Learner Models in the Generalized Intelligent Framework for Tutoring: Current Work and Future Directions

Gregory A. Goodwin,
U.S. Army Research Laboratory
GIFTSym 5, Orlando, FL
May 10, 2017

Research Vectors

Real Time Dynamic Processes

Individual Learner & Team Modeling

- Learner & Team Data Acquisition
- Learner & Unit State Classification
  - Cognitive
  - Affective
  - Physical
- Shared States
  - Social, Trust

Instructional Management Principles

- Real-time Adaptation
- Applied Learning Theory
- Modeling Behaviors of Expert Human Tutors

Domain Modeling

- Training domains matched to operational dimensions
  - Definition
  - Complexity
  - Alignment
- Training in the wild

Offline Processes

Authoring Tools & Methods

- Standards & Content Reuse
- Automated Authoring Methods
  - Expert Modeling
  - Game-Tutor Middleware
- Authoring Job Aids
- Interface Specifications

Evaluation Tools & Methods

- Training Effectiveness
  - Performance
  - Learning
  - Retention
  - Time to Competency
  - Transfer
- Data Analytics

Architectural/Ontological Support

Generalized Intelligent Framework for Tutoring

- Existing training systems & games
- Existing training content
- New adaptive tools & methods

Adaptive Instructional Systems

- Improved Performance
- Improved Knowledge & Skill Acquisition
- Longer Retention & Less Refresher Training
- Shorter Time to Competency
- Improved Transfer to Operational Environments

