ARMY RESEARCH LABORATORY

Adaptive Tutoring for Self-Regulated Learning: A Tutorial on Tutoring Systems

by Robert A Sottilare and Anne M Sinatra

ARL-SR-0305 December 2014

NOTICES

Disclaimers

Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5425

ARL-SR-0305 **December 2014**

Adaptive Tutoring for Self-Regulated Learning: A Tutorial on Tutoring Systems

Robert A Sottilare and Anne M Sinatra
Human Research and Engineering Directorate, ARL

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**			
1. REPORT DATE *(DD-MM-YYYY)* December 2014	**2. REPORT TYPE** Final		**3. DATES COVERED (From - To)** January 2014–August 2014
4. TITLE AND SUBTITLE Adaptive Tutoring for Self-Regulated Learning: A Tutorial on Tutoring Systems			**5a. CONTRACT NUMBER**
			5b. GRANT NUMBER
			5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Robert A Sottilare and Anne M Sinatra			**5d. PROJECT NUMBER**
			5e. TASK NUMBER
			5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Research Laboratory ATTN: RDRL-HRT-T Aberdeen Proving Ground, MD 21005-5425			**8. PERFORMING ORGANIZATION REPORT NUMBER** ARL-SR-0305
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			**10. SPONSOR/MONITOR'S ACRONYM(S)**
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			
13. SUPPLEMENTARY NOTES			
14. ABSTRACT The tutorial described in this report was conducted at the Human-Computer Interaction International Augmented Cognition Conference in Creta Maris, Crete, Greece, in June 2014. The purpose of this tutorial was 3-fold: 1) familiarize participants with the fundamental principles of adaptive Intelligent Tutoring System (ITS) design; 2) illustrate how ITS design influences/enables self-regulated learning; and 3) discuss the need for standards for authoring of ITS, modeling of learners and experts, automated instructional strategies, and methods of analysis for ITS technologies.			
15. SUBJECT TERMS adaptive tutoring, intelligent tutoring systems, self-regulated learning, authoring adaptive systems, adaptive instruction, educational technology			

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Robert A Sottilare
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** (*Include area code*)
Unclassified	Unclassified	Unclassified	UU	80	407-208-3007

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Contents

1. **Tutorial Objectives** **1**

2. **Fundamentals of Tutoring** **1**

3. **Generalized Intelligent Framework for Tutoring** **6**

4. **Learner Modeling** **26**

5. **Instructional Management** **42**

6. **Domain Modeling** **48**

7. **Authoring** **50**

8. **Analysis of Effect** **63**

Bibliography **67**

Distribution List **72**

INTENTIONALLY LEFT BLANK.

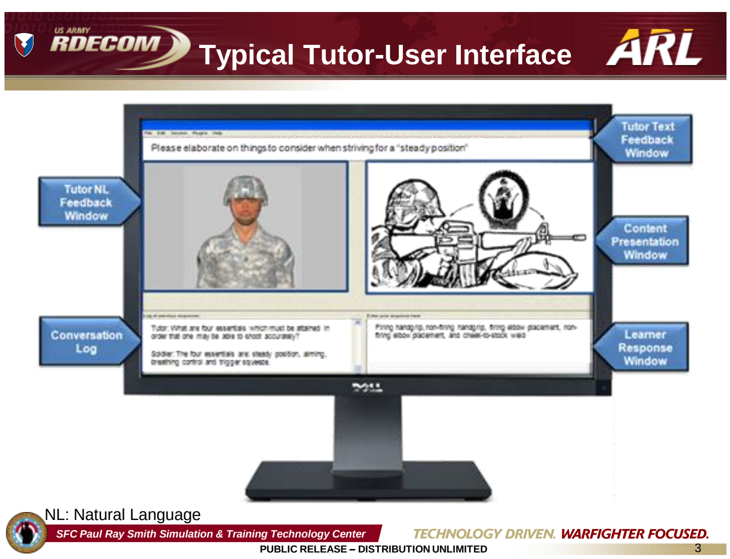
1. Tutorial Objectives

The purpose of this tutorial is 3-fold:

- Familiarize participants with the fundamental principles of adaptive Intelligent Tutoring System (ITS) design.
- Illustrate how ITS design influences/enables self-regulated learning (SRL).
- Discuss the need for standards for authoring of ITS, modeling of learners and experts, automated instructional strategies, and methods of analysis for ITS technologies.

2. Fundamentals of Tutoring

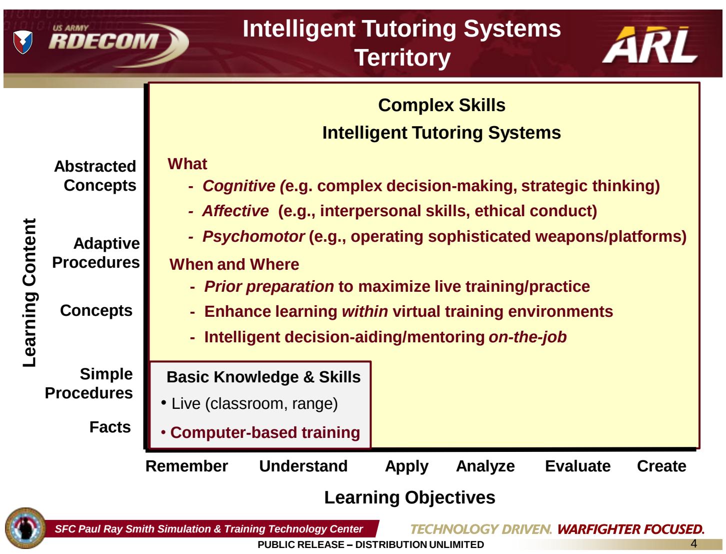
This section reviews the fundamentals of ITSs. Slide 3 illustrates a typical tutor-user interface used by the ITS to deliver content and feedback to the learner, and receive learner input. This interface may include a tutor natural language feedback window, which is used by the ITS to provide verbal feedback or direction through a virtual human. It usually provides a text feedback window, a content presentation window, and a learner response window where the learner provides text input in response to ITS directions, questions, or feedback. A running log of the conversation or chat window may also be part of the tutor-user interface.



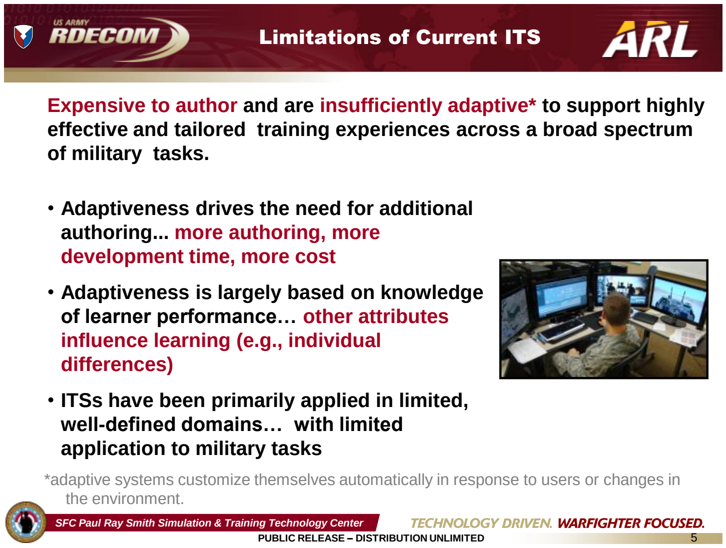
Slide 4 illustrates the "sweet spot" for ITSs, the area where they may be most useful. This is within tutoring for complex skills versus simpler tasks. To support SRL, tutors adapt their delivery and the challenge level of scenarios to match those of the learner. If there is no adaptive change to match the learner's needs, then this is simple computer-based training where the training is the same for everyone and not adaptive tutoring.

What is SRL? SRL is learning (acquisition of knowledge or skills) that is guided by metacognition (thinking about one's thinking), strategic action (planning, monitoring, and evaluating personal progress against a standard), and motivation to learn. It takes great awareness and discipline to guide your own learning. Expert human tutors are much more effective and efficient at guiding learning. Just as expert human tutors guide learners, adaptive ITSs may also augment SRL by shaping instructional content and scaffolding support to meet the learner's needs. The computer-based ITSs must be situationally aware of the learner's state and the instructional context to be effective guides and support efficient instruction.

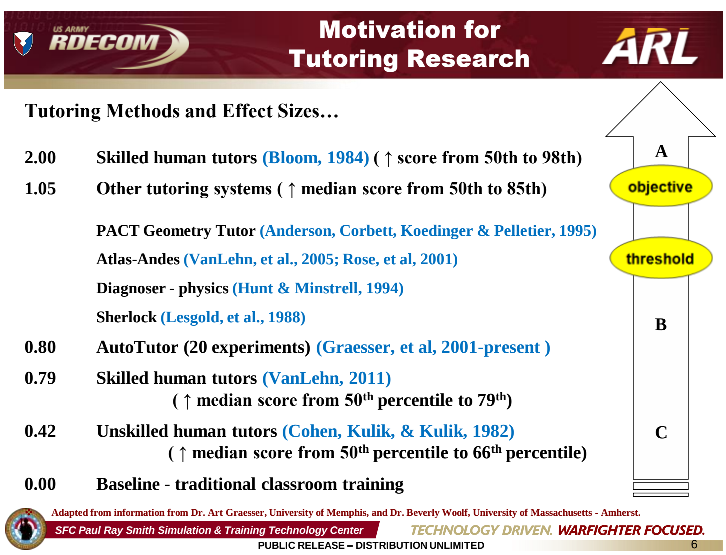
As noted in Slide 4, complex skills may include cognitive tasks where challenging decision-making and strategic thinking are exercised or affective tasks where interpersonal skills and ethical conduct are tested or psychomotor skills where coordination and timing are critical to physical tasks (e.g., land navigation) or operating sophisticated systems. ITSs may be used to prepare for live training, enhance learning in conjunction with virtual training environments, or act as job or decision aids during actual operations.



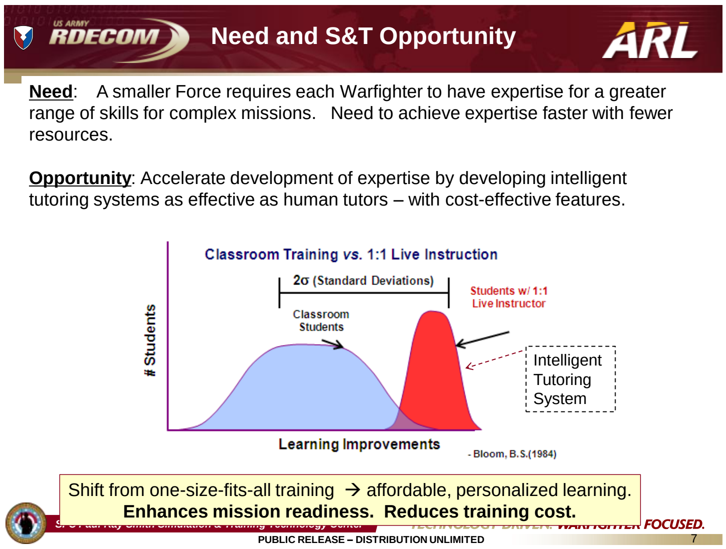
The primary reasons that tutors are limited in their use in education and training (see Slide 5) are 1) they have insufficient ability to adapt to learner needs and 2) they are expensive to author. It takes approximately 200 h of interdisciplinary team labor to make 1 h of coursework for tutoring. More adaptive equals more expensive.



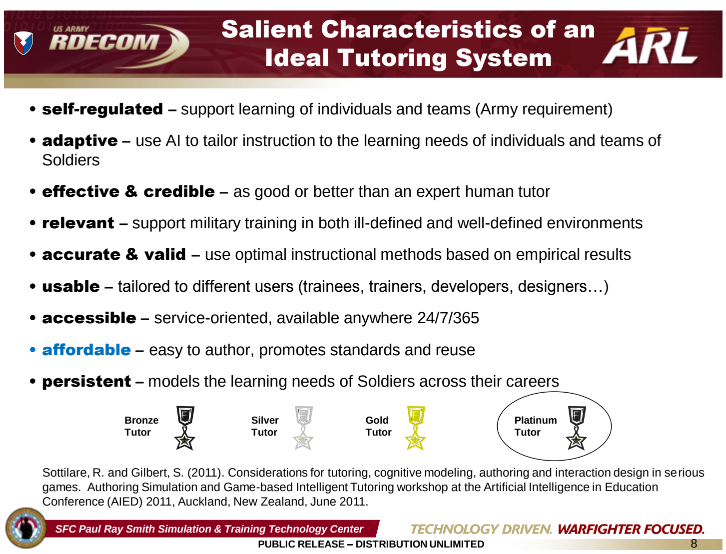
Significant evidence exists that computer-based intelligent tutoring systems are just as effective as human tutors under certain conditions and generally within more well-defined domains (e.g., mathematics, physics) where there is generally one correct answer to a problem. The goal is for ITSs to be as effective as expert human tutors under all conditions and domains. The effect sizes shown in Slide 6 are baselined against traditional classroom training. The ultimate goal for ITSs is to impact learning with effect sizes equivalent to raising average ("C") students to experts ("A" students) through tailored instruction and reinforcement of deep learning principles. In other words, the goal is to be as effective as or more effective than expert human tutors.



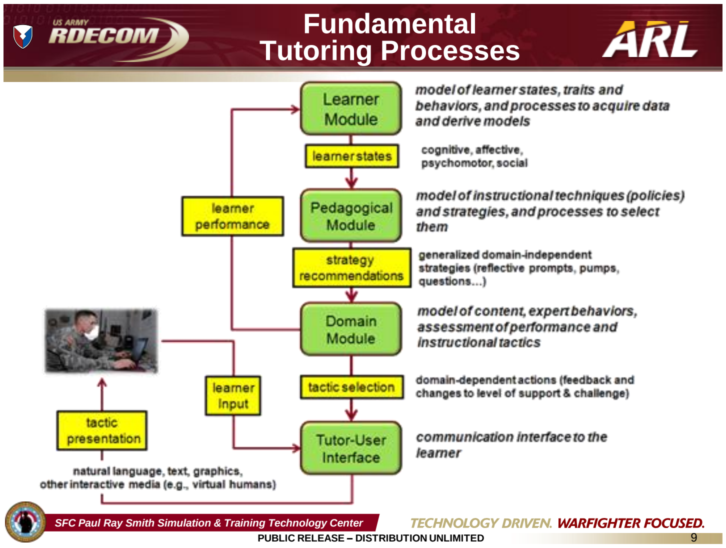
Many organizations are feeling the crunch to achieve more with less. While training and education remain important to maintaining organizational competency, it may not be practical or feasible to achieve and maintain competency in a traditional classroom. One-to-one training (Bloom 1984) has been shown (Slide 7) to be more effective than classroom training, but it is not practical to have one-to-one tutoring for every person in a large organization.



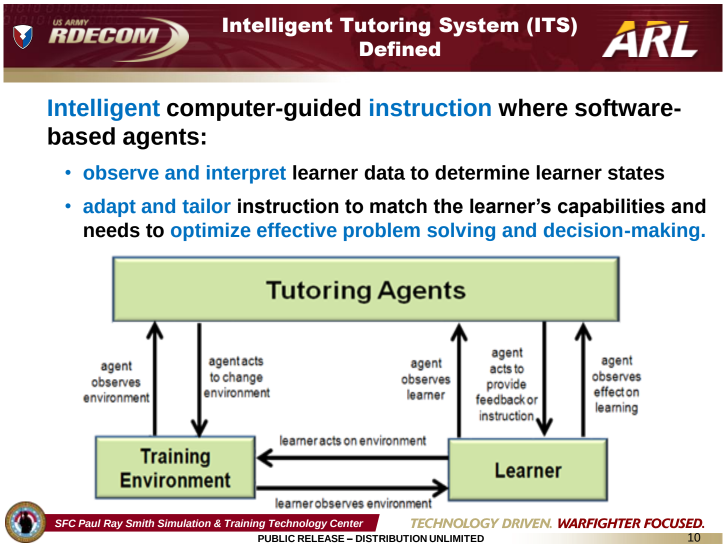
So, if we wanted an ideal tutoring system that could adapt to our needs, what would it look like? Slide 8 shows a set of salient characteristics for a platinum-level tutor as described by Sottilare and Gilbert (2011).



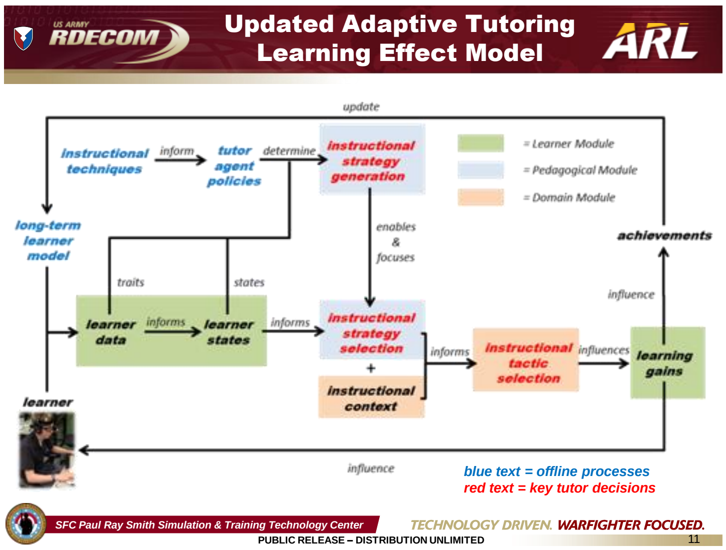
Before we continue in our discussion of tutoring systems, we should examine their fundamental elements and processes (Slide 9). Nearly every tutoring system has 4 fundamental elements: a learner model, a pedagogical (instructional) model, a domain model, and a communication model. The green boxes in the slide below show these fundamental elements as *modules* versus models because they manage processes in addition to modeling the learner, the instruction, the domain, and the communication.



ITSs use the processes in Slide 9 to assess the learner and manage instruction. ITSs are defined as intelligent software-based agents that guide instruction by observing and interpreting learner data (behaviors, physiology, demographics) to classify learner states (e.g., engagement, competency, emotions). The ITS uses these states to adapt/tailor instructions to match the learner's capabilities and needs to optimize learning. Slide 10 shows the interaction between tutoring agents, the learner, and the training environment (e.g., simulation, game, presentation).



