Challenges & Opportunities: Creating AR/VR content to teach complex problem solving

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The workforce content creation opportunity...

Employers seek:
- Problem solvers
- Critical thinkers
- Troubleshooters
- Particularly in technical maintenance fields...
How complex skills are learned...

Learning science indicates:

- Novices rely on bottom up processing:
  - Look for similarities to simple models
  - Favor color

- Experts rely on top-down processing:
  - Use rules
  - Build on pattern-learning

- Quality problem solving relies on both

Cognition:
Choosing to implement plans

Perception:
Noticing sensory attributes
The challenge in AR/VR content generation...

Basic procedural learning¹
- “Show one, do one”
- Step-by-step

Complex problem solving¹
- Iterative, dynamic application
- Multiple concepts and procedures
- Multiple cases over time

¹Jonassen, 1999
The challenge in AR/VR knowledge extraction...

**Basic procedural learning**
- Can rely on technical manuals
- Routinized knowledge

**Complex problem solving**
- Requires engagement with experts
- Requires methods to deal with “expert blind spot”

\(^2\)Harteis, Koch, & Morgenthaler, 2008
Tools that instructional designers use…

Developers of intelligent instruction\(^3\) create:

- Domain model
- Student model
- Task model

\(^3\)Based on Park & Lee, 2003
Specialized tools needed for to create these models

Requirements

- Anticipates learner needs
- Documents range of problem situations, activities
- Elicits and documents experts’ tacit knowledge

Evidence-centered design approach\(^4\)

\(^4\)Mislevy & Haertel, 2006
Step 10 of 34

Tools:
- Socket wrench 3/8" drive
- Adapter 3/8" female to 1/2" male

(1) Head-up Hands-Free
- Glasses with See-through Display for seeing directions
- Head-phone for giving direction
- Mic for listening to user
- Sensors for observing user

(2) User can talk to AR-Mentor

I want to Adjust TOW Lift upper position switch on an M3A3 Bradley CFV

(3) AR-Mentor Talks back to soldier. And...

Remove the 4 screws highlighted in red from the housing shield (highlighted in green)

Remove shield from the housing (highlighted in green)

Warning: Missile Launcher, in the up position, can fall rapidly and injure personnel. Stay clear of the launcher path when launcher is up. Stand in front of gunner’s sight when manually raising or lowering launcher

(4) . . . AR-Mentor shows you what to do by animation overlays drawn over real objects in your live view

Housing Shield
AR Mentor Models for Troubleshooting Created with ECD

- **Domain Model:** Troubleshooting procedures to be learned
  - Top-down cognition: Decision making based on rules
  - Bottom-up perceptions: “Seeing” electrical problems in vehicle

- **Student Model:** Novices will vary in knowing useful starting strategies
  - Top-down cognition: Split-half heuristic strategy
  - Bottom-up perception: Fluency in using electrical schematics that focus attention on specific parts of the electrical circuit and components
Task Model

- 3 knowledge checks embedded in step-by-step procedure to develop dynamic skill of making decisions during troubleshooting.
Results

Novice mechanics’ overall scores on the 3 knowledge checks were:

- **KC1:** 80% of time they chose to “keep checking” – higher than desired
- **KC2:** Only 44% correct on identifying nonfunctioning circuits
- **KC3:** Only 33% correct on identifying functioning circuits
Implications and Next Steps

Prototype illustrates feasibility of:

- Using ECD to analyze domain and student model and develop task model for AR application to complex troubleshooting

- Using AR embedded quizzes to:
  - Determine whether novices are using expert strategies, both top-down and perceptual
  - Prompting novices when to use those strategies in a complex troubleshooting process
  - Giving novices repeated practice in these expert strategies over the course of a complex task
Implications and Next Steps

Questions for further exploration:

- When is the best point in AR-based learning to “phase in” such embedded AR quizzes for novices (e.g., not too much cognitive load)?
- What pre-requisite knowledge or procedural skill automaticity needs to be in place in the learners?
- Can the model of embedded AR quizzes be used to measure those pre-requisite forms of knowledge and skill?
Current Work, Reference Article, and Contact

- SRI’s Artificial Intelligence Center and SRI Education are using the ECD approach now with a new AR technician technology:
  - We are modeling both basic and expert knowledge of metalworking manufacturing troubleshooting procedures for a major automotive parts manufacturer
  - This will form the foundation of a knowledge management system that will build libraries of intelligent learning content by creating ontologies and using knowledge extraction techniques from machine learning and vision technologies
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