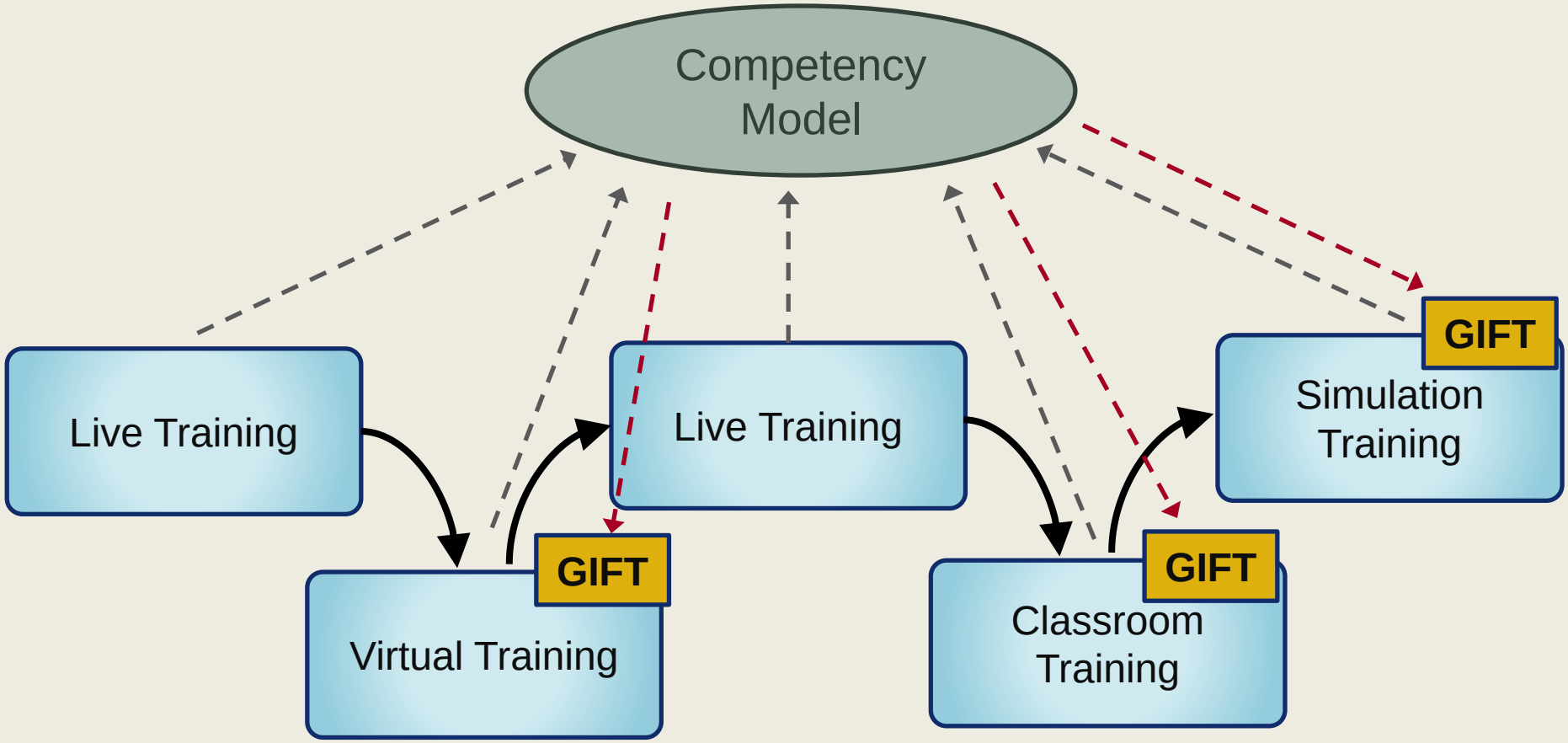
A Framework for Learner Modeling

	Learner Measure Category	Trait-Like (Outer Loop Adaptation)	State-Like (Inner Loop Adaptation)
Content Dependent	Cognitive	Relevant prior cognitive experience/knowledge/training	Comprehension of concepts presented in the training
	Psychomotor	Relevant prior psyhomotor	Measures of Skill improvement
	Affective	Fears, likes, goals, attitudes, training	Arousal and emotions in response to the training
Content Independent	Cognitive	Meta-cognitive skills	Attention, Cognitive Workload
	Psychomotor	Physical strength, stamina, sensory acuity	Endurance and fatigue
	Affective	Personality Traits, general test anxiety	Arousal, emotions resulting from factors independent of training

