Technology to Individualize Training

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Objectives

• Move away from traditional E-Learning
  – digital classrooms, lectures and publishing

• Engage trainees in learning by doing, inquiry learning

• Expand the technology
  – Model a trainee’s knowledge and reason about his/her affect and disposition.
  – Adapt teaching to cognitive ability
  – Use machine learning, Bayesian for probabilistic reasoning
  – Use multimedia, wireless, hand held computers
Success of Intelligent Tutors in Training

**Improved learning.** 11% improvement; cost effective savings
(Woolf et al., 2000; Dufresne, et al., 2002; Lesgold et al., 1990; Conati & VanLehn, 2004; Rickel & Johnson, 1999).

**Reduced Training.** Reduce by 1/3 to 1/2 time required for learning (Regian, 1997)

**Increased effectiveness.** increase effectiveness by 30% as compared to traditional instruction (Fletcher, 1997; Region, 1997).

Students outperform control group and progress more rapidly through material and (Aleven & Koedinger, 2002; Corbett, et al., 2001).

These outcomes are not particularly surprising; individualized tutoring would be expected to be more effective than lecture-based instruction whether provided by a human or by computer software.
Commandments of Industry Training

1. Don’t waste money.
2. Time is money.
3. Deliver quality product
4. Deliver on time.
5. Deliver within budget.
6. Be effective.
7. Work with the system.
8. Make money. (Return On Investment (ROI))
Industry Training Requirements

• Focus on training:
  – Skills
    • Work with the tools, equipment, and materials.
    • Ability to communicate.
  – Knowledge
    • Theoretical.
    • Of processes and methods.
  – Attributes
    • Self directed / self learner.
    • Responsible.
    • Problem solver.
Just in Time (JIT) Training

• Industry uses JIT - for materials, capabilities, and worker training
  – To keep ahead of competition
  – Pushed by advancing technology
  – Forced by employee mobility

• JIT Training
  – On-demand - both development and delivery
  – Efficient and effective
  – Laser targeted
  – Tailored to learning styles and prior knowledge/experience
Agenda

A. Chip Shooter Tutor
B. Manufacturing Tutors
C. Visualization Tutors
D. Diagnosis Tutor
E. Geometry Tutor
A. Computer Chip Tutor

Cabletron Company

Educational Development Corporation

University of Massachusetts

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Alternative cases are presented to the trainee

1. Log in
   - username: user1
   - password: *******
   - Log Out

2. Select Problem Scenario
   - Scenario-1
   - Scenario-2
   - Scenario-5
   - Scenario-6
   - Scenario-7
   - Scenario-8
   - Scenario-10
   - Select

3. Start Troubleshooting
   - intro: You have successfully produced a batch of boards, but upon visual inspection of a board you see that some of the components on the board are misplaced. You'll need to figure out why the components are not placed correctly.
   - difficulty level: 1
   - status: Not Solved
   - Continue
All procedures and machine states are simulated in the tutor.
The tutor coaches the trainee.
All trainee actions are possible; no sequence of actions are required.
The tutor tracks the trainee’s actions and advises the trainee about optimal steps.
The tutor interrupts the trainee to indicate problems.
Intelligent Tutors Address:

- **Individualized** learning: react to each trainee’s knowledge
- **On-demand delivery**: even at the workstation
- **Flexibility**: Adapt to a wide range of trainee learning skills and educational backgrounds
- Exercise **problem solving** and **decision-making skills** in addition to technical knowledge development
- Support **ISO900X** training records and certification
Intelligence in Tutors

Machine Learning is used to:

• Predict time students will send on problem (Beck et al., 2001)

• Identify probability that students know a topic (VanLehn et al., 99)

• Identify affective features (“I am challenged,” “I want to leave,” “I am not interested.”) (Arroyo et al., 2004).

• Store knowledge about the domain
Coaching used in Tutors

• Coach advises trainee about errors and ideal approaches

• Indicates inconsistent actions

• Indicates that more evidence should be located.
We describe tutors that are:

- **Web-based.**
  - Available anytime/anyplace; easily modifiable and reinforced;
  - Internet on Mars?
- **Intelligent.**
  - They infer a student’s learning level; training is customized;
  - Personnel do not waste their time;
- **Simulation-based.**
  - Animations and multimedia produce effective training;
  - Students are active and engaged.
- **Investigation-based.**
  - Users solve problems; tutor indicates successes and failures;
  - Clinicians diagnose health problems.
- **Collaborative.**
  - Teammates work together.
- **Built by teachers using Authoring Tools.**
B. Manufacturing Tutors

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Injection Molding, Forging and Stamping Video Clips
Animated Version:
Injection Molding, Forging and stamping
Forging is a bulk deformation process in which a part, called a workpiece, is shaped by squeezing (with a mechanical or hydraulic press) or hammering (with a gravity or power-assisted hammer) a hot workpiece between two die halves attached to a press or hammer. For cast or disk-like parts the initial shape of the workpiece is in the form of a billet or blank. For long parts, bar stock is used. The forging equipment shown above is a mechanical press.
Open and Closed Die Forging