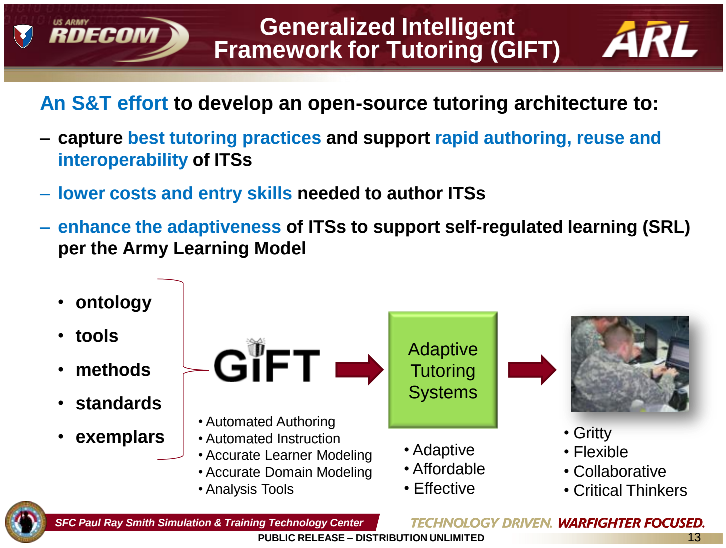
Finally, the adaptive tutoring learning effect model shown in Slide 11 illustrates the interactive loops of the tutoring process. Learner module data/processes are shown in green boxes. Pedagogical module data/process are shown in light blue boxes and domain module processes in light orange.



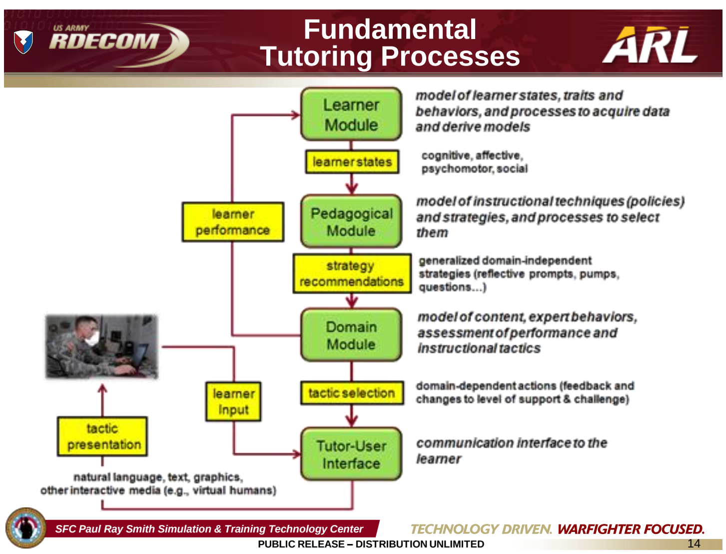
---

3. Generalized Intelligent Framework for Tutoring

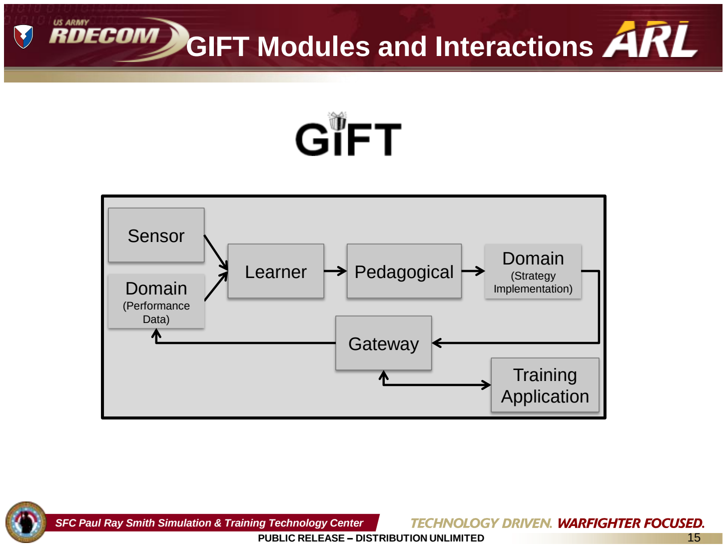
Traditionally, ITSs are expensive and time consuming to develop. Additionally, they tend to be linked to specific content and are not easily changed. Reuse in tutoring systems is virtually nonexistent. The Generalized Intelligent Framework for Tutoring (GIFT) is an open-source, domain-independent intelligent tutoring framework (Slide 13). It is intended to provide flexibility and the ability to create full tutors with content of the author's choice. By being domain-independent, it allows for the reuse of materials and a reduction in both the time and monetary costs of developing tutoring systems.



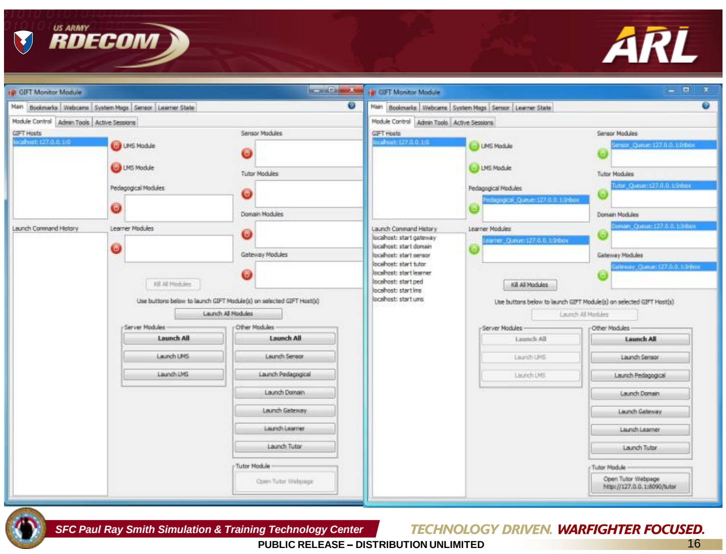
The fundamental tutoring processes within GIFT are consistent with the previously described components of the tutoring process, which are reviewed in Slide 14.



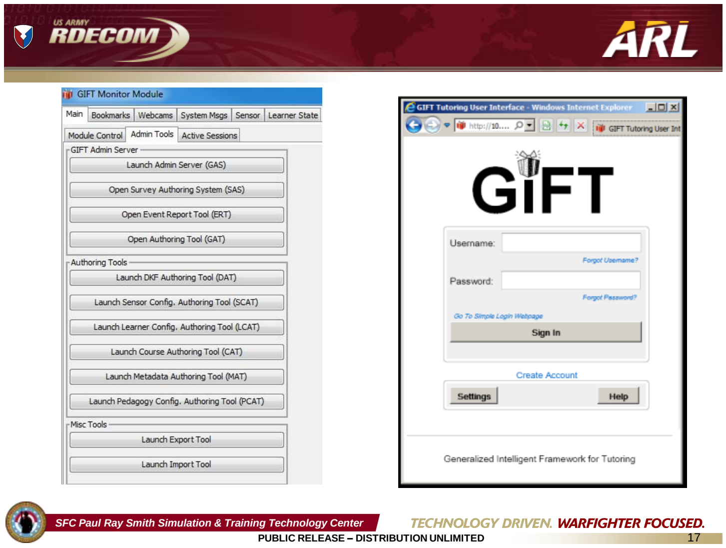
As with most ITSs, GIFT has 4 primary modular components: Domain Module, Learner Module, Pedagogical Module, and Gateway Module. Additionally, this diagram represents the process that occurs with user input to GIFT when the user is interacting with a training application. Additional information about these modules and their processes is provided further along in the "GIFT Tutors GIFT" portion of this tutorial. In addition to the 4 primary modules, GIFT also provides a sensor module that is used to capture behavioral and physiological data about the learner which can then be used to interpret/classify that data into learner states for use by the learner module and the pedagogical module as described in the "Adaptive Tutoring Learning Effect Chain". The interaction of the modules is illustrated in Slide 15.



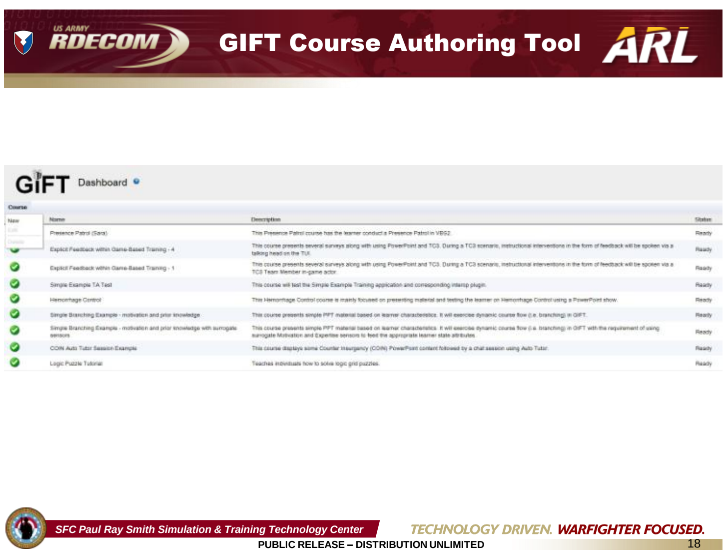
The modules in GIFT can be launched manually through the Module Monitor shown in Slide 16. The image on the left is the Module Monitor before the modules have been launched. The image on the right is the Module Monitor after the modules have been successfully launched. In GIFT 3.0 and above, it is also possible to launch the modules in one step, which includes the launching of the tutor web page.



Slide 17 provides a visual of the Admin Tools in the Module Monitor (left) and the GIFT login screen on the tutor web page (right). There is also a simple login page that can be used for experiments and does not require a password.

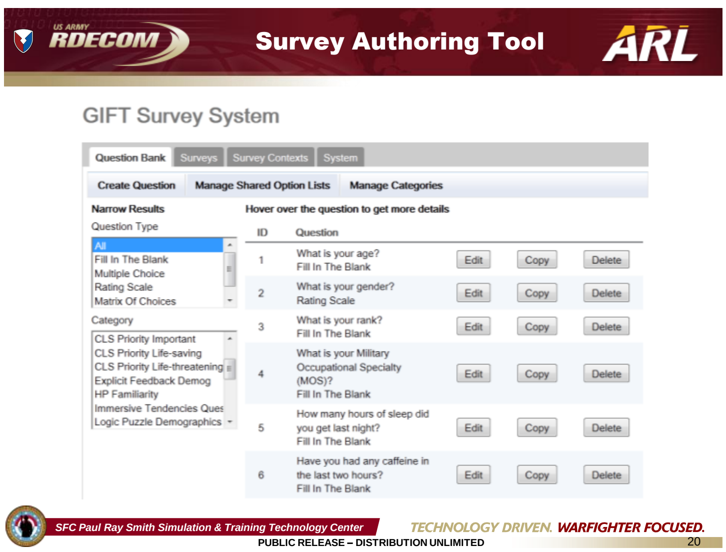


Within the Admin Tools Tab is a series of authoring tools. The GAT (GIFT Authoring Tool) is a new element of GIFT 2014-1-X, as is shown in Slide 18. It provides a user-friendly way for authors to create their courses in GIFT. The course selection dashboard is pictured in the current slide. Each line represents a current course within GIFT, and the green checkmark indicates that it is complete and validated. Courses can be opened by highlighting the name and then clicking "Edit".

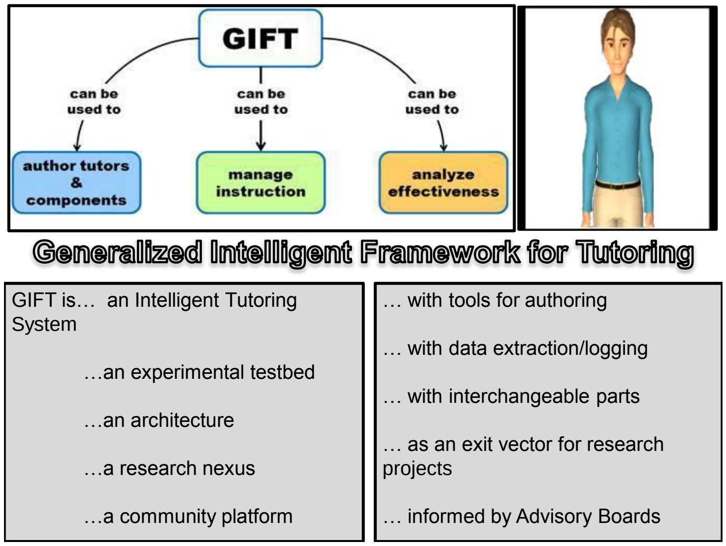


The functionality of the new GAT is demonstrated in Slide 19. The transitions and elements of the course are presented on the left side of the screen. Once one of transitions is selected, the associated fields to enter content into are displayed on the right side of the screen. Additional transitions can be added using the menu on the top left of the page.

Surveys are authored in GIFT through the Survey Authoring System. It provides the ability to create questions and surveys. Additionally, it can be programmed such that the surveys are automatically graded.



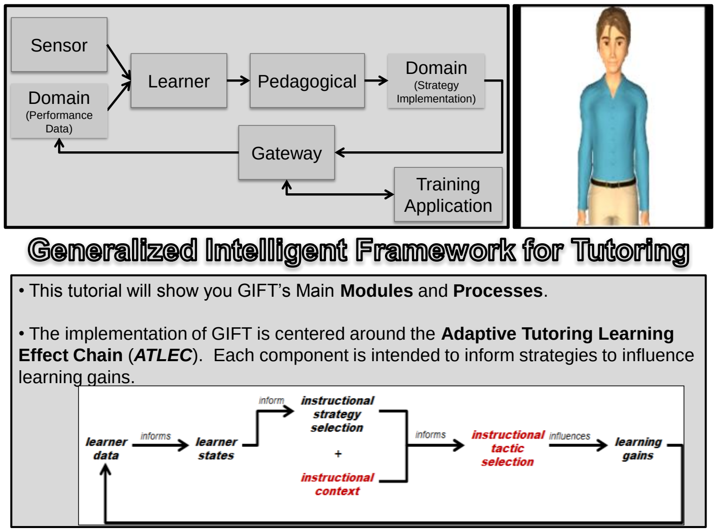
The next set of slides (pp. 11–15) provides an animated sequence that explains GIFT in simple terms. GIFT has 3 distinct functions. First, it is an authoring capability to develop new ITS components and whole tutoring systems. Second, it's an instructional manager that integrates selected tutoring principles and strategies for use in ITSs. Third, it's an experimental test bed to analyze the effectiveness and impact of computer-based tutoring systems components, tools, and methods. GIFT is intended to be a community platform for you to contribute to and to help you with your research and development.



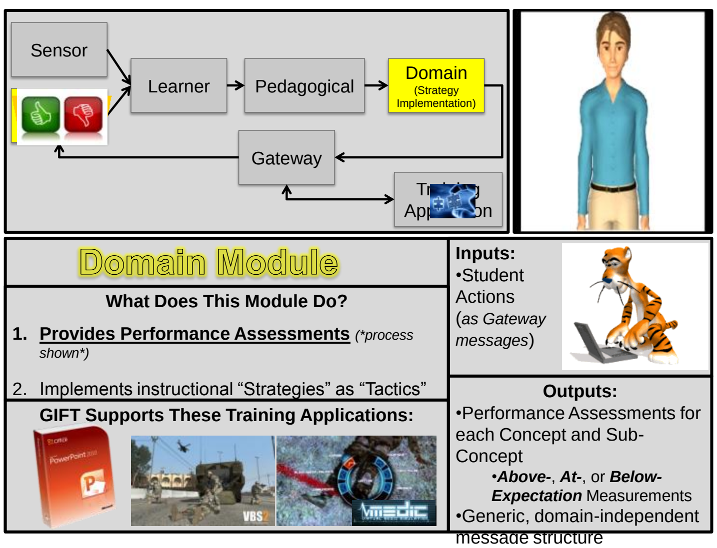
GIFT is based on a learner-centric approach and is therefore designed to be consistent with the Adaptive Tutoring Learning Effect Chain. In this chain, the learner data informs learner states, which then informs instructional strategy. Selection of the appropriate strategy at the correct time is expected to lead to learning gains.

Each of these processes is captured in individual modules of GIFT. For this tutorial, we will go though the functions, inputs, and outputs of each GIFT module. Let's talk about the first one, the Domain Module. Although the Domain Module is one module in reality, it is divided into 2 modules for you to better understand each of its 2 functions: performance assessment and strategy implementation.

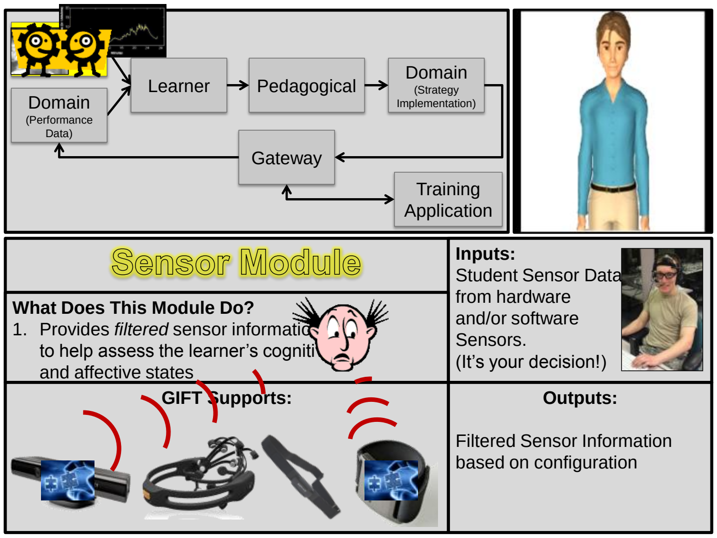
The learning effect chain starts by monitoring learner performance and sensor data. Learner performance is assessed from data captured in a training application, which is fed into GIFT's Domain Module via the Gateway Module. GIFT processes learner interaction data by comparing the Domain Module inputs against designated models of expert performance. In order to keep GIFT generic to all training applications, domains are represented as a hierarchical structure of "Concepts".