Competencies

Long-Term Learner Model

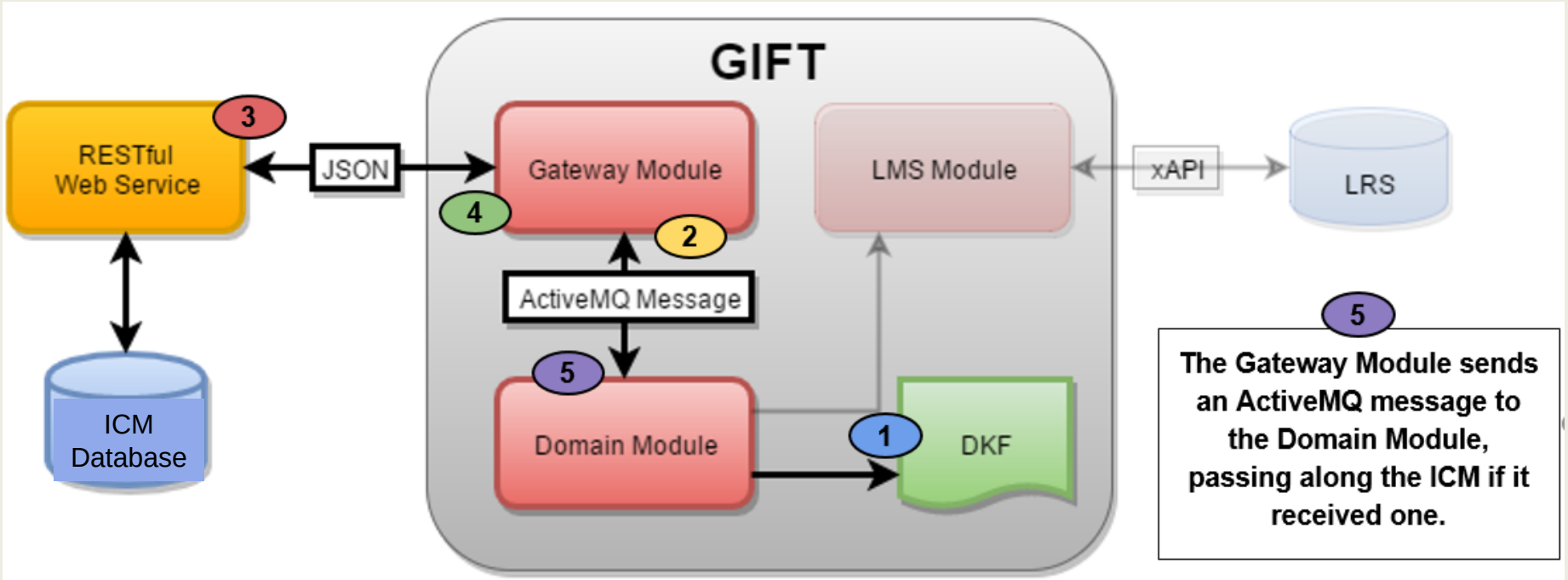
Competency Modeling



Interoperable Competency Models

- Marksmanship Use Case
- Development of an Interoperable Competency Model that lives outside of GIFT.
- Competencies must be updated at run-time (forgetting, new experiences & training, etc.)
- Approach involves a competency model which defines or maps learner activities to competencies along with a database of all learner activities.
- Database employs the xAPI format developed by the DoD Advanced Distributed Learning Lab.

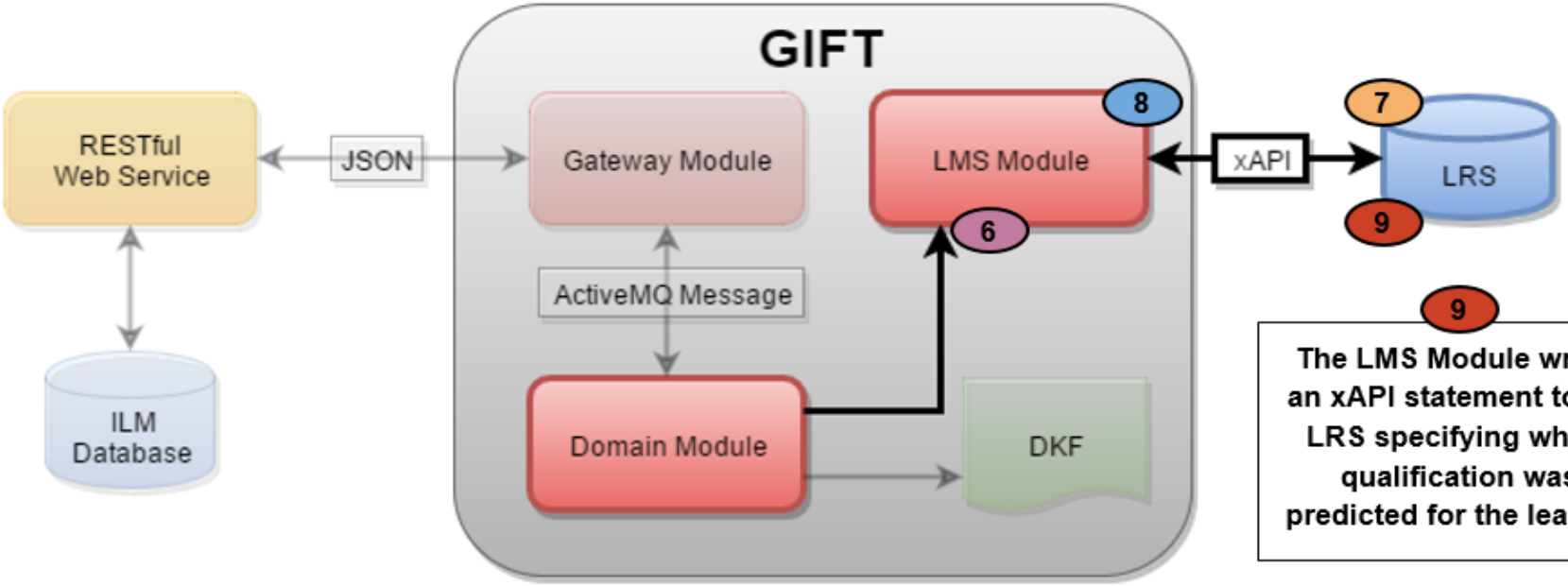
Interoperable Competency Model



5 — The Gateway Module sends an ActiveMQ message to the Domain Module, passing along the ICM if it received one.

