Training systems thinking skills using microworlds: Integration of metrics for intelligent tutoring

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Introduction

- Complex systems of systems involving social, economic, security, and political dimensions can pose dire challenges to decision makers:
  - Numerous (often nonlinearly) interacting factors that must not be neglected;
  - Systems are dynamic: evolve/change with human interventions and independently;
  - Effects of interventions are hard to anticipate and often do not take place immediately after human actions.
- In complex situations, human interventions tend to lead to failure or to new unintended problems (Dörner, 1996).
- Here we present a prototype microworld training aiming to help develop the cognitive skills / attitudes required to deal effectively with complex decision making (CxDM) situations.

Microworld

- Complex Decision Making Experimental Platform (CODEM; Lafond et al., 2011).
- Simulates dynamic decision making problems characterized by key features of complexity.
- Produces detailed logs of user behaviors (information acquisition, decision time, etc.).
- 3 fictitious scenarios including defense, security, economic, social and political factors.
- Gradual increase in complexity across the 3 training scenarios (DuCharme et al., 2011):
  - **Arctic operation.** A transparent system with feedback loops and delay.
  - **Foreign disaster response.** Partially opaque system with uncertainty.
  - **Full spectrum multi-agency operation.** Multiplayer offensive, defensive, stability and civil support operation.

Training method

- Serious gaming approach complemented by:
  1) a targeted instructional tutorial
  2) intelligent online tutoring
  3) performance-based debriefing

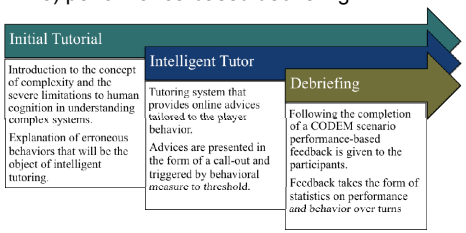

Fig. 1. Three forms of learning support

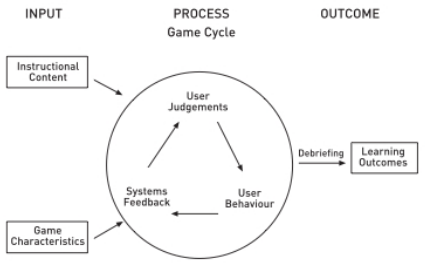

Fig. 2. The microworld-based training process

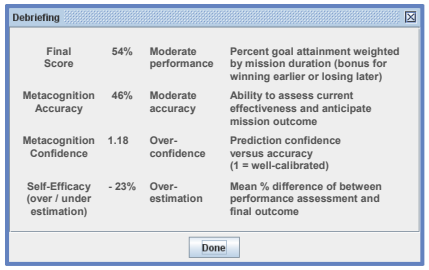

Fig. 3. Example debriefing summary

- **Duration**. 6-8 hours for a training cycle of 3 scenarios (repeatable).

Cognitive metrics

Situation assessment

- Involves gathering relevant information on
  1) the current state of system variables
  2) relationships between variables
  3) the effects of interventions
  4) changes/outcomes as time advances
- These four metrics quantify behaviors on a scale ranging from no information acquisition to complete inspection of the system.
- Online tutor provides corrective feedback to avoid tunnel vision (insufficient info seeking).

System management

- Heuristics (strategies to avoid overloading the cognitive system) can be effective, yet often oversimplify the problem and lead to failure.
- Four non-adaptive heuristics are operationalized herein as behavioral patterns:
  1) *Reactive*. Single-focus repair-shop behavior
  2) *Goal-distance*. Reactive with spread focus
  3) *Static*. Unchanging resource allocations
  4) *Flat*. Equally distributed resource allocation
- Online tutor provides corrective feedback to detract use of overly simple heuristics.

Metacognition

- Defined as "thinking about thinking" to adapt or improve one's cognitive strategies. One of the key abilities characteristic of good CxDM.
- Requires an awareness of one's own thought processes and the ability to evaluate their effectiveness by judging one's own progress.
- Probe questions are integrated to scenarios. Each turn player must predict his final score.
- Feedback provided during debriefing: meta-cognition accuracy, confidence, and self-efficacy (see Fig. 3).

Discussion

- Research in CxDM has shown that even highly educated and motivated people often fail to properly understand complex problems and tend to make poor decisions that can lead to disastrous consequences.
- Training using system dynamic simulations has been found to improve performance, yet performance tends to reach a plateau well below potential (Yasarcan, 2009).
- An integration of approaches (e.g., classroom education, serious gaming, intelligent tutoring, feedback to improve metacognition) seems necessary to better prepare decision makers.
- Tools enabling *what-if* reasoning and visual analytics are also needed to augment CxDM (e.g., Vester, 2007; Lizotte et al., 2008).
- Thresholds for corrective feedback specific to each metric will be calibrated using data from a microworld experiment.
- Effectiveness of this prototype training will be tested experimentally by comparing results in a test scenario to those from a control group.

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This research was supported by a Department of Defence postdoctoral fellowship to D. Lafond and a contract to Thales Canada from Defence R&D Canada. Contact: michel.ducharme@drdc-rddc.gc.ca