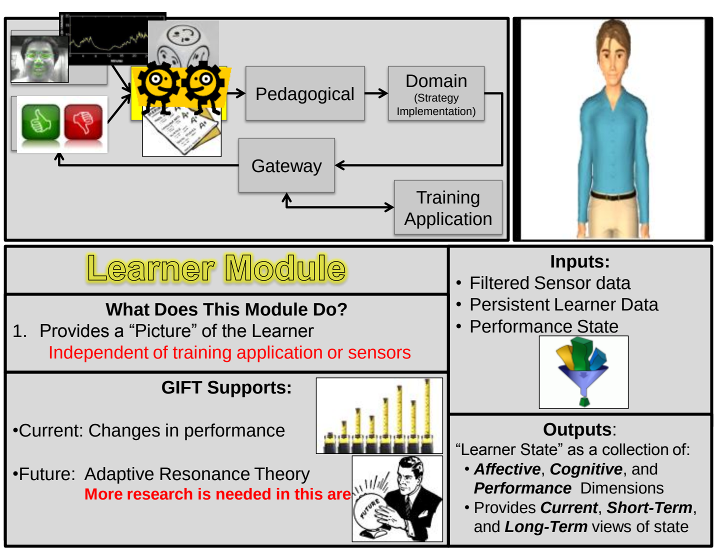
For all identified Concepts and Subconcepts, a learner can perform "at standard", "above standard", or "below standard", as determined by comparsion of performance to the expert model. Outputs from the Domain Module are fed into the Learner Module and contain performance states associated with specific concepts represented in the domain representation.



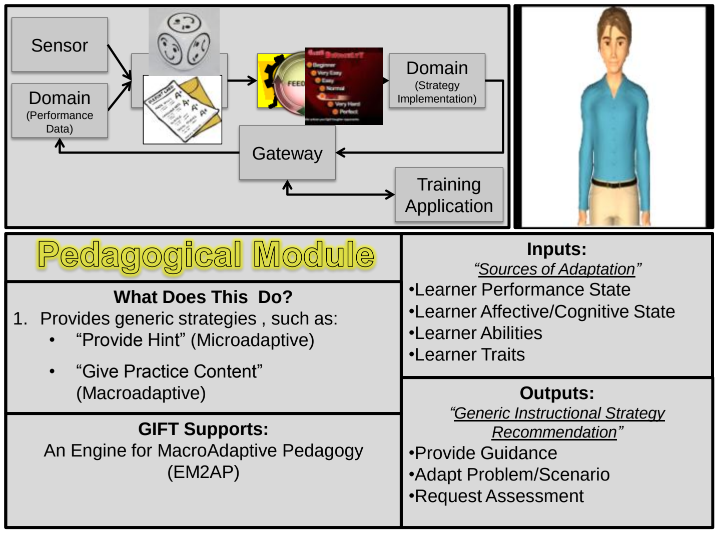
GIFT also uses information collected from sensors to monitor a learner's reactive states while interacting with a system. The Sensor Module takes in raw sensor data streams as inputs and applies filters to convert the data into metrics correlated with cognitive and affective states. This filtered data is passed to the Learner Module for inferring affective and cognitive state determinations. You wouldn't use the same instruction for a bored student as an energetic one, would you? Sensors may be used to collect data about the learner and determine the learner's states. Data from the learner may be filtered or unfiltered.



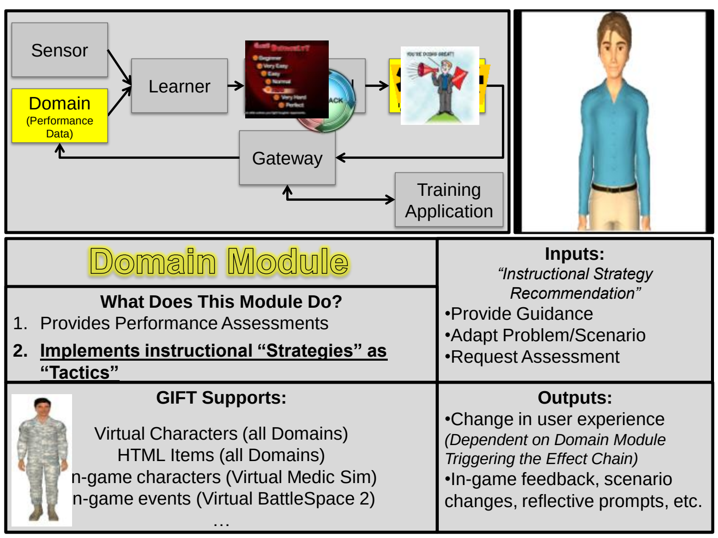
So far we've learned that performance information from the Domain Module and sensor information from the Sensor Module serve as inputs to the next function of the learning effect chain, the Learner Module. The Learner Module consumes this information and performs processes to designate a "Learner State", which may be cognitive (e.g., engagement), affective (e.g., emotions), or physical (e.g., fatigue or arousal). Once a state is classified, the results are then fed to the Pedagogical Module. In addition, the Learner Module maintains information about the learner's stable traits, experiences, and competencies, which are also used to customize strategy selections for the individual learner.



The Pedagogical Module uses the "Picture of the Learner" state information and learner trait data, and then recommends generic strategies to accommodate individual learners. If the student is bored and passing your course, then you probably want to adjust the course. For instance, the Pedagogical Module may provide guidance and feedback to aid in performance, adjust course difficulty, present more interactive material, or request an assessment of the learner's ability.

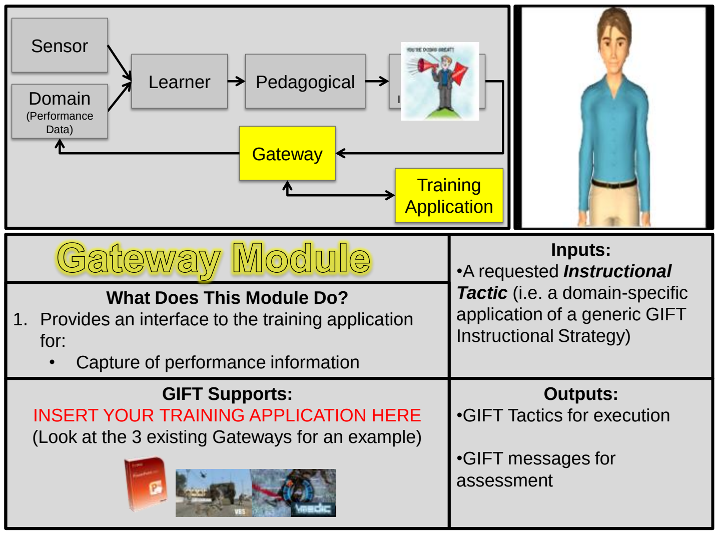


Once the Pedagogical Module uses learner state information to select a strategy, the strategy selected is then sent to the Domain Module. The Domain Module then chooses an appropriate method to implement the request as a defined tactic or action. The selection of the tactic is based on the learner's ability levels. For example, it may be more appropriate for one learner to receive a hint while a metacognitive prompt may be more suitable for another.



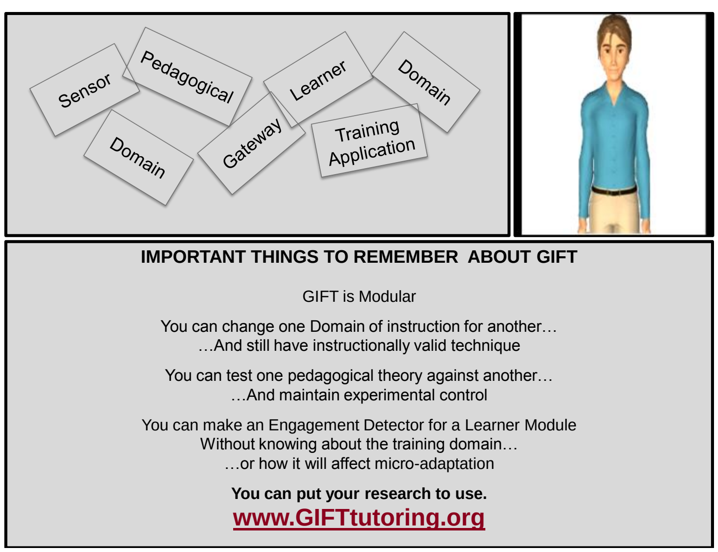
The Gateway Module receives the tactic that was output by the Domain Module and presents it to the learner. Depending on the type of request, this can involve actions to execute tactics within the training application environment (e.g., serious game) or by the Tutor User Interface, a window to present information to and receive information from the learner.

The Gateway Module translates this interface into GIFT-assessable messages, allowing for the whole learning effect to operate. If you already have a training application, the Gateway Module is where you can build an interface to it and add individualized and research-based instructional strategies.



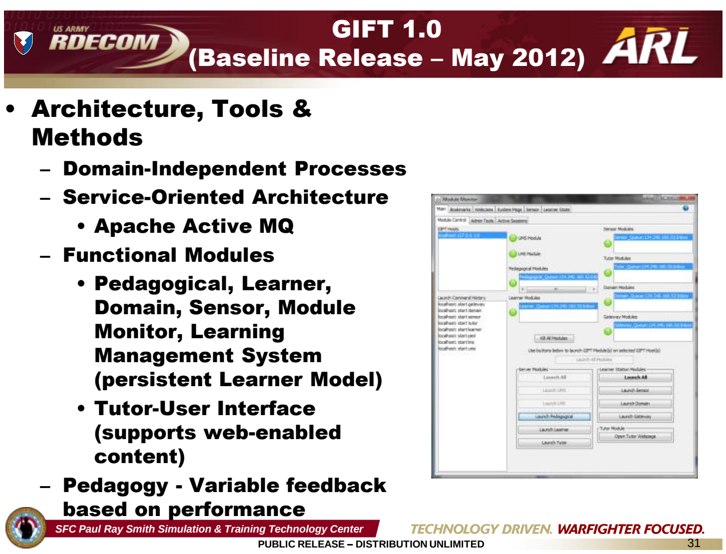
All of the modules communicate to each other via defined protocols. This means that you can easily replace one version of a module with another, which assists in setting up experiments and training with a variety of applications. You can make one module and know with confidence that the rest of the modules will do their duty. Research done for GIFT can make its way back to the community.

You can download GIFT for free (for life) and get support for your development at www.gifttutoring.org.

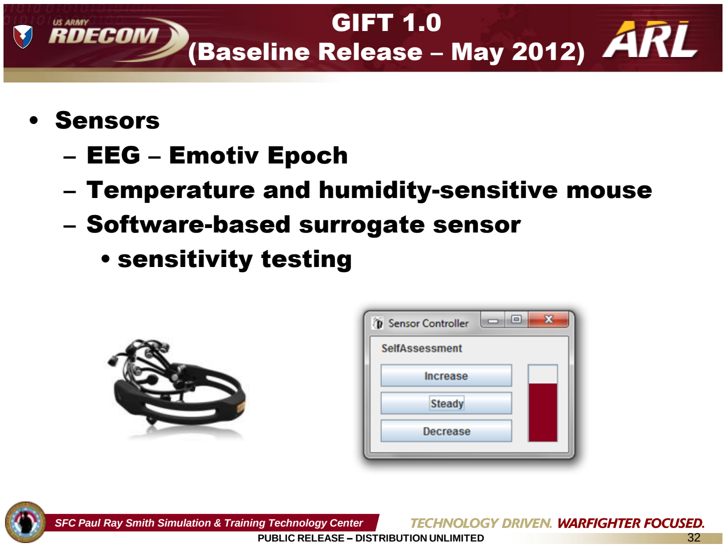


Slides 30–48 discuss the various releases of GIFT and their affiliated capabilities.

GIFT has been continuously developing and growing since its initial release in May 2012. The initial release included the fundamental modules and elements that are still part of the current releases. An initial version of the Module Monitor is pictured in Slide 31.

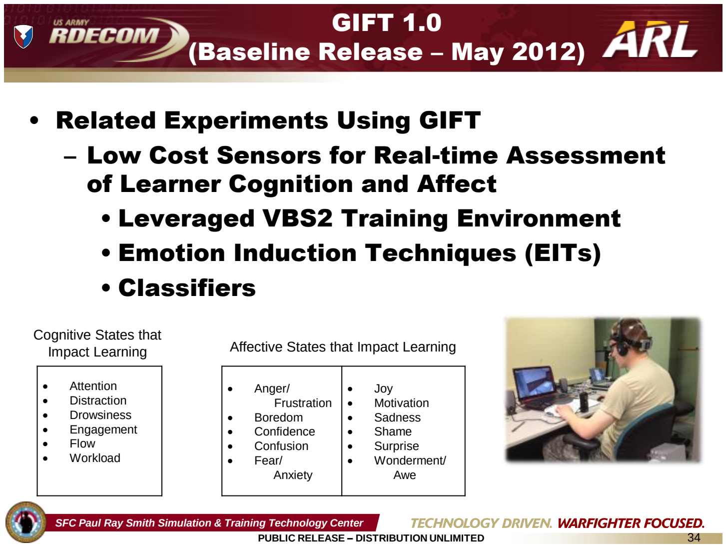


The initial release also included the ability to record information from sensors, such as EEG (electroencephalography), a temperature/humidity-sensitive mouse, and a self-assessment sensor.

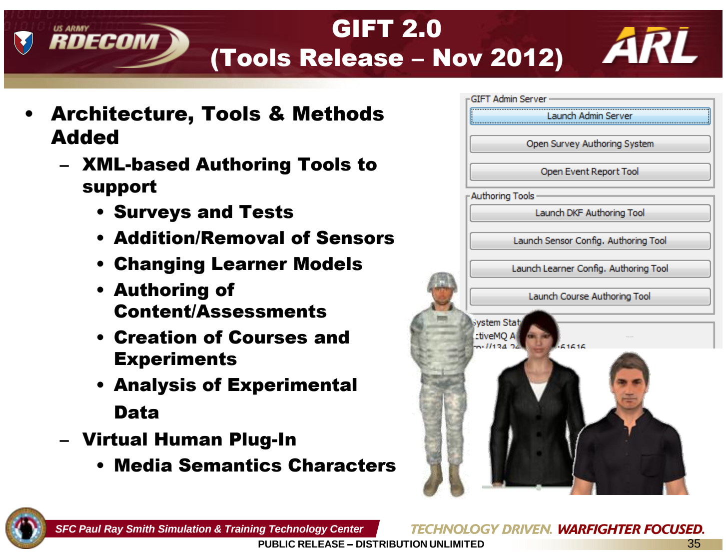


Research has been performed with the various releases of GIFT. An initial experiment was performed to assess low-cost sensors and their impact on learning cognition and affect. This work helped to inform the future direction of sensors within GIFT. Work is consistently being done with GIFT to improve and add to its capabilities.

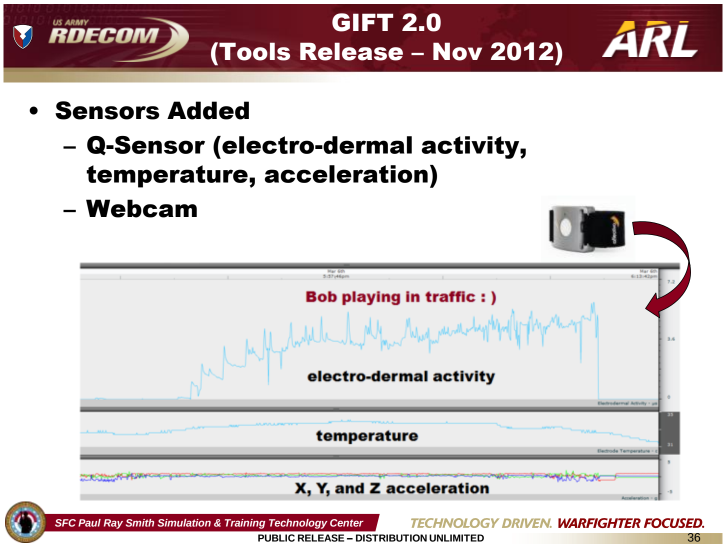
The initial release included support for Virtual BattleSpace 2, a serious game, as an external training application.



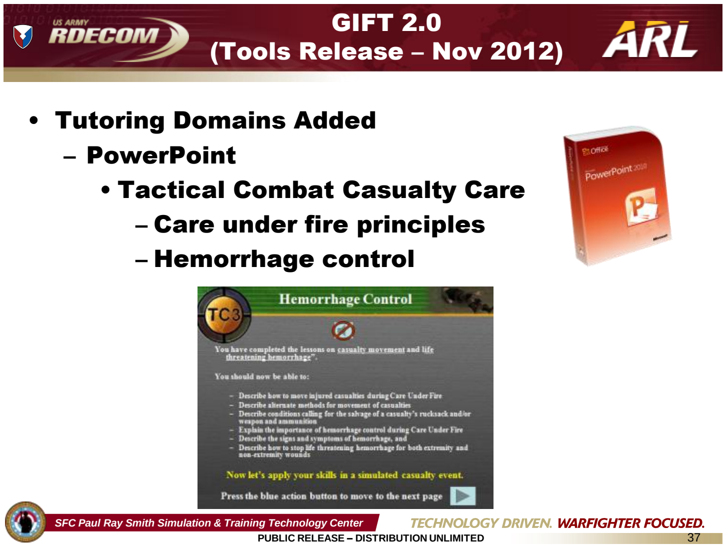
Additional features are being consistently added to GIFT based on both research objectives and user input. GIFT 2.0 was upgraded by including a number of different tools that are of use to course designers and researchers.



Additional sensors were added to GIFT 2.0. Once an interface for a commercial sensor is added to GIFT, the GIFT community benefits by never having to integrate that sensor again.