1	2	3	4
When the user selects a course, the course concepts are read from the DKF into the Domain Module.	The Domain Module sends an ActiveMQ message to the Gateway Module, passing along the course concepts.	The Gateway Module sends an HTTP GET request to the ICM server, passing along the course concepts as a query parameter.	The ICM server searches and retrieves ICMs relating to the course concepts and returns them in JSON format.

Interoperable Competency Model (cont)

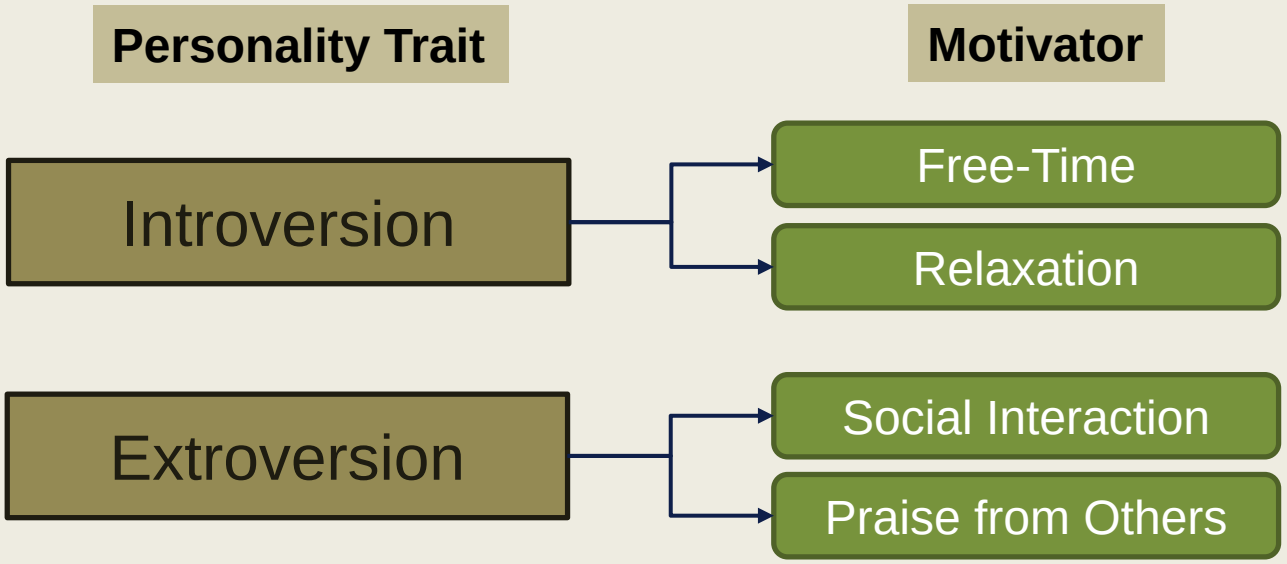


A Framework for Learner Modeling

	Learner Measure Category	Trait-Like (Outer Loop Adaptation)	State-Like (Inner Loop Adaptation)
Content Dependent	Cognitive	Relevant prior cognitive experience/knowledge/training	Comprehension of concepts presented in the training
	Psychomotor	Relevant prior psyhomotor experience or training,	Measures of Skill improvement
	Affective	Fears, likes, goals, attitudes relevant to the training.	Arousal and emotions in response to the training
Content Independent	Cognitive	Intellect/Aptitude, Memory, Meta-cognitive skills	Attention, Cognitive Workload
	Psychomotor	Physical strength, stamina, sensory acuity	Endurance and fatigue
	Affective	Personality, state general test anxiety	Arousal, emotions resulting from factors independent of training

