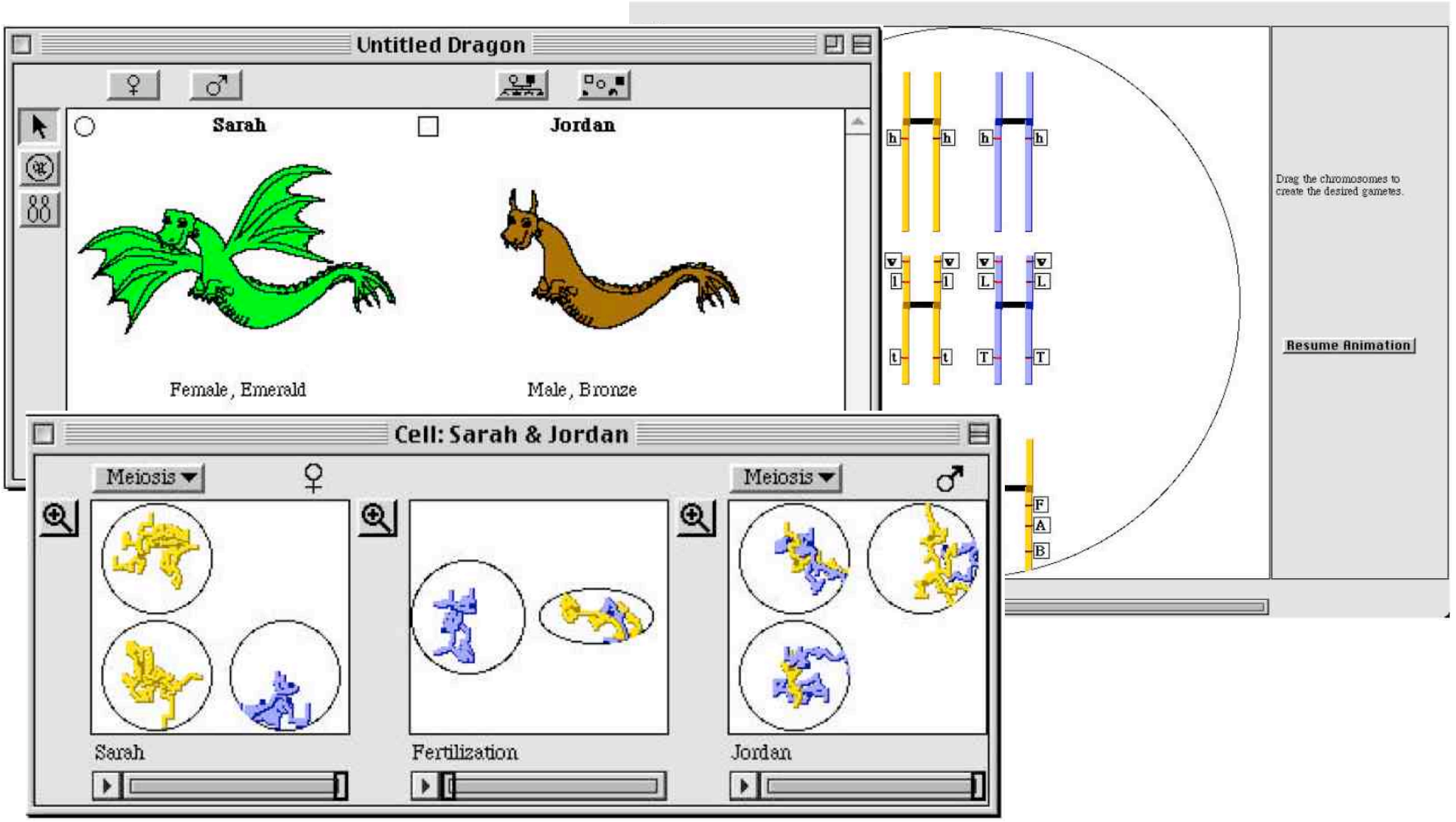


Created with “Microworlds EX”

Example: “Squish”

Created with “Microworlds EX”