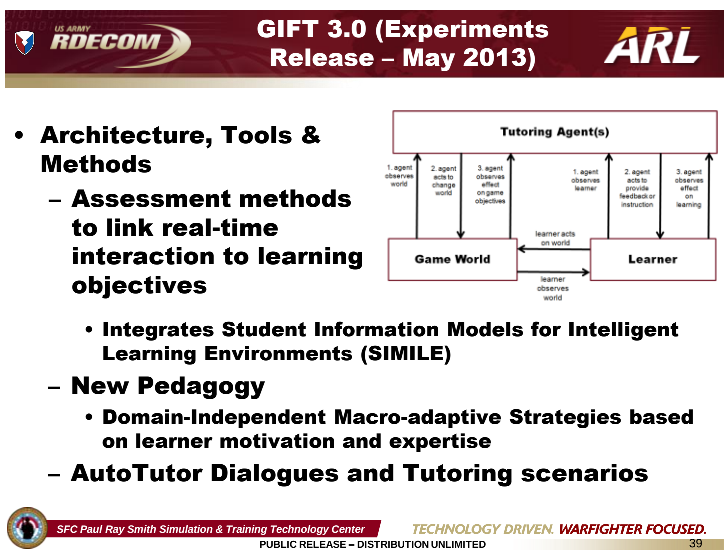


GIFT 2.0 also included the addition of Microsoft PowerPoint as a training application. This addition is extremely useful, as it makes it easier to harness reusable content in the form of PowerPoint presentations. Additionally, PowerPoint is a program that individuals of many skill levels are familiar with, and it increases the flexibility that GIFT course designers have with their included material.



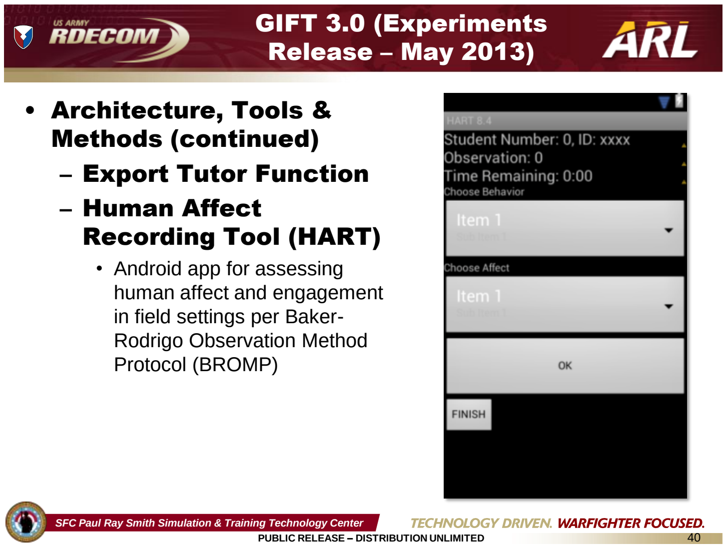
The photo in Slide 38 demonstrates an experiment in action. GIFT is visible on the left side of the screen, with the training application on the right. Additionally, the participant is wearing the Q-sensor, which measures electrodermal activity.

GIFT 3.0 included tools such as SIMILE, which made the ability to link real-time interactions to learning objectives more straightforward for GIFT course authors. In its present form, SIMILE works for TC3Sim/Vmedic; however, future work is being done that will allow it to work with additional training applications. Further, the 3.0 release included the engine for Macro and Micro Adaptive Pedagogy (eM2AP) for managing instruction and elements of AutoTutor through dialogues and tutoring scenarios.



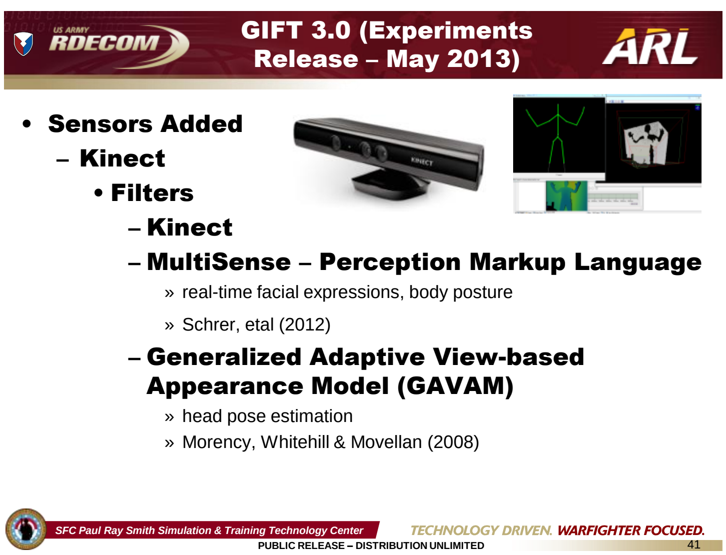
GIFT 3.0 included a very useful feature: the ability to export a created tutor. This allows more flexibility in the way that an individual student will interact with GIFT. Additionally, a full installation of GIFT no longer needs to be completed on each computer that will be running the developed tutor.

The Human Affect Recording Tool (HART) was included with the release and can be used by researchers. HART is an app for the Android platform that implements the Baker-Rodrigo Observation Method Protocol (BROMP) 1.0, a method for assessing human affect and engagement in field settings, allowing for synchronization between field observations and log files of student-software interaction.



HART is described in Baker et al. (2012) and implements the protocol described in Ocumpaugh et al. (2012).

Additionally, the ability to track facial expressions, posture, and head pose was added with the integration of the Microsoft Kinect as a sensor.

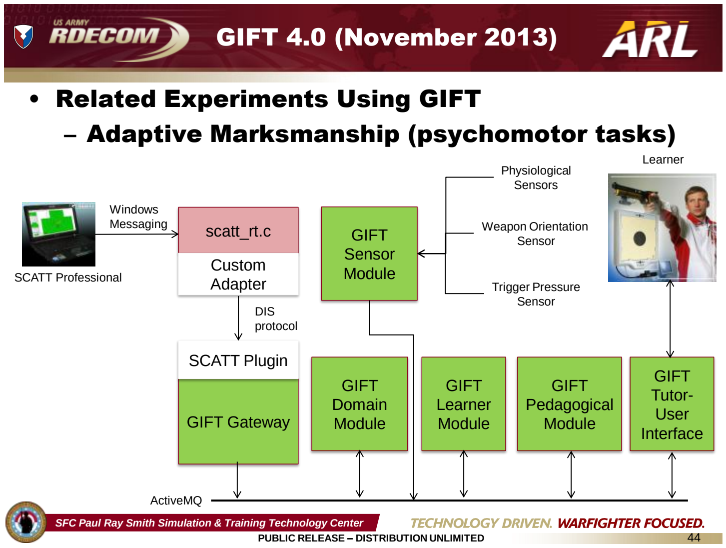


GIFT 3.0 also included additional example courses that used TC3Sim/Vmedic. Additional research was conducted using GIFT as a test bed to examine the self-reference effect in context

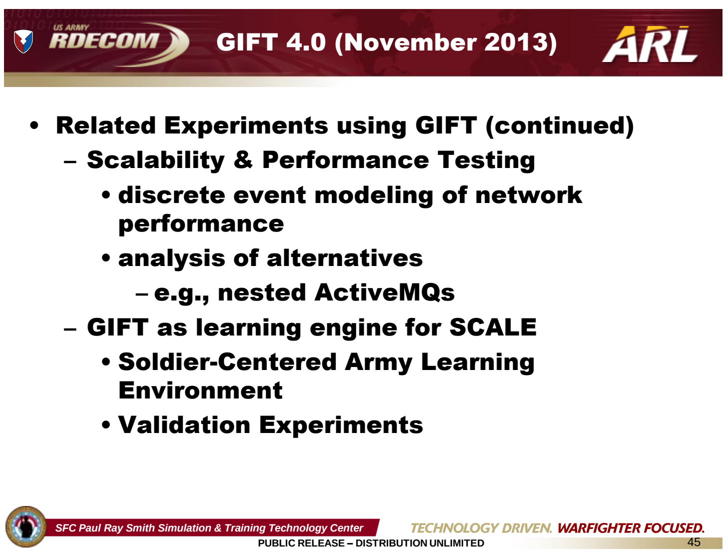
of cognitive tasks in a computerized learning environment. The materials that were used in this study were released as an additional course titled "Logic Puzzle Tutorial" in GIFT 4.0.

GIFT 4.0 also included an enhanced version of eM2AP, additional sensor filters, and integration with new training domains (Marksmanship and Logic Grid Puzzles) based on experimentation with GIFT 3.0.

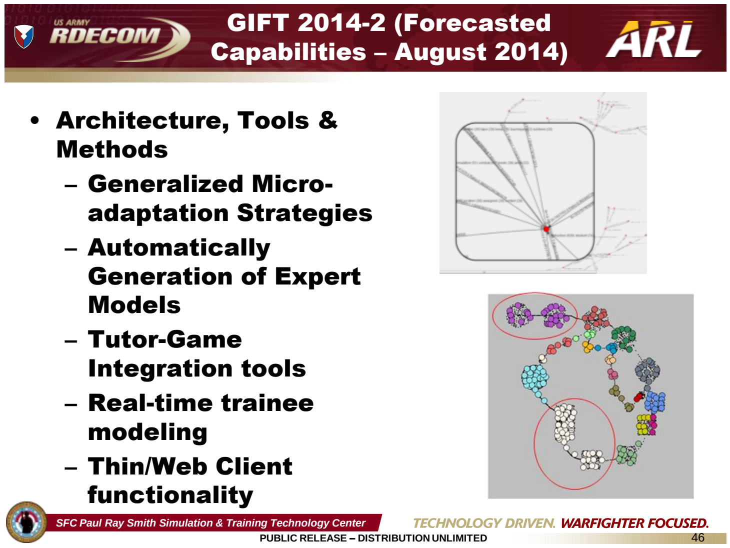
As mentioned previously, a psychomotor training domain, Marksmanship, was facilitated through capabilities in GIFT 4.0. This allows for the development of expert marksmanship models. Slide 44 displays the interaction between the different GIFT modules and the marksman (learner).



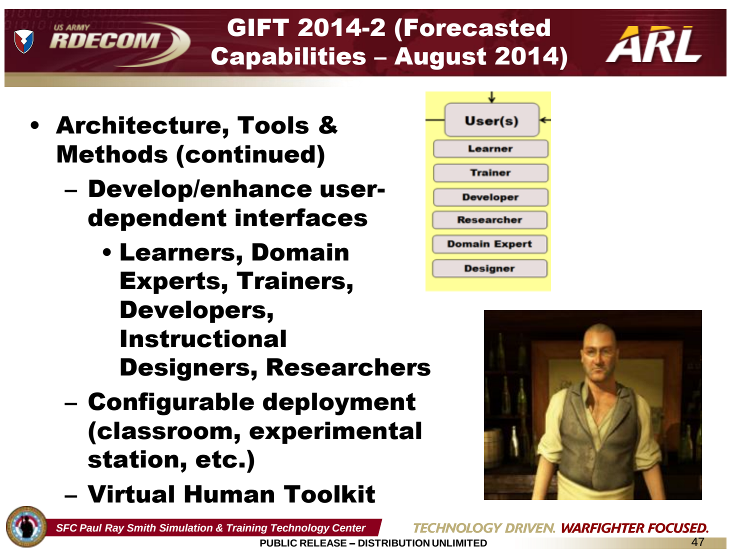
Further, GIFT 4.0. is being used to assess future capabilities. As it continues to develop, GIFT will be adapted to support use by multiple learners in a server-based environment. Further, GIFT is being integrated into a mobile learning environment (The US Army Research Laboratory's [ARL's] Soldier Centered Army Learning Environment [SCALE]) as a learning engine.



Research efforts are ongoing to mature architecture, authoring tools, and modeling of the learner. As they mature, these capabilities are integrated within GIFT.



GIFT 2014-2 and future versions are moving toward separate interfaces and tools for different users (learners, power users, and domain experts). In addition, there will be different configurations for different situations/environments (e.g., classrooms, experiments, mobile learning).



ARL has the goal for GIFT to be a learning engine for several types of training environments. Targets of opportunity include the US Department of Energy's National Training & Education Resource, the US Advanced Distributed Learning Initiative's Personalized Assistant for Learning (PAL), and ARL's SCALE.

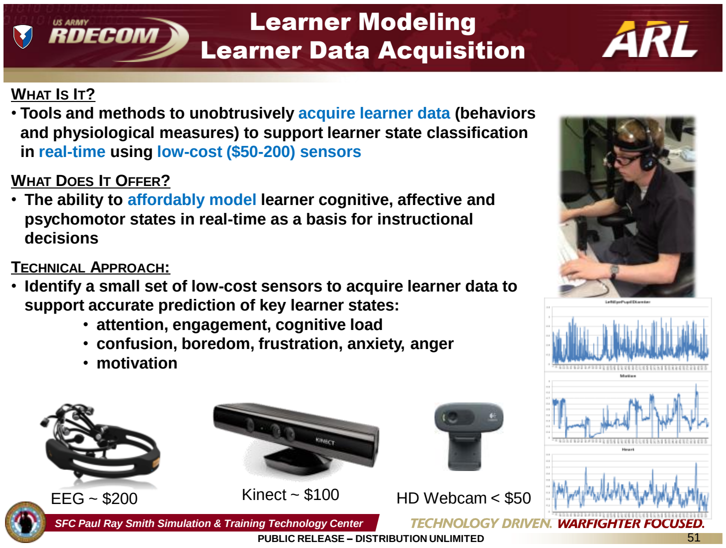
Beyond GIFT 2014-2

- **Continue to leverage AutoTutor and AutorTutor Lite functionality**
  - Speech Act Analysis, Complex Dialog Management, Artificial Intelligence Markup Language, Learner Characteristics Curves
- **Enhanced cognition and affect detectors**
- **Extend learning environments to military training domains (complex and ill-defined domains)**
- **GIFT as learning engine for PAL**

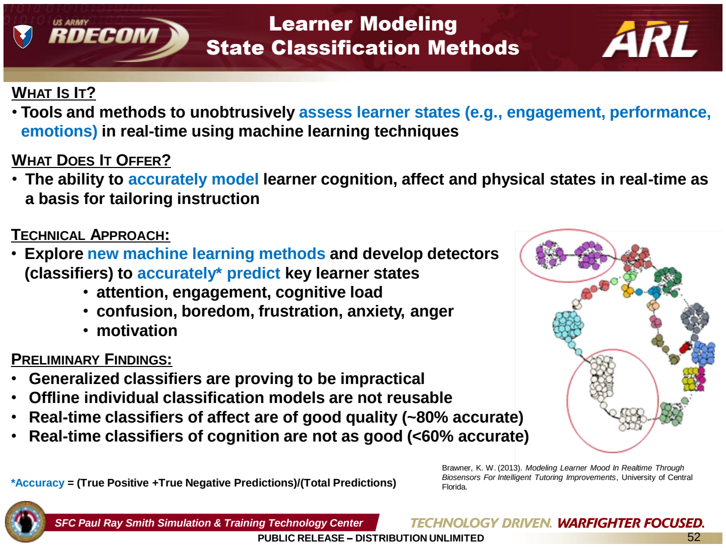
Demo of GIFT bootup

4. Learner Modeling

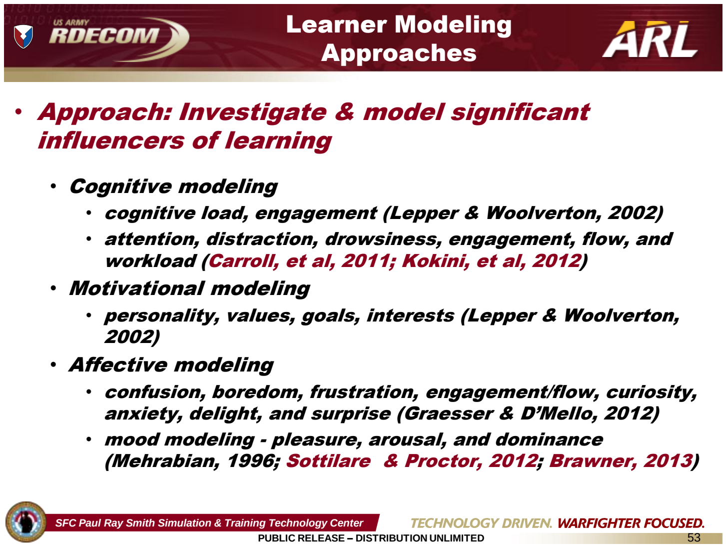
There are 2 key steps in learner modeling: data acquisition and state classification. Learner data, as noted in the adaptive tutoring learning effect model, may be acquired in real-time from sensors or learner input (e.g., surveys, interaction with training environment) or in pretutoring from a long-term learner model (LTLM) sometimes called a persistent learner model. Slide 51 examines low-cost sensors for acquiring learner data.



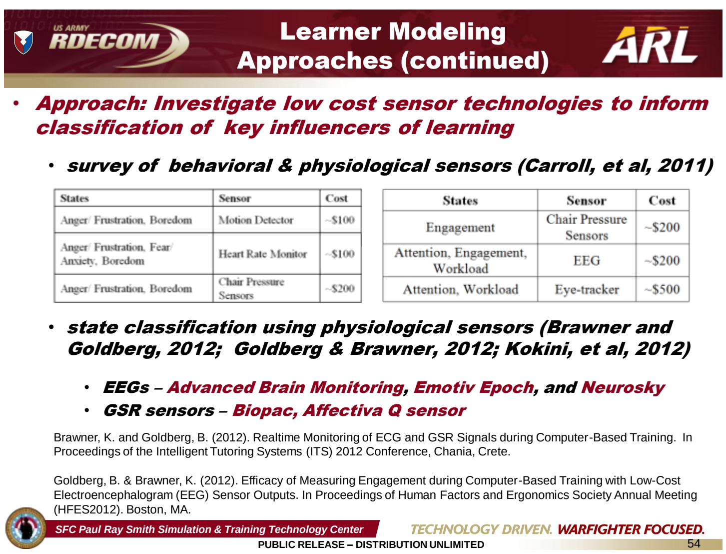
Slide 52 reviews approaches for using learner data to classify learner states (e.g., emotions, engagement, performance, competence). Of particular note are the preliminary findings on this slide.