Personality, Motivation, & Affect

Matching Motivators to Personality Traits



Phase 1 Develop motivation taxonomy and assessor

Phase 2 Experimental Validation of taxonomy and assessor

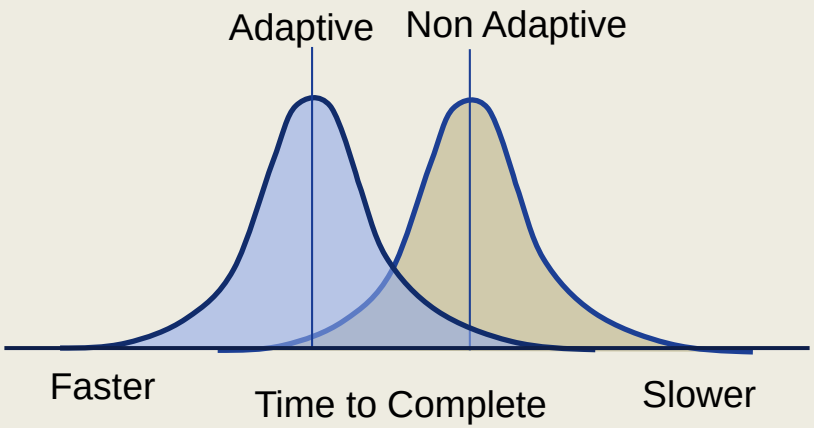
Phase 3 Extend model to other domains, populations, and scenarios

A Framework for Learner Modeling

	Learner Measure Category	Trait-Like (Outer Loop Adaptation)	State-Like (Inner Loop Adaptation)
Content Dependent	Cognitive	Relevant prior cognitive experience/knowledge/training	Comprehension of concepts presented in the training
	Psychomotor	Relevant prior psyhomotor experience or training,	Measure of skill improvement
	Affective	Fears, likes, goals, attitudes relevant to the training.	Arousal and emotions in response to the training
Content Independent	Cognitive	Intellect/Aptitude, Memory, Meta-cognitive skills	Attention, Cognitive Workload
	Psychomotor	Physical strength, stamina, sensory acuity	Endurance and fatigue
	Affective	Personality Traits, general test anxiety	Arousal, emotions resulting from factors independent of training

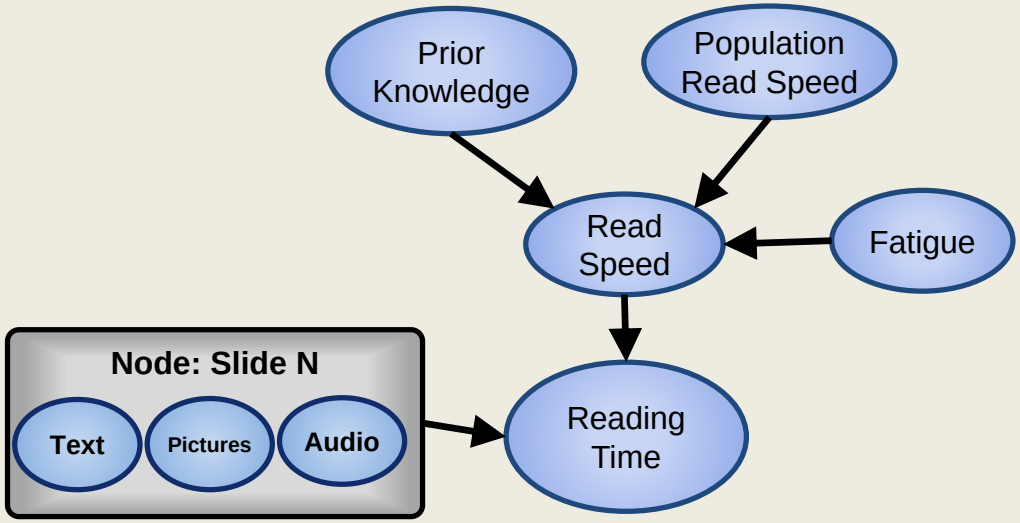
Acquisition Rate

Predicting Training Time in GIFT



One advantage of adaptive training is greater training efficiency (reduced time to train to criterion)

- Employ a probabilistic model to predict training time for learners that accounts for characteristics of learners, content, and training strategy.
- Implications for ROI, Authoring, and Run-time Evaluation