**Open Die Forging**
- Upper Die
- Lower Die
- Workplace

**Closed Die Forging**
- Blocker Die
- Conventional Die
- Flash Gutter
- Flashing
Two Station Forging Die

While the preceding depicted the blocker and conventional dies as two separate entities, this is not always the case. Often a forging die is divided into two or more stations with the first station consisting of the blocker portion of the die, while the second station consists of the conventional portion of the die. The flashing is usually removed in a separate trimming die to produce the trimmed part shown above.
Injection Molding Tutor
The Stamping Tutor

Identical - Widely Spaced

Identical - Closely Spaced

Two Distinct Features
From Stamping Workshop

4 Distinct Features

**EXPLANATION OF TOOLING:**
As you can see from the animation, there are five die stations used in the tooling for your design. This is the most expensive tooling you could have created. A separate station is needed for blanking the part from the strip as well as separate stations for the rib, the hole, the extruded hole, and the emboss. Each of these unique features requires its own die station. This is due to the fact that the punch and die for each of the features wear at a different rate and, therefore, must be able to be reground or replaced separately.

Try a design using only one type of feature, to see the difference in tooling as well as cost.
From Stamping Workshop

Identical Features

Design Evaluation:
Number of Stations: 2
Relative die material cost: 1.7100

The cost of your previous design was 2.9800. The new design resulted in a 74.2690% decrease in cost due to the higher number of die stations used in the tooling.

EXPLANATION OF TOOLING:
As you can see from the animation there are only two die stations used in the tooling for your design. The station on the left is needed to blank the final part from the strip. The station on the right is used to create the 4 holes.

I have no design suggestions for you.
Bending Metal

Bending and Side-Action Feature
C. Visualization Tutors

- Identify procedural or conceptual rules of visualization and spatial reasoning from experiments;
- Build tutors that support mental models and scaffolding
Visualization tutors . . .

• …Improve visual skills, e.g., rotation, drawing and unfolding through active manipulation of 3D objects;
• . . .Support trainees as active participants in forming, testing, and modifying their spatial abilities;
• …Incorporate identified learning strategies and remediate student difficulties;
• …Provide new and efficient means of training students in spatial aptitude;
• ...Scaffold instruction: provide a simplified version of the final skill and perform some of the operations;
The Tutor provides two views of an object and asks the student to identify the rotation by clicking (left).
The tutor ...

- Tests user’s prerequisite skills;
- Monitors student performance;
- Adjusts the problem and hints based on user performance.
Track Student’s Spatial Activities

The student clicks features of the inferred rotations, including orthogonal axes, direction clockwise (C) or counterclockwise (CW) and number of degrees (90, 180, or 270).
Graduated Hints

The tutor provides four levels of graduated hints (two shown) including an animated version of the student’s proposed rotation steps (“play” button, top) as well as alternative correct solutions.
Track Student Skills

(Left) The student’s “skill” values stored as “probability known” coefficients for edges, faces, protrusions, notches, axes, degrees and direction.

(Right) The linear approximator returns the resulting probability that a student knows a skill, based on the skill's current probability and “hint level”
Evaluation

• People with lower spatial ability and high spatial used the tutor reached the same mastery criterion;

• A significant difference existed between high and low spatial participants on spatial skills, PSVT, score increase.

• People with lower spatial ability received more practice and feedback and required more problems to reach mastery criterion. Statistically significant

*The practice low spatialss received with the tutor helped their overall scores the same amount as practice helped the high spatialss.
Box Folding Tutor

“Active manipulation of 3D Objects”
Box Folding Tutor

“Scaffold instruction”
Orthogonal Drawing Tutor

Comprehend Block

Study the diagrams of the isometric, top, and front views. Then draw the side view by clicking on a red circle and dragging the mouse over another one. Release the mouse button to finish the line.

You can draw 20 lines but you won't need them all. If you make a mistake, push the clear button. You can also turn on hints to see which lines in one diagram represent the same edge in another view of the object. A dotted line means there is a line on the other side of the face of the object that you're looking at.
Orthogonal Drawing

Verify projection
Orthogonal Drawing

Student forms, tests, and modifies spatial theories"
Orthogonal Drawing

“Students form, test, and modify spatial theories”
D. Diagnosis Tutor

Patient:
Ms. Janet Stone
21 years old

Had you been trying to lose weight before these symptoms started?

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The Diagnosis Tutor

• Trains a student to reason critically, to make a diagnosis.