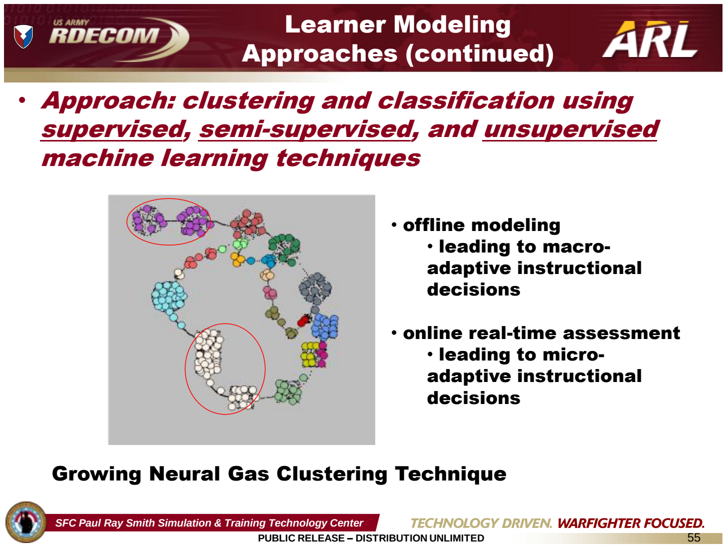
The learner states of interest during tutoring are primarily centered in 3 areas that moderate learning (acquisition of knowledge and skills): cognition, motivation, and affect (see Slide 53).



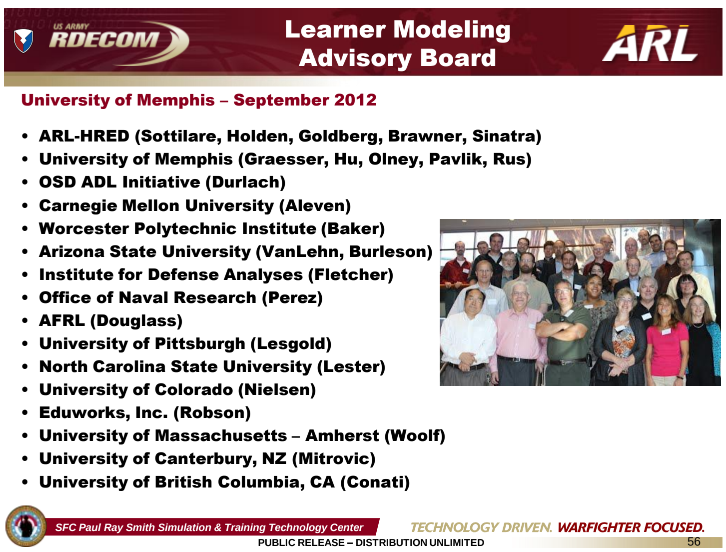
The results of an experiment that sampled low-cost sensors and their ability to reliably detect learner states is shown in Slide 54.



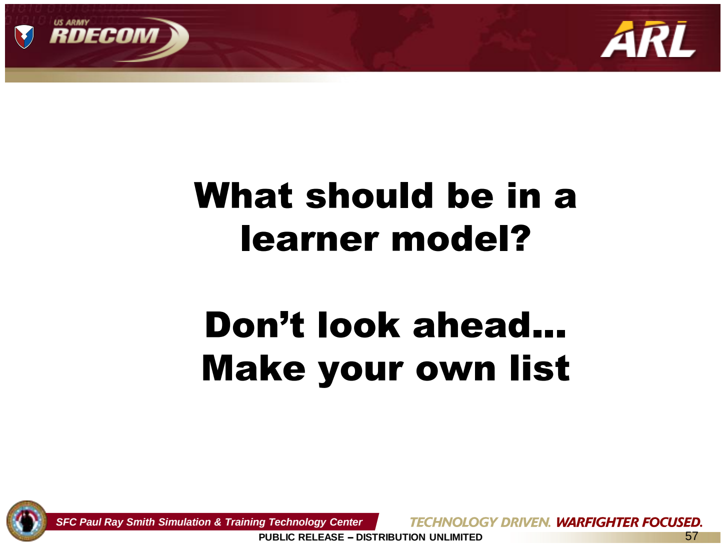
Various machine learning techniques have been evaluated for use in classifying learner states. Slide 55 illustrates a clustering technique called "growing neural gas". Learner data may be labeled (supervised), unlabeled (unsupervised) or semi-supervised. If you are interested in machine learning techniques, check out WEKA, an open-source software tool for machine learning: http://www.cs.waikato.ac.nz/ml/weka/.



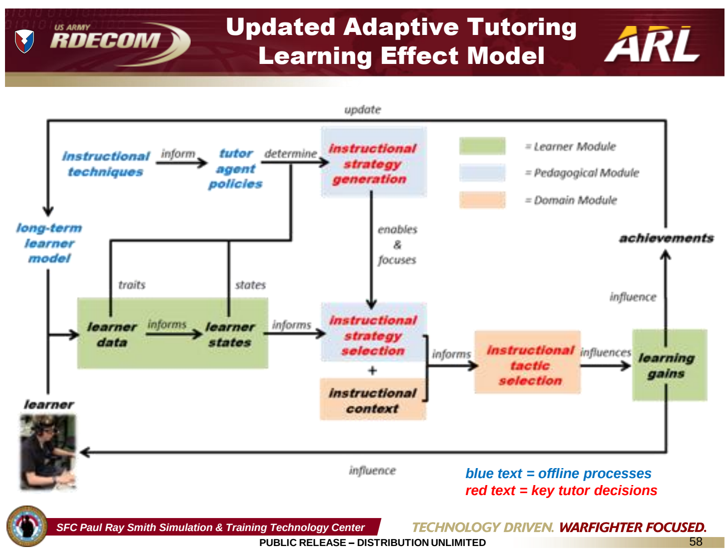
In an effort to develop ITS best practices for learner modeling, ARL convened a group of experts in 2012 to examine the state of practice, emerging concepts, and future directions. This information was captured in the first volume of the *Design Recommendations for ITSs*, which is available for free at: https://gifttutoring.org/documents/42.



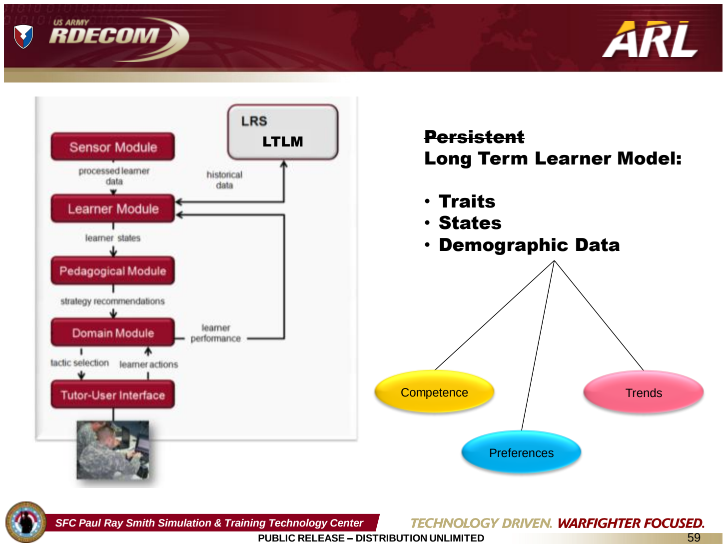
If you were to build a learner model, what kinds of data would you want to capture and what states would you want to classify/detect?



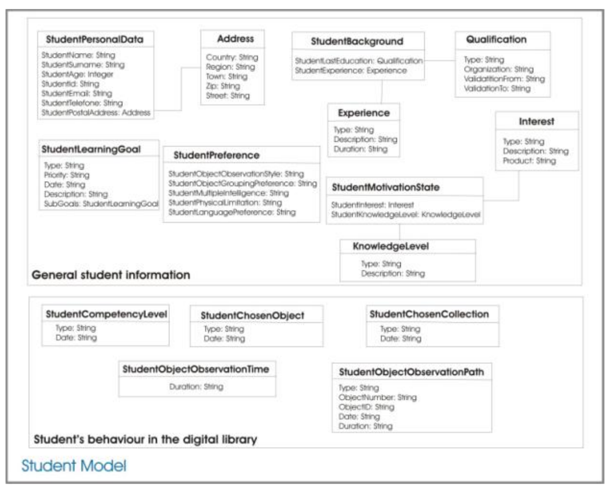
Learner data, states, traits, and demographics may be useful in the ITS decision processes, but data are generally expensive to collect and maintain. So, we want to be selective about which data we choose for our model.



LTLMs may span careers or lifetimes of learners and are used to store enduring, variable, and transient characteristics of the learner, including traits, states, and demographics.

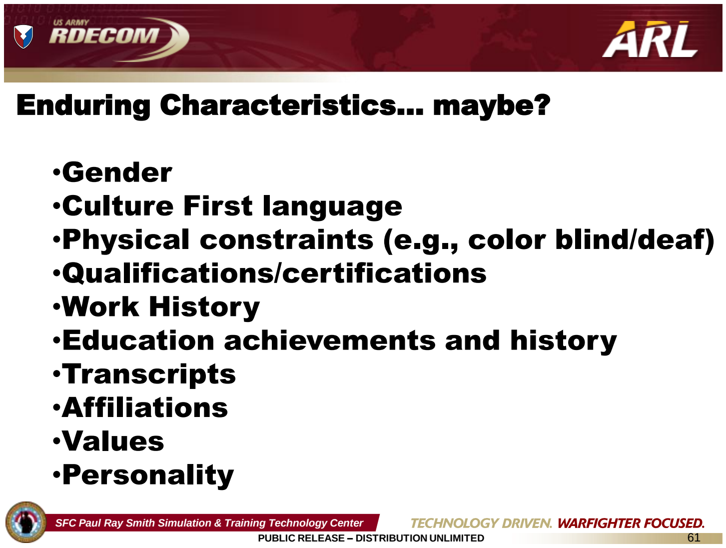


Slide 60 shows some student (learner) data that is separated into general information and recorded behaviors.

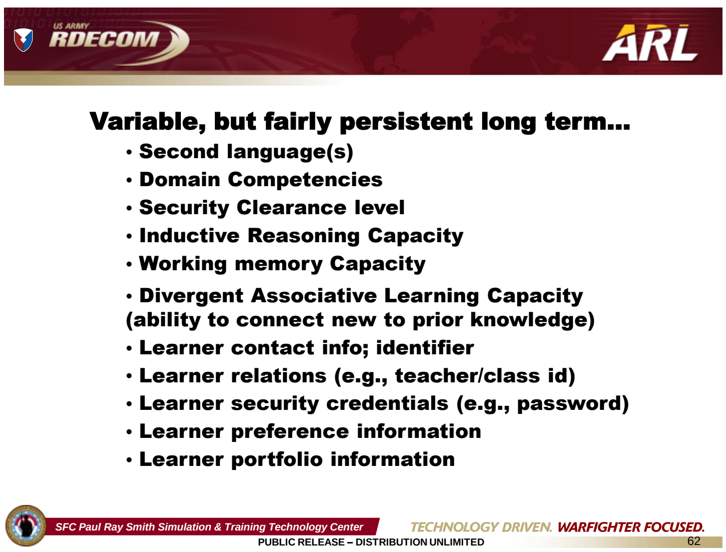


Paneva, D. (2006, September). Use of Ontology-based Student model in Semantic-oriented Access to the Knowledge in Digital Libraries. In proc. of HUBUSKA Fourth Open Workshop "Semantic Web and Knowledge Technologies Applications", Varna, Bulgaria (pp. 31-41).

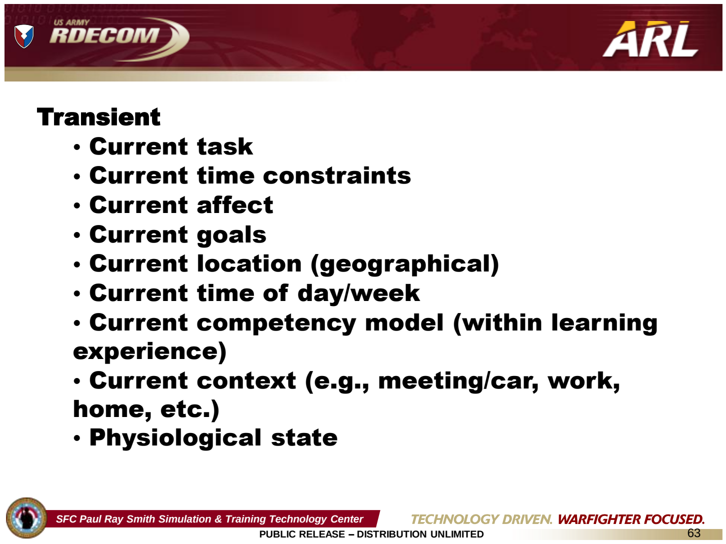
Learner characteristics may be enduring, but even enduring characteristics may change over a long period of time. For this reason, the label of long-term learner model may be more appropriate than persistent learner model.



Slide 62 lists learner characteristics that are variable but fairly persistent.

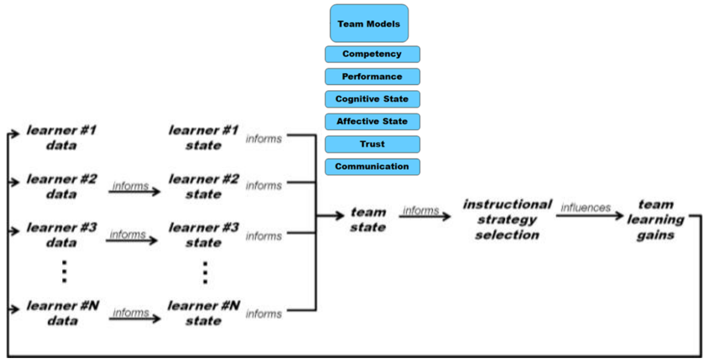


Slide 63 lists transient characteristics that may be worth tracking/detecting.



We just discussed what might be useful to include in an individual learner model. What should be in a model of a team of learners?

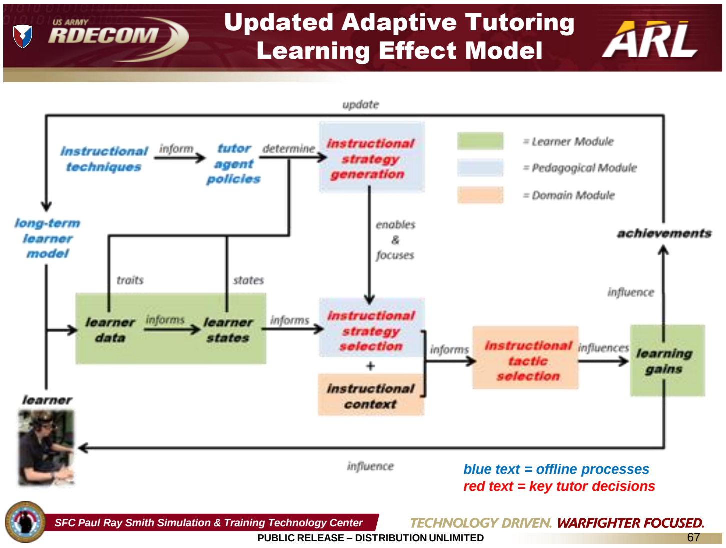
Adaptive Tutoring Learning Effect Chain for Teams



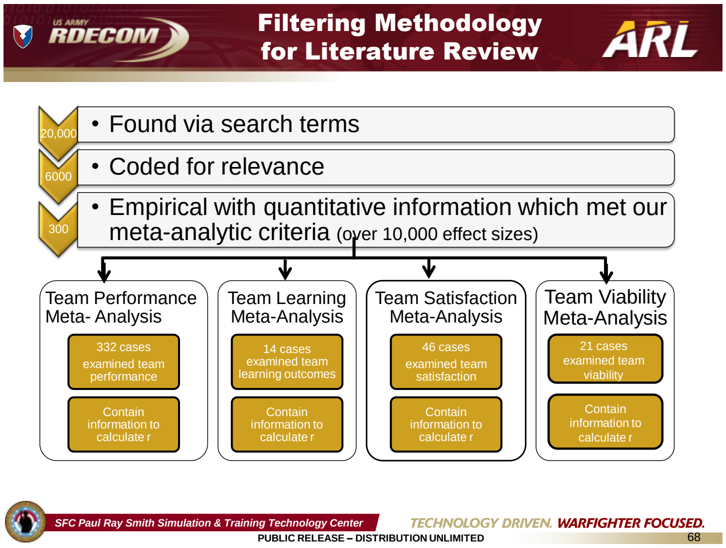
Fletcher, J.D. and Sottilare, R. (2013, *in press*). Shared Mental Models and Intelligent Tutoring for Teams. In Sottilare, R., Hu, X., Graesser, A. and Holden, H. (Eds.) *Design Recommendations for Intelligent Tutoring Systems: Learner Modeling, Volume I.* Army Research Laboratory.

Team Model Development Process

- **Structured Literature Review**
  - **Individual Tutoring**
  - **Team Performance**
- **Model Constructs**
  - **What models are needed?**
  - **What variables influence each model?**
  - **What variables are observable/unobservable?**
  - **What is the effect size of each variable?**
  - **How do we measure critical variables?**
- **Structural Equation Models**
- **Model – Test – Model**



In 2013, an extensive review of the literature was undertaken relative to the target team models identified by Sottilare et al. (2011) and later described by Sottilare (2013). A sample of the outcome for the performance model is shown in Slide 68.



The results of the team performance model literature review revealed the following antecedents (influencers) of team performance (see Slide 69).