Example: GenScope, 1993

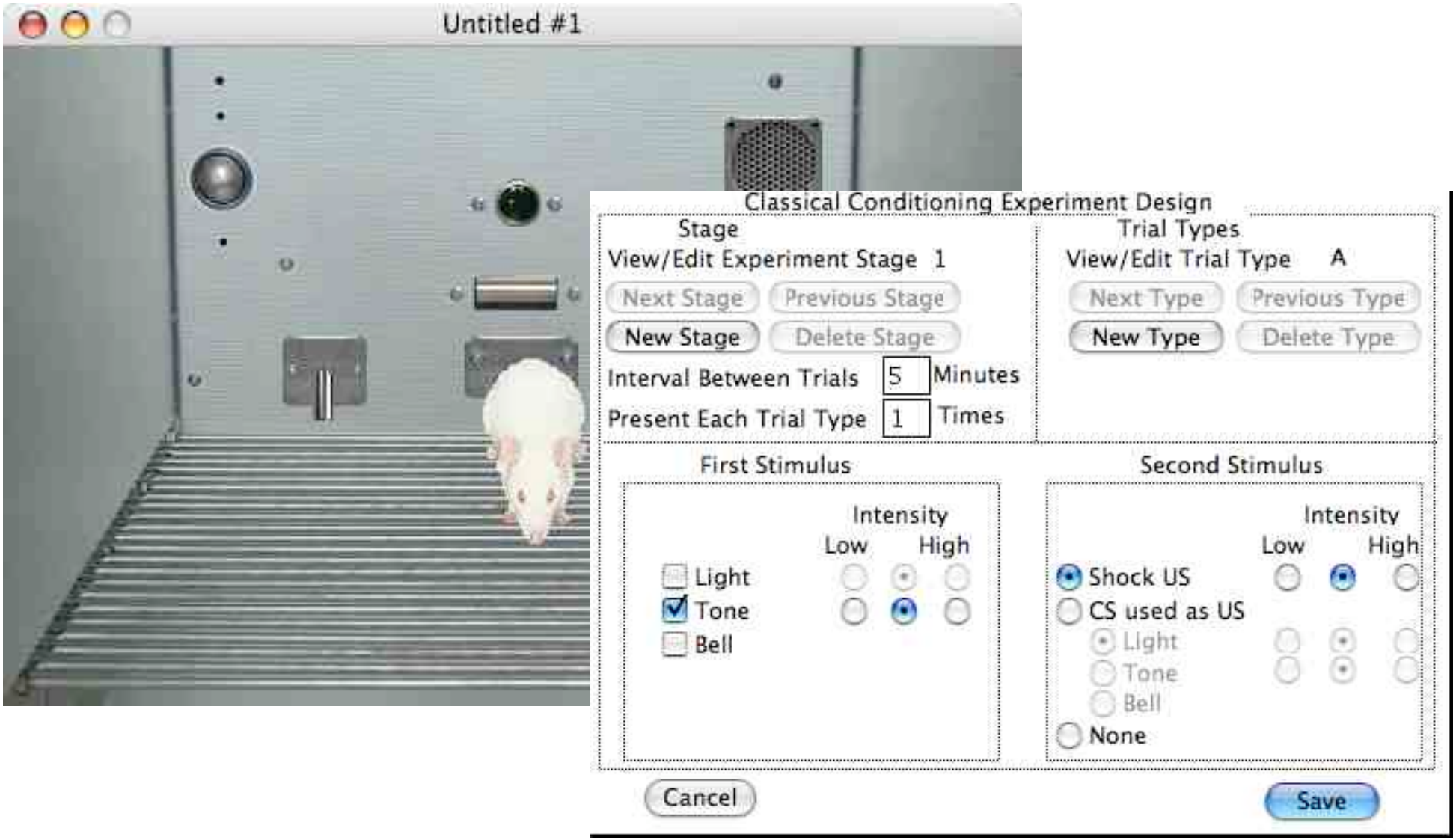


http://genscope.concord.org/

Games and Simulations

- Very popular in the military during Cold War...
- Types of simulations:
  - Experiental simulations (e.g. flight simulator)
  - Symbolic simulations (learner is observer only)
  - Problem solving with simulated materials
  - Virtual environments
- Educational games
  - Challenge the student
  - High motivation
- Little empiric evidence on learning effects

Example: Sniffy the Virtual Rat



Situated Learning

- Embedding learning into real-life problems
  - see e.g. Anchored Instruction
  - Social interaction is important
- Computer-based support for situated learning?
  - James Greeno (1996)
  - Using computer simulations as tools
    - » e.g. constructing a house
  - Actual learning process takes place in the group
    - » Problems are solved jointly

- Literatur:
  Heinz Mandl, Hans Gruber, Alexander Renkl: Situiertes Lernen in multimedialen Lernumgebungen, in: Klimsa 2002, S. 139 – 148

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Handbook ... (D.H. Jonassen (ed), 2nd ed. 2004), Chapter 23

R. Schulmeister: Grundlagen hypermedialer Lernsysteme, Kap. 7

Hypermedia Learning, WBT

- Web-based Training
  - Realizing Computer-Based Training with Web technologies
- History:
  - NoteCards 1985, HyperCard 1987
  - Tim Berners-Lee 1989
- Specifically (Hypermedia learning):
  - Learning environments based on hypertext
- Often associated with “Self-regulated learning”
- Well-known examples:
  - Large hypertext knowledge collections (e.g. Wikipedia)

Problems in Hypermedia Learning

- Reading on screen is unnatural for many readers
- Additional cognitive load on the reader:
  - Making choices about how to proceed
  - Hypertext may *interfere* with text understanding (e.g. Shapiro 1999)
  - Tutoring or “metacognitive training” helpful
    - » Increases transfer abilities
- Well-structured and unstructured hypermedia
  - Good structure essential for beginners
  - Less structure provokes a more explorative approach (Mannes & Kintsch 1987)
- “Lost in hyperspace” (Dede 1988)
- “Keyhole phenomenon” (Woods 1984)