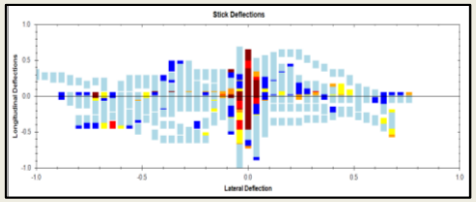
A Framework for Learner Modeling

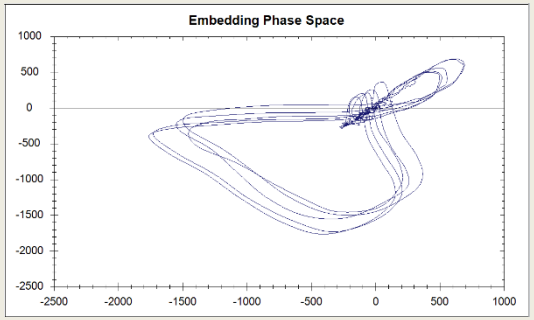
	Learner Measure Category	Trait-Like (Outer Loop Adaptation)	State-Like (Inner Loop Adaptation)
Content Dependent	Cognitive	Relevant prior cognitive experience/knowledge/training	Comprehension of concepts presented in the training
	Psychomotor	Relevant prior psyhomotor experience or training,	Measures of Skill improvement
	Affective	Fears, likes, goals, attitudes relevant to the training.	Arousal and emotions in response to the training
Content Independent	Cognitive	Intellect/Aptitude, Memory, Meta-cognitive skills	Attention, Cognitive Workload
	Psychomotor	Physical strength, stamina, sensory acuity	Endurance and fatigue
	Affective	Personality Traits, general test anxiety	Arousal, emotions resulting from factors independent of training

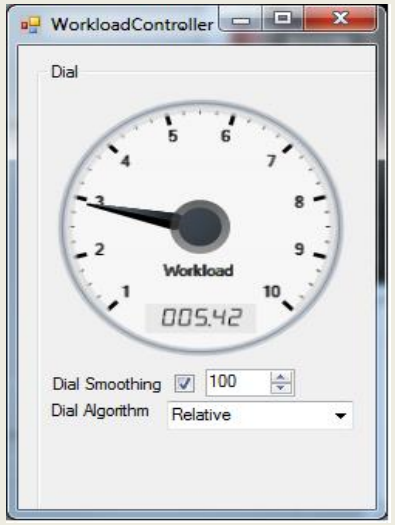
Cognitive Workload

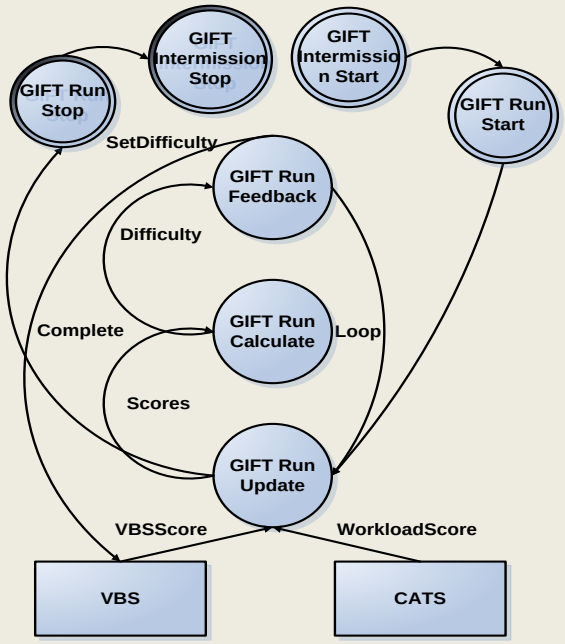
Assessment of Trainee State: Cognitive Workload

Cognitive Assessment Toolkit: Uses behavioral and physiological measures to assess cognitive workload









(b) Run State

- **Unobtrusive Physiological and Adaptive Training (UPCAT)**
  - Combination of GIFT, VBS3 and CATS
  - Advances training according to trainee performance and workload

Conclusions and Future Directions

- Research on Learner Modeling is progressing in all quadrants of our framework.
- Learner modeling is a complex task and much remains to be done
- Future challenge areas include:
  - Integration with future learning architecture (e.g., the Total Learning Architecture)
  - Continued research on lightweight sensors for unobtrusive measurement of learner states.
  - Research into how to best adapt training to maximize efficiency and effectiveness