Examining antecedents to effective team performance

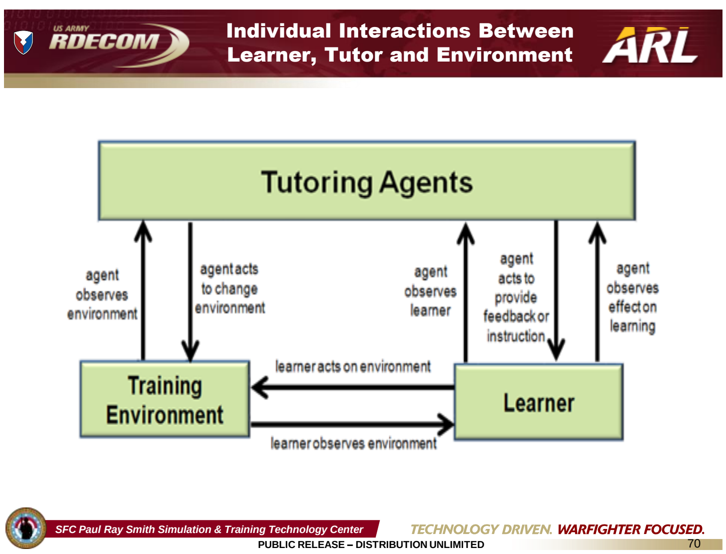
Outcome	K^1	N^2	Ro	Rho	% Variance accounted for
Overall	183	12910	.18	0.19*	30.0%
Communication	48	3367	.23	0.26*	26.2%
Coordination	25	1798	.21	0.23*	28.8%
Conflict	32	2061	-0.08	-0.09*	23.3%
Coaching/Leadership	50	3863	.22	0.24*	33.3%

1. K is the number of effect studies analyzed for this outcome
2. N is the number of individuals evaluated in this outcome
3. Rho is the corrected effect size, Ro is the uncorrected effect size; both weighted for sample size

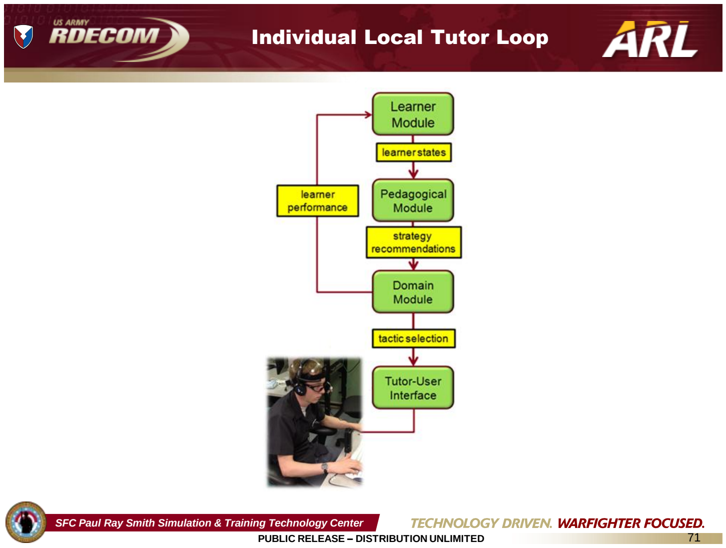
**Statistically significant; confidence interval excludes zero*

SFC Paul Ray Smith Simulation & Training Technology Center — TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
PUBLIC RELEASE – DISTRIBUTION UNLIMITED 69

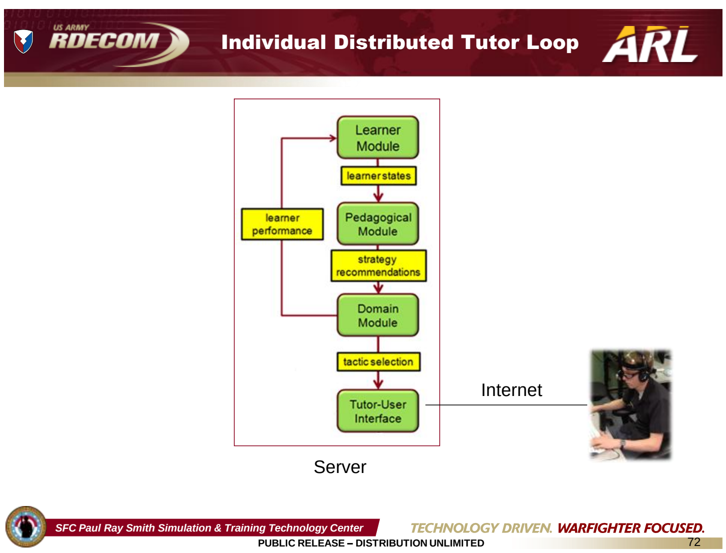
The process of identifying antecedents for each of the primary team models continued, and these are being used to construct initial team models for GIFT. Moving forward, we will examine the relationship between individual and team modeling. Slide 70 shows the interaction between the tutoring agents, the training environment, and the learner. Tutoring agents for teams may have similar functions but will track progress toward team objectives.



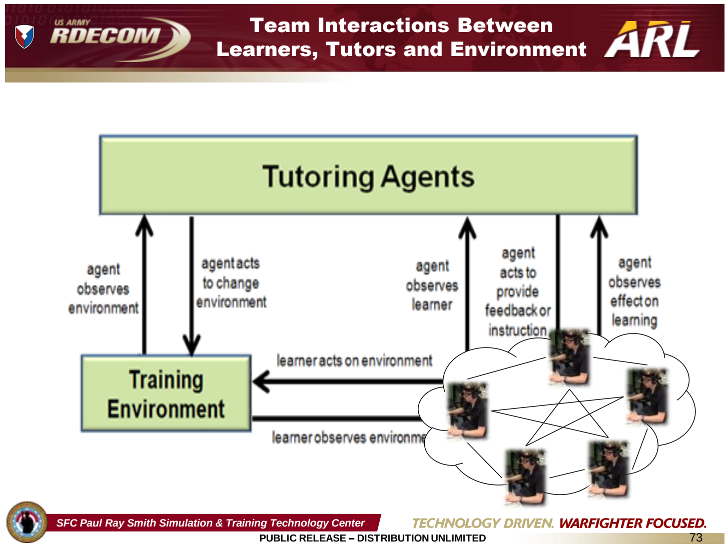
You have seen this diagram before—it is the individual tutor loop.



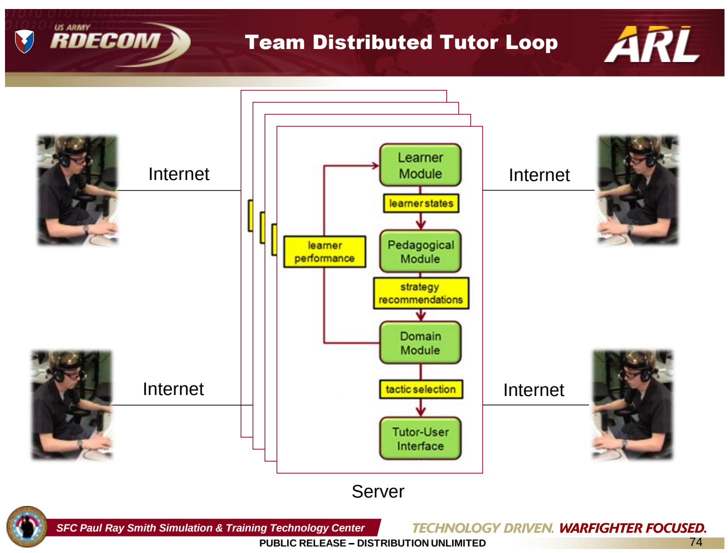
The tutor loop in Slide 72 shows a distributed or server-based interaction between an individual learner and the tutor. How will this need to be modified for teams?



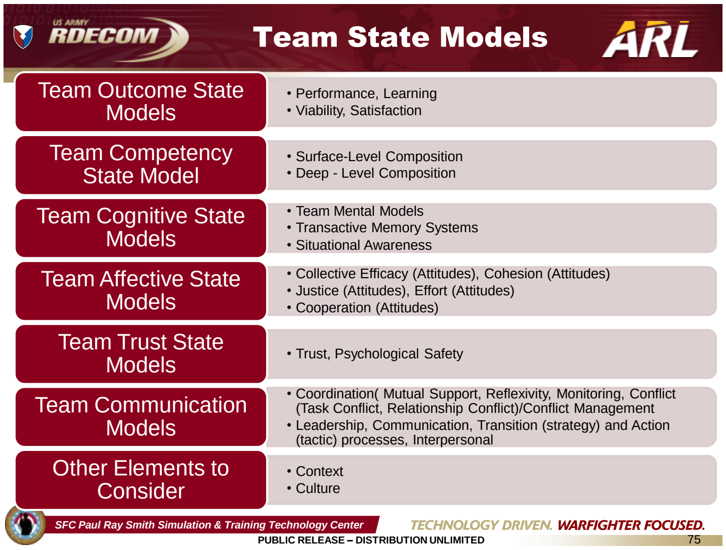
Going back to the agent-environment-learner interaction for a moment, Slide 73 shows interaction between a team of 5 learners and the tutoring agents, a team of 5 learners and training environment, and finally, what is different in this diagram, interaction between learners who must be accounted for in the team models of the tutor.



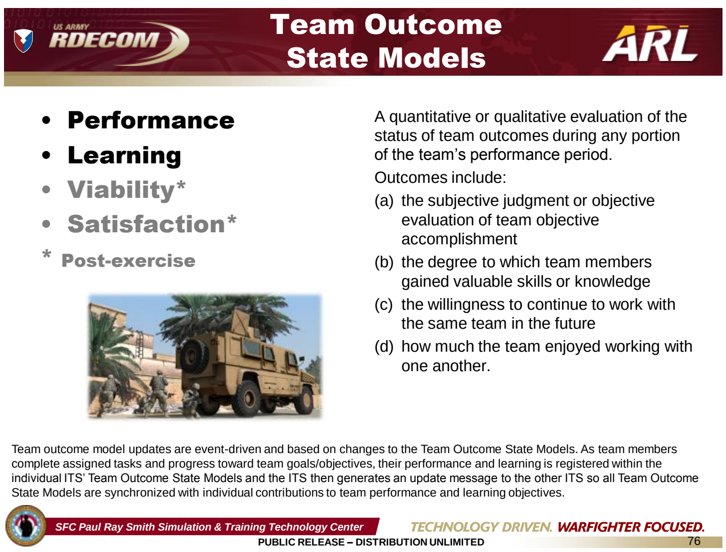
Slide 74 shows individual learners interacting with their own tutor loops (something must moderate/manage the team interaction), interaction between the learners (communication, trust, performance, shared mental models [cognition, affect]), and how competency influences the other models.



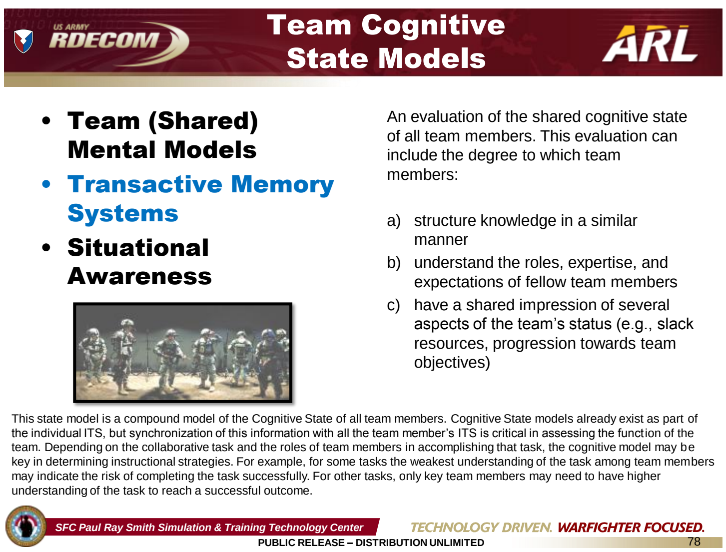
Team modeling has evolved into 6 state models with consideration for 2 additional models for context and culture pending the determination of their influence on team performance.



Each of the team models is reviewed in Slides 76–82.



See Fletcher and Sottilare (2013) for additional insight on Shared Mental Models.



US ARMY RDECOM

Team Affective State Models

ARL

- **Attitudes** **(not observable)**
  - **Collective Efficacy**
  - **Cohesion**
  - **Justice**
  - **Effort**
  - **Cooperation**
  - **Trust (next slide)**

Values-Attitudes-Behaviors

The general of feelings of team members towards one another during team interaction. This can include, but is not limited to feelings regarding

(a) the team's ability to accomplish their goals

(b) the team emotional sentiments towards one another

This state model is a compound model of the Affective State of all team members. Affective State models already exist as part of the individual ITS, but distribution of this information to all the team members ITS is critical in assessing the function of the team. For example, if team performance is below expectations and the affective state of one or more team members is negative, knowledge of their state by other individual ITS provides the opportunity to prompt their associated team members to take action (e.g., communicate – support or direct).

US ARMY RDECOM

Team Trust State Models

ARL

- **Trust**
- **Credibility**
- **Psychological Safety (Openness)**

The shared belief that all team members will fulfill their role responsibilities, perform delegated tasks, and not attack fellow team members for expressing their opinion.

This state model is a compound model of the Affective State of all team members. Affective State models already exist as part of the individual ITS, but distribution of this information to all the team members ITS is critical in assessing the function of the team. For example, if team performance is below expectations and the affective state of one or more team members is negative, knowledge of their state by other individual ITS provides the opportunity to prompt their associated team members to take action (e.g., communicate – support or direct). This team state model is a compound model of the trust states existing between team members. The trust relationships are bi-direction in that Team Member „A" may trust Team Member „B" more, the same or less than Team Member „B" trusts Team Member „A". Trust is influenced by several factors including perceived competency, perceived integrity, perceived benevolence, knowledge of the other team members (Hung, Dennis and Robert, 2004) and perceived benefits of the relationship (Gujral, DeAngelis, Fullam and Barber, 2006). Since teams work toward common goals where roles and responsibilities are distributed, perceived competency is an essential element of team performance. The perception that other team members may be unable to perform their tasks is detrimental to trust and team performance. Personality may also play a part in trust.

Individuals with low openness and/or high neuroticism scores in the Five Factor Model of Personality (McCrae and Costa, 1994) may have developed habits unfavorable to the development of trust. Low openness scores might indicate an unwillingness to disclose information while high neuroticism scores might result in more frequent perception of events/interactions as negative. Positive or negative emotions can also influence the assimilation of information (Linnenbrink and Pintrich, 2002) and thereby communications, understanding and trust.

Team Communications State Models

- **Coordination**
  - **Mutual Support**
  - **Reflexivity**
  - **Monitoring**
- **Conflict**
  - **Task Conflict**
  - **Relationship Conflict**
- **Leadership**
  - **Leadership Styles**
  - **Shared Leadership**
  - **Leadership Behaviors**

- **Communication (frequency, source, receiver(s)**
- **Transition Processes**
- **Action Processes**
- **Interpersonal Processes**
- **Conflict Management**
- **Organizational Citizenship Behaviors (OCBs)**

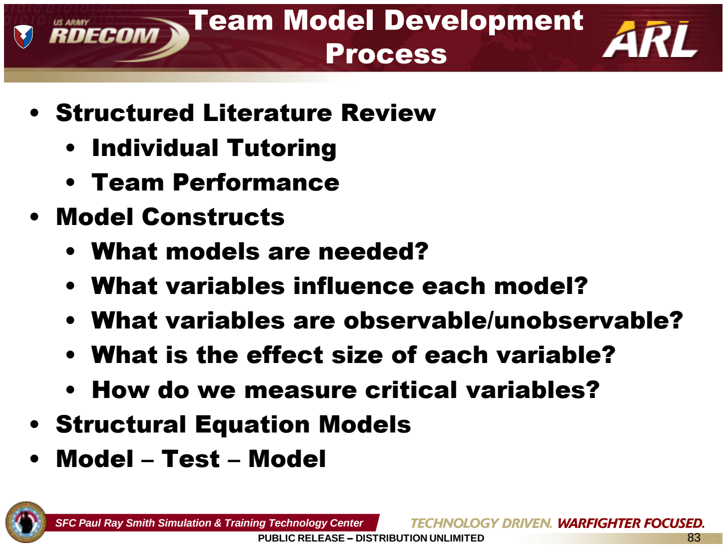
Observable behaviors between group members which either directly impact progression towards task completion or indirectly facilitate synchronization between team members.

This model is composed of interaction data between team members for the purpose of observing team cohesion and task execution. Providing accurate information in accordance with operating procedures, providing communications when asked, repeating communications to ensure delivery, sharing information and acknowledging receipt of information are all vital actions observed in teams with effective communication skills (U.S. Coast Guard, 1998). In team settings communication among members builds holistic situational awareness and coordinates future actions to be carried out. Based on events and interactions in a scenario, team members are responsible for updating one another in real-time

Other Influencing Factors

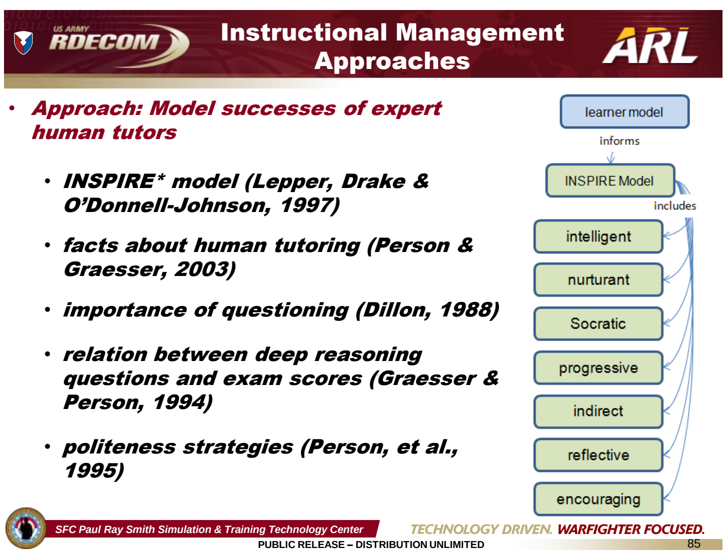
- **Context**
  - **Task or Project Characteristics**
  - **Autonomy**
  - **Interdependence**
  - **Familiarity**
  - **Team Tenure**
  - **Organization Type**
  - **Leader Characteristics (Age/Tenure)**
  - **Organizational Resources**
- **Culture**
  - **Individual Culture**
  - **Team Culture**
  - **Organizational Culture**
  - **National Culture**
  - **Team Climate**
  - **Organizational Climate**
  - **Diversity**


The team model development process is shown in Slide 83.