• Encourages students to:
  – Make observations, ask questions, gather evidence.
  – Justify the need for additional data to support conjectures.
  – Critique a hypothesis and judiciously find support for hypotheses.
Interview Tool

The student interviews the patient through free text, e.g., by typing "fever" into the tool. The patient answers in audio, video and transcript.
Patient Examination Tools

Students measure weight, pulse, blood pressure, etc. By selecting, the user can then examine eyes, ears, neck, etc.
Students receive results of medical tests and records these in a notebook.
Student receives lab results

Lab Results for Patient

- Tests:
  - ACE
  - ALD (Aldolase)
  - ALP (Alkaline Phosphatase)
  - ALT (alanine aminotransferase)
  - Ammonia
  - Amylase
  - Angiotensin
  - Antibody: ELISA
  - Antibody: heterophil
  - Antibody: IgG
  - Antibody: indirect fluorescent titer less than 1:4
  - AST (aspartate transaminase)
  - Biopsies
  - Bleeding Time: Ivy method
  - Blood count: eosinophils
  - Blood count: basophils
  - Blood count: leukocytes
  - Blood count: lymphocytes
  - Blood count: monocytes

- Test Details:
  - ALT (alanine aminotransferase)
  - 10 U/L at 37 deg C
Student receives results of allergy tests

Results of the skin prick test are shown in the accompanying image.
Differential Diagnosis task model

- Hypothesis leads to search for confirming/disconfirming data
- Data lead to more hypotheses
- Ruling out alternatives and deciding when done
Student states propositions about the patient

Student edits each observation, inference, hypothesis and fact. She adds a belief value and provides ‘supports’ or ‘refutes’ links.
Student edits statements in the Inquiry Notebook

Interview responses and clinical data are automatically recorded.
Student changes the level of hypotheses and support

Student edits hypotheses, e.g., “patient has mono,” and formulates arguments for or against each hypothesis.
On-line medical sources are available
Collaboration

• Several students work in collaboration remotely on problems;

• Students develop collaborative skills;
  – Learn principles of effective teamwork and collaboration;
  – Learn good communication skills;
  – Report to local and distant team;

• Students compile reports according to plan, notify team about inconsistencies
Coach

• On-demand help, hints and feedback
  – “You have several hypotheses that have no supporting arguments.”
  – “You have a circular argument associated with hypothesis 3.”
  – “You argue that the strike slip fault supports the choice of Route #2. I suggest you reconsider this argument.”

• Ordered according to priority for Inquiry Notebook and Hypothesis Editor
  – “There is important data for this case that you have not found nor recorded in your notebook. See the picture of the strike slip fault.”
E. Geometry Tutor

WAYANG OUTPOST

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What is the perimeter, in feet, of this figure?

A) 38
B) 41
C) 44
D) 46
E) 48

Polygon perimeter

What is the perimeter, in feet, of this figure?

A) 38
B) 41
C) 44
D) 46
E) 48

Rectangle sides

What is the perimeter, in feet, of this figure?

A) 38
B) 41
C) 44
D) 46
E) 48

Figure re-composition
Hint Selection

• Hints are associated with steps of the solution;

• Each hint is associated with a skill;

• Not all hints will be necessary to see;
  – Because students have trouble with different skills
Two teaching strategies for selected problems

In the figure above, what is the value of $v$?

A 65  
B 45  
C 40  
D 30  
E 25

In the figure above, what is the value of $x$?

A 65  
B 45  
C 40  
D 30  
E 25

How are the rest of the angles related to $x^\circ$?

$x$ is about a third of the green angle.

The green angle is a bit less than 90 degrees.

$x$ is a bit less than $90/3$

$x$ is a bit less than 30

Choose (E) for an answer.
Pre testing Cognitive Abilities

Math Fact Retrieval

Spatial ability
Matching abilities to strategies
Transfer Problems
Solving environmental problems in Borneo

Lori Perkins is the director of conservation technology at Zoo Atlanta in Georgia. She is co-chair of the American

As you can see, their manifest shows that they are only permitted to load 5 logs in their truck but your photo shows 9 logs. They're cutting much more than allowed. Can you create a graph showing the amount illegally harvested each month?

What is the slope of the line that goes through points (1,2) and (3,1).

The slope is the ratio of the change in y over the change in x.

\[ m = \frac{y_2 - y_1}{x_2 - x_1} \]

\[ m = \frac{(2 - 1)}{(3 - 1)} \]

\[ m = \frac{1}{2} \]

Choose (b)
Motivation

• How can we diagnose student attitude and learn about student motivation?
• Remediation should change to be consistent with student attitude, e.g.,
  • If the student doesn’t care about help, suggest the student might like an example, an animation or an explanation.
  • If the student just wants to finish quickly, ask what kind of help she might like.
In Sum

• We have much evidence that intelligent tutors are efficient and effective.

• We have numerous examples of effective training:
  – Chip Shooter Tutor
  – Manufacturing Tutors (Injection molding, Stamping and Forging)
  – Visualization Tutors (Rotation, Folding, Drawing)
  – Diagnosis Tutor
  – Intelligent Simulations
  – Authoring Tools