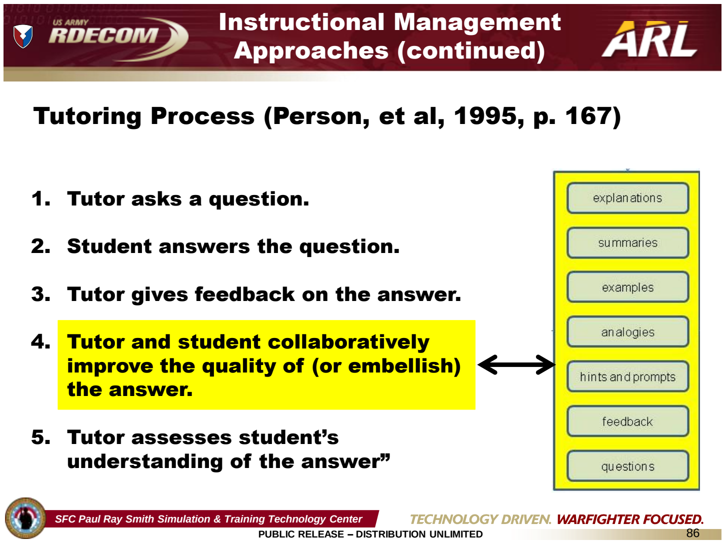


5. Instructional Management

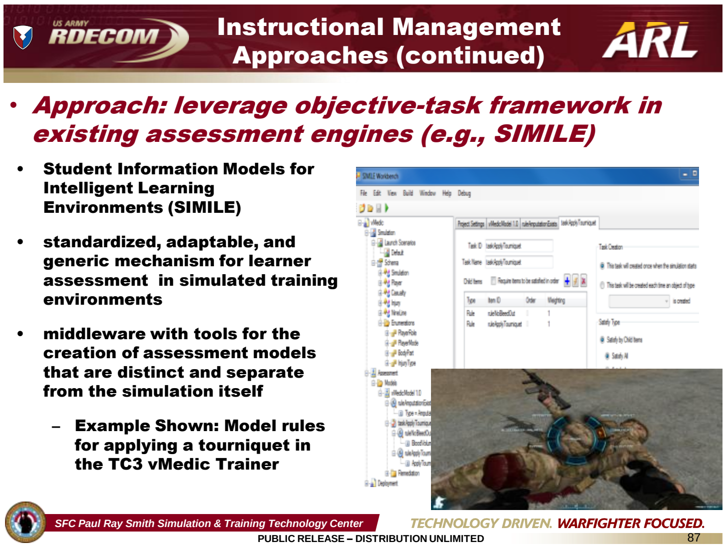
Good instructional practices are hard to replicate. Modeling expert human tutors is a good place to start.



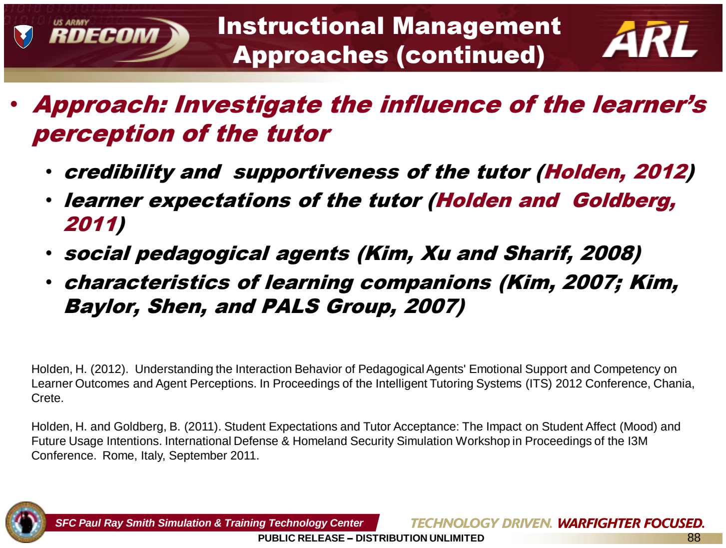
Dialogue-based tutors take turns interacting with the learner (see Slide 86) to improve the quality of their answers without giving them the answer. Dialogue-based tutors guide the learner and assess their understanding of concepts. GIFT has incorporated many of the web-based services used in AutoTutor and AutoTutor Lite to support dialogue-based tutoring.



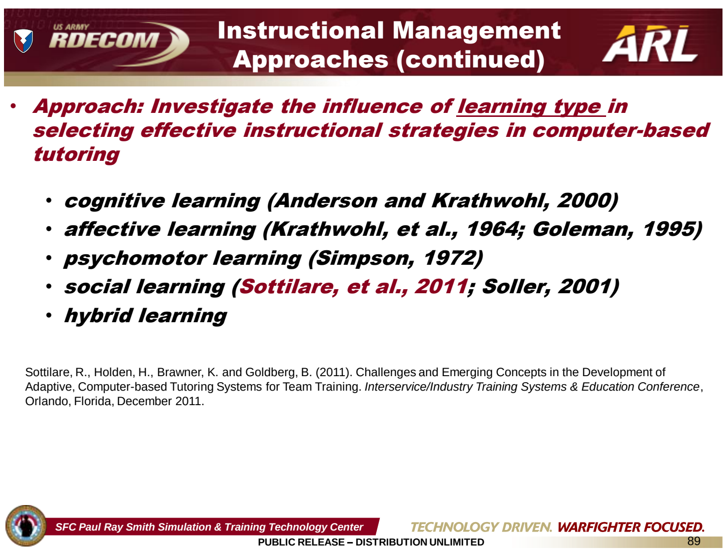
SIMILE is a tool to link learner actions in a simulation or game to performance assessments and ultimately to tutor decisions about instructional options (e.g., feedback, support, change in challenge level).



The relationship between the tutor and the learner is critical to the learner's engagement and motivation. The learner should perceive the tutor as credible and supportive for significant learning to occur. While this might not be important for single exposures of the learner to the tutor, over the long term, it is critical for the learner to develop a relationship with the technology.



Another approach to managing instruction is to categorize instructional differences in different learning domains. Research is ongoing to determine generalized instructional management methods across and within learning domains.



Each of the learning categories (cognitive = thinking, affective = feeling, and psychomotor = doing) is reviewed in Slides 90–93.

Cognitive Learning

- **Cognitive learning (thinking) – Anderson & Krathwohl, 2001**
  - ***behaviors indicating increasingly complex and abstract mental capabilities***

  - **Creating (high):** ability to put parts together to form a new whole
  - **Evaluating:** ability to judge the value of learned material
  - **Analyzing:** ability to break down material into its component parts
  - **Applying:** ability to use learned material in new situations
  - **Understanding:** ability to grasp the meaning of material
  - **Remembering (low):** ability to recall previously learned material

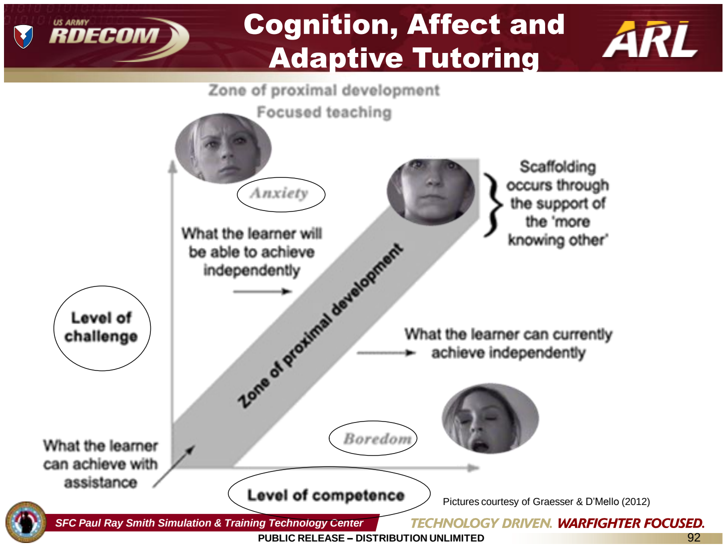
Anderson, L. W., and Krathwohl, D. R. (Eds.). (2001). A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of Educational Objectives: Complete edition, New York : Longman.

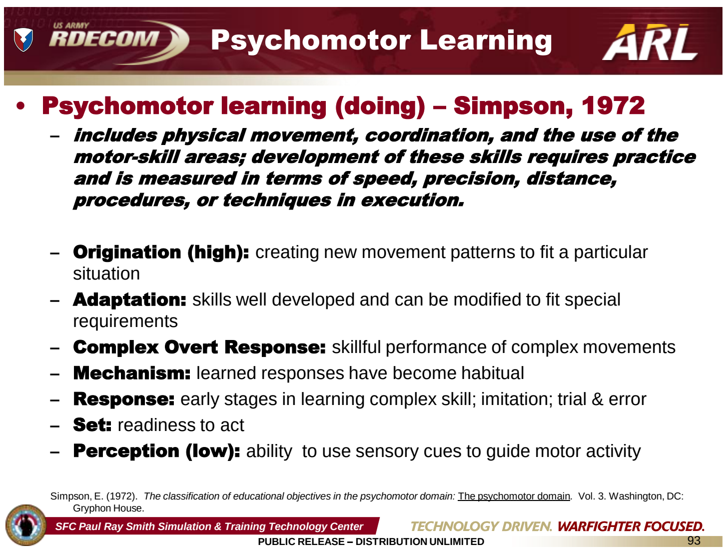
Affective Learning

- **Affective learning (feeling) – Krathwohl, Bloom and Masia, 1964**
  - ***behaviors indicating emotional growth; the manner in which we handle emotions, such as feelings, values, appreciation, enthusiasms, motivations, and attitude***

  - **Characterizing (commitment - high):** has a value system that controls their behavior
  - **Organizing (responsibility):** organizes values into priorities; comparing, relating and synthesizing values
  - **Valuing (appreciation):** the worth or value a person attaches to a particular object, phenomenon, or behavior
  - **Responding (interest):** active participation on the part of the learner
  - **Receiving (awareness - low):** awareness, willingness to hear, selected attention

Krathwohl, D.R., Bloom, B.S., and Masia, B.B. (1964). Taxonomy of Educational Objectives: Handbook II: Affective Domain. New York: David McKay Co.





Another approach to enhanced adaptive instruction is to implement best practices based on learning theories. Two theories are Component Display Theory (Merrill et al. 1992) and the Zone of Proximal Development (Vygotsky 1978), which are described in Slides 94 and 95, respectively.

Component Display Theory (Merrill, et al, 1992)

- **Strategies that account for the learner's state:**
  - *Gain attention and motivate*
  - *Adapt to prior knowledge*
  - *Adapt to type of knowledge being presented*
  - *Adapt to learner attributes*
  - *Adapt to the learner's ability (IQ, EQ, adaptability…)*

Merrill, D. , Reiser, B, Ranney, M., and Trafton, J. (1992). Effective Tutoring Techniques: A Comparison of Human Tutors and Intelligent Tutoring Systems. The Journal of the Learning Sciences, 2(3), 277-305.

Automated Instruction Zone of Proximal Development

WHAT IS IT?

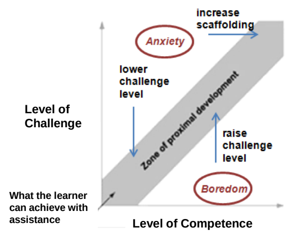
- Tools and methods to adapt instruction based on the learner's state (e.g., cognitive and affective) and level of domain competence

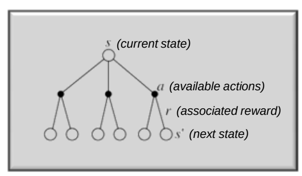
WHAT DOES IT OFFER?

- The ability to select real-time instructional strategies which automatically lower/raise the training scenario challenge level and regulate the type and frequency of scaffolding (support) provided to the learner

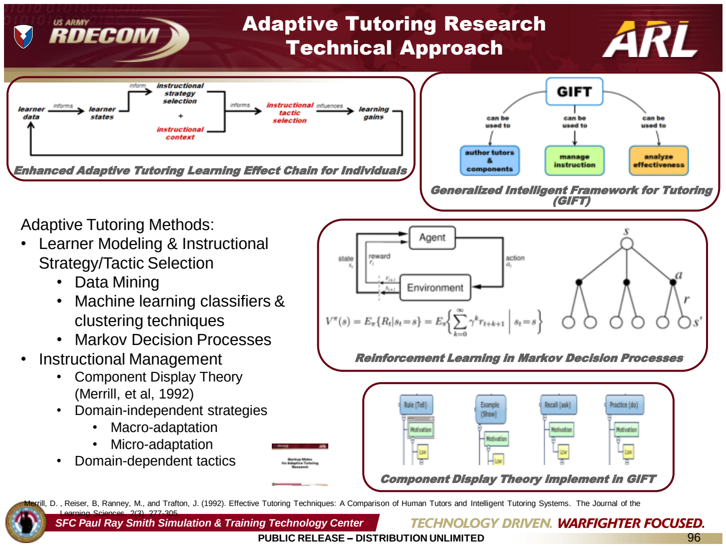
TECHNICAL APPROACH:

- Literature Review to identify negative learning states (e.g., anxiety, boredom, frustration) and associated effective strategies
- Develop classification rules for incorporation within GIFT (*eM²AP)
- Develop a Markov Decision Processes to address uncertainty associated with learner state classification





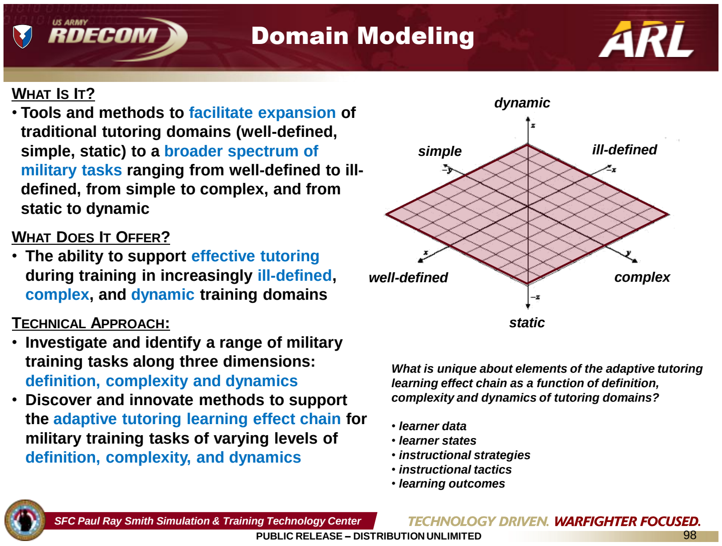
*eM²AP = engine for Macro & Micro-Adaptive Pedagogy



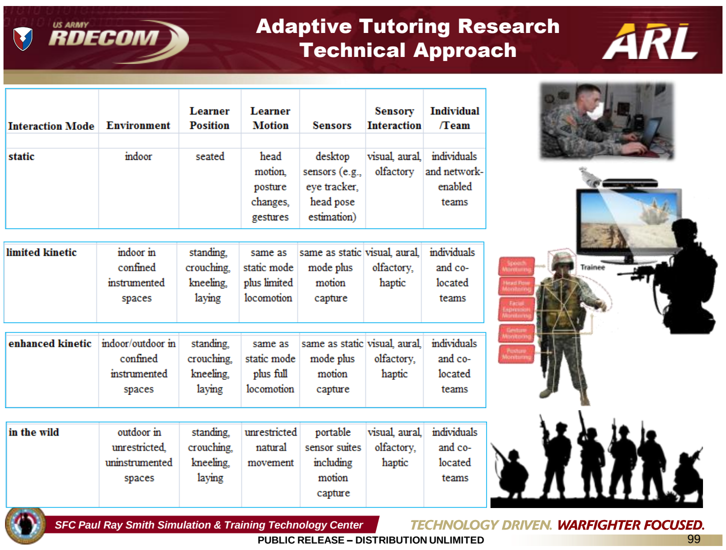
6. Domain Modeling

While domain modeling is primarily associated with presentation of content to the learner, it also includes the following aspects: modeling of experts (also known as an ideal student model), which is used to assess the progress of the learner and identify errors and misconceptions; assessment of performance; and presentation of tactics (actions by the tutor to present content, change content, provide feedback, or provide support).

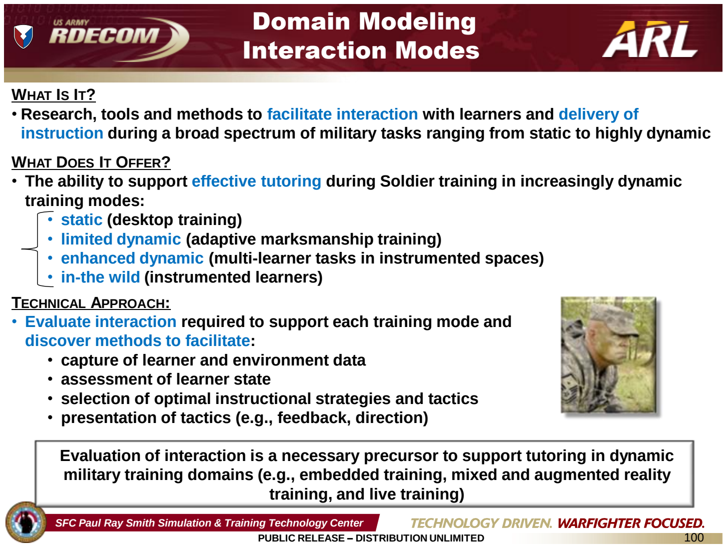
Domain models for typical ITSs today are in well-defined domains (math or physics are popular) and are generally procedural in nature (simple). Very few tutors cover psychomotor domains and are generally desktop and cognitive. ARL is exploring methods to expand domains to allow them to support tutoring in a wider range of domains and a broader range of dimensions, as shown in Slide 98.



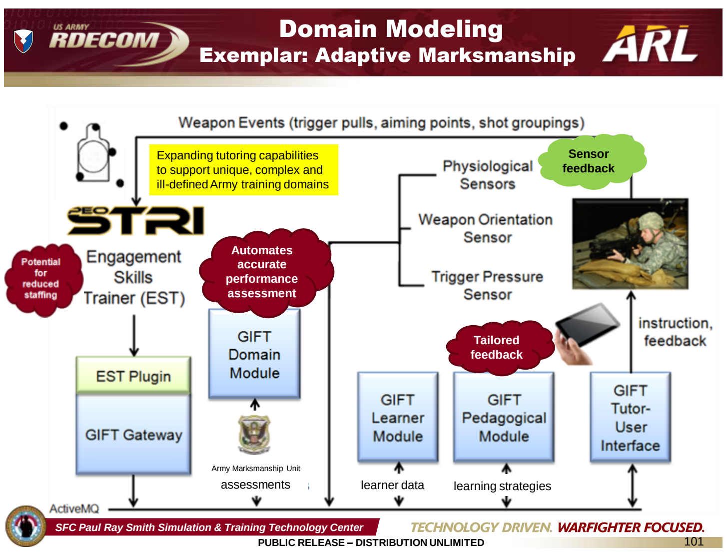
Dynamic interaction modes and their associated characteristics are explored in Slides 99 and 100.



Interaction Mode	Environment	Learner Position	Learner Motion	Sensors	Sensory Interaction	Individual /Team
static	indoor	seated	head motion, posture changes, gestures	desktop sensors (e.g., eye tracker, head pose estimation)	visual, aural, olfactory	individuals and network-enabled teams
limited kinetic	indoor in confined instrumented spaces	standing, crouching, kneeling, laying	same as static mode plus limited locomotion	same as static mode plus motion capture	visual, aural, olfactory, haptic	individuals and co-located teams
enhanced kinetic	indoor/outdoor in confined instrumented spaces	standing, crouching, kneeling, laying	same as static mode plus full locomotion	same as static mode plus motion capture	visual, aural, olfactory, haptic	individuals and co-located teams
in the wild	outdoor in unrestricted, uninstrumented spaces	standing, crouching, kneeling, laying	unrestricted natural movement	portable sensor suites including motion capture	visual, aural, olfactory, haptic	individuals and co-located teams



An example of a more dynamic psychomotor domain is presented in Slide 101.



7. Authoring

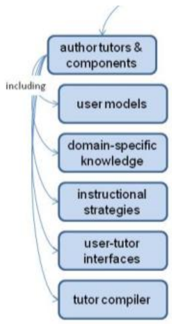
Authoring may be divided into 2 primary areas: reuse and automation. Improving methods to be able to use existing training environments as adaptive tutors is a major goal of our research. Automated authoring methods are the most critical need in ITS development today. Tutors are expensive and laborious to author, and they require sets of specialized skills to develop them. A long-term goal is to have any person with expert domain knowledge be able to author an effective tutoring system.

US ARMY RDECOM

Authoring Goals

ARL

Authoring Goals for GIFT
(adapted from Murray, 1999; Murray, 2003)



- **Decrease the effort (time, cost, and/or other resources) for authoring and assessing CBTS;**
- **Decrease the skill threshold by tailoring tools for specific disciplines to author, assess and employ CBTS;**
- **Provide tools to aid the designer/author/trainer /researcher organize their knowledge;**
- **Support (i.e., structure, recommend, or enforce) good design principles (in pedagogy, user interface, etc.);**
- **Enable rapid prototyping of CBTS to allow for rapid design/evaluation cycles of prototype capabilities.**
- **Employ standards to support rapid integration of external training/tutoring environments (e.g., games) (Sottilare & Gilbert, 2011)**

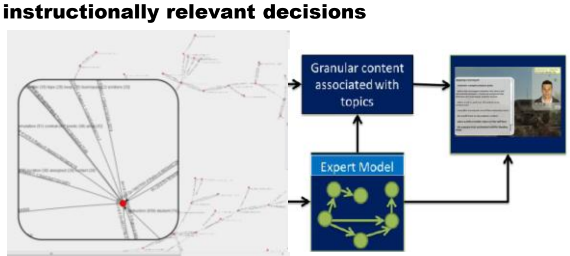
Sottilare, R. and Gilbert, S. (2011). Considerations for tutoring, cognitive modeling, authoring and interaction design in serious games. Authoring Simulation and Game-based Intelligent Tutoring workshop at the Artificial Intelligence in Education Conference (AIED) 2011, Auckland, New Zealand, June 2011.

US ARMY RDECOM

Authoring Approaches

ARL

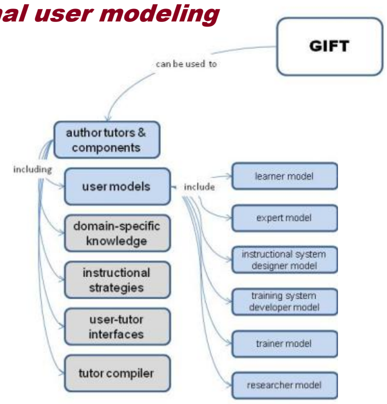
- ***Approach: Investigate methods and develop tools for rapid automated development of expert models***
  - **Expert model development is an intensive process**
  - **Exploring automated methods to author via text analysis**
  - **Integrate with tutoring system(s) which make instructionally relevant decisions**



Authoring Approaches

US ARMY RDECOM — ARL

- ***Approach: functional user modeling***
  - ***standard structures and graphical user interfaces for a variety of users***
  - ***GUIs based on function (e.g., researcher) and functional competency***
    - ***learners***
    - ***subject matter experts***
    - ***instructional system designers***
    - ***system developers***
    - ***trainers***
    - ***researchers***



Authoring Approaches

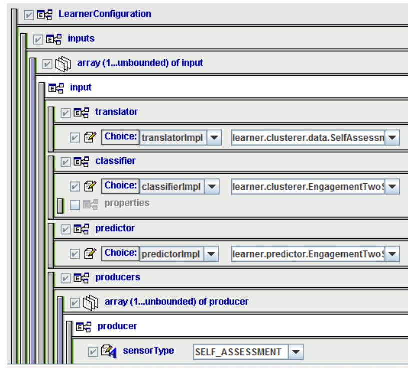
US ARMY RDECOM — ARL

- ***Approach: learner affect modeling***
  - ***what does the tutor need to know about the learner to classify their affect?***
  - ***how does the tutor get that information?***
  - ***which affective states are important to recognize?***
  - ***how does classification of state influence instructional decisions?***

Graesser and D'Mello (2012)

Authoring Approaches

- *Approach: learner configuration authoring tool*
  - **simple interface for authoring learner models**
  - **tree structure driven by XML schema**
  - **prevents learner model authoring errors by validating against the learner model XML schema**
  - **provides ability to validate learner model using GIFT source w/o having to launch the entire GIFT architecture**



Authoring Approaches

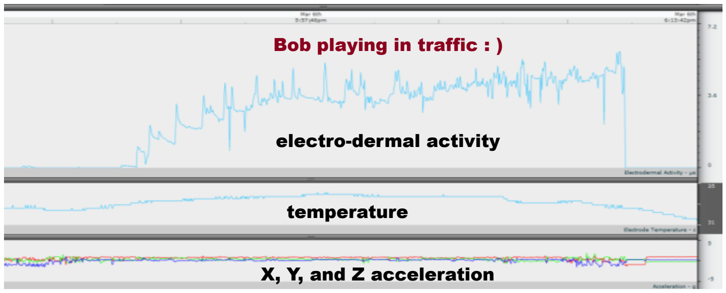
- *Approach: sensor configuration authoring tool*

- ***Implemented sensors***
  - ***Affectiva QSensor***
    - ***electro-dermal activity (EDA)***
    - ***skin temperature and acceleration***
  - ***Emotiv EEG***
  - ***temperature and humidity mouse (custom)***
  - ***Surrogate sensors for temp, humidity and assessment***

- ***behavioral sensors***
- ***physiological sensors***
- ***state classification models***

- ***Sensors under consideration***
  - ***NeuroSky and ABM EEGs***
  - ***Webcam (1Hz)***
  - ***Zephyr heart rate monitor***
  - ***Sonar distance sensor***
  - ***Pressure chair (custom)***
  - ***Pupil diameter (custom)***
  - ***Design Interactive EmoPro***

Passive Sensing – Q Sensor

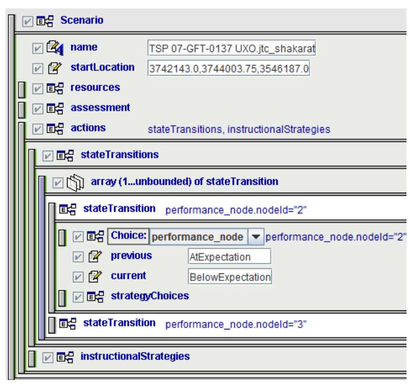


Research question: what is the minimum set of sensors needed to assess engagement, workload, motivational level and emotional state?

Authoring Approaches

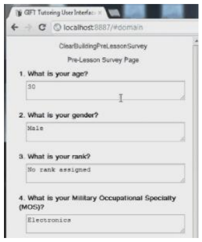
- *Approach: Domain Knowledge File (DKF) authoring tool (DAT)*

- simple interface for authoring DKFs
- tree structure driven by XML schema
- prevents DKF authoring errors by validating against DKF XML schema
- provides ability to validate DKF content using GIFT source w/o having to launch the entire GIFT architecture

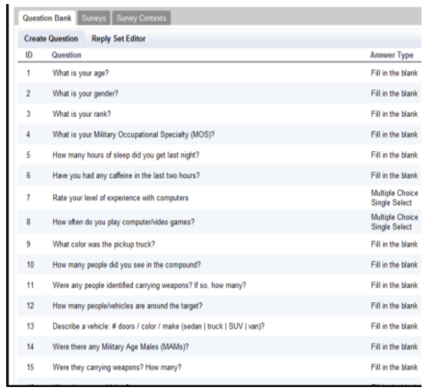


Authoring Approaches

- *Approach: survey authoring tool*



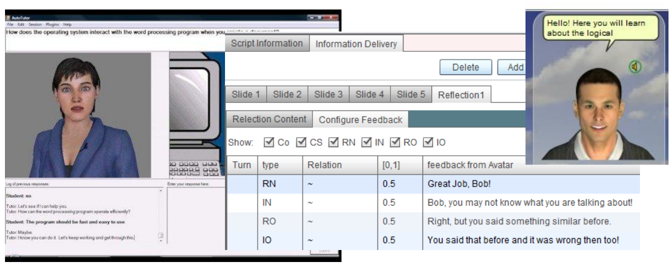
- *author questions*
- *author surveys*
- *assign surveys*
- *present surveys*



ID	Question	Answer Type
1	What is your age?	Fill in the blank
2	What is your gender?	Fill in the blank
3	What is your rank?	Fill in the blank
4	What is your Military Occupational Specialty (MOS)?	Fill in the blank
5	How many hours of sleep did you get last night?	Fill in the blank
6	Have you had any caffeine in the last two hours?	Fill in the blank
7	Rate your level of experience with computers	Multiple Choice Single Select
8	How often do you play computer/video games?	Multiple Choice Single Select
9	What color was the pickup truck?	Fill in the blank
10	How many people did you see in the compound?	Fill in the blank
11	Were any people identified carrying weapons? If so, how many?	Fill in the blank
12	How many people/vehicles are around the target?	Fill in the blank
13	Describe a vehicle: # doors / color / make (sedan | truck | SUV | van)?	Fill in the blank
14	Were there any Military Age Males (MAMs)?	Fill in the blank
15	Were they carrying weapons? How many?	Fill in the blank

Authoring Approaches

- *Approach: leverage elements of existing tutoring systems (e.g., AutoTutor & AutoTutor Lite)*



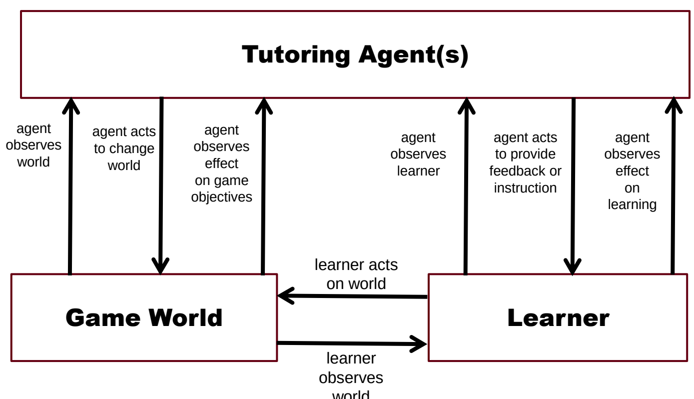
INSTITUTE for INTELLIGENT SYSTEMS

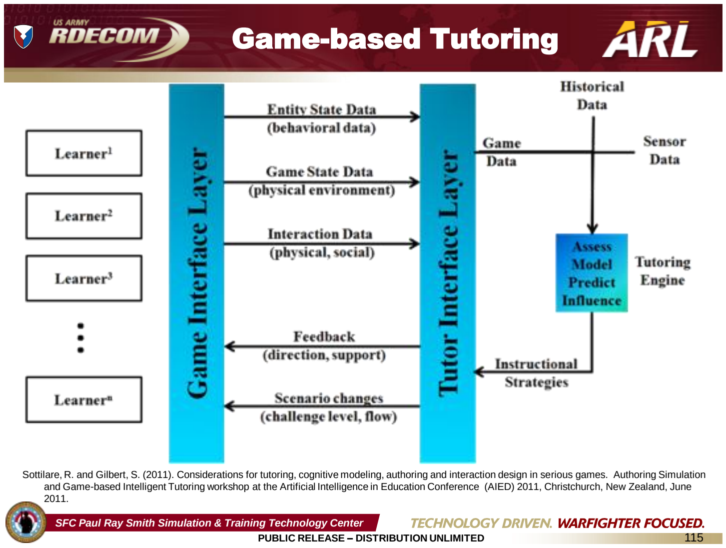
THE UNIVERSITY OF MEMPHIS. Dreamers. Thinkers. Doers.

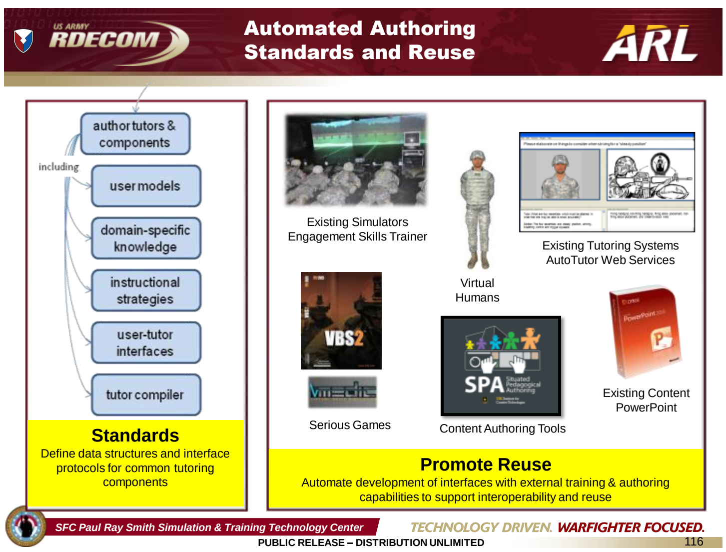
FedEx INSTITUTE OF TECHNOLOGY MEMPHIS

- ***Approach: game-based tutoring***

- ***prototype integration with VBS2***
- ***real-time feedback***
- ***learner model influences challenge level within game***




US ARMY
RDECOM
Game-based Tutoring
ARL
Learner1
Learner2
Learner3
Learnern
Game Interface Layer
Tutor Interface Layer
Entity State Data
(behavioral data)
Game State Data
(physical environment)
Interaction Data
(physical, social)
Feedback
(direction, support)
Scenario changes
(challenge level, flow)
Historical
Data
Game
Data
Sensor
Data
Assess
Model
Predict
Influence
Tutoring
Engine
Instructional
Strategies
Sottilare, R. and Gilbert, S. (2011). Considerations for tutoring, cognitive modeling, authoring and interaction design in serious games. Authoring Simulation and Game-based Intelligent Tutoring workshop at the Artificial Intelligence in Education Conference (AIED) 2011, Christchurch, New Zealand, June 2011.
SFC Paul Ray Smith Simulation & Training Technology Center
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
PUBLIC RELEASE – DISTRIBUTION UNLIMITED
115


US ARMY
RDECOM
Automated Authoring
Standards and Reuse
ARL
author tutors & components
including
user models
domain-specific knowledge
instructional strategies
user-tutor interfaces
tutor compiler
Standards
Define data structures and interface protocols for common tutoring components
Existing Simulators
Engagement Skills Trainer
Virtual
Humans
Existing Tutoring Systems
AutoTutor Web Services
VBS2
Serious Games
SPA
Content Authoring Tools
Existing Content
PowerPoint
Promote Reuse
Automate development of interfaces with external training & authoring capabilities to support interoperability and reuse
SFC Paul Ray Smith Simulation & Training Technology Center
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
PUBLIC RELEASE – DISTRIBUTION UNLIMITED
116

Automated Authoring
Expert Modeling

What Is It?

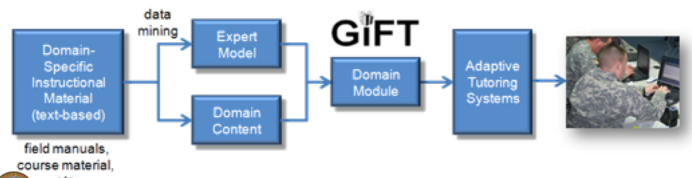
- Tools, and methods to automate the development of expert models (modeling desired trainee behaviors) for use by adaptive tutors;
- Expert models, part of the GIFT domain module, are used to assess learner performance and the correctness of learner actions during tutoring

What Does It Offer?

- Reduced time, cost, and skill needed to develop expert models for training domains

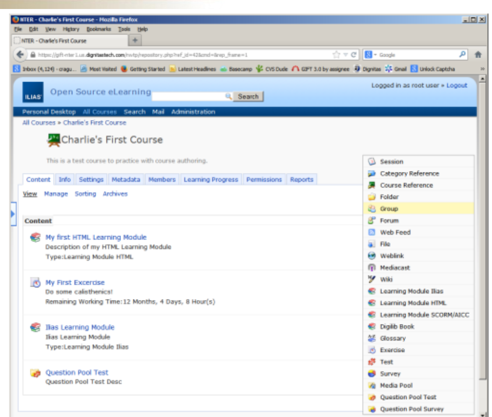
Technical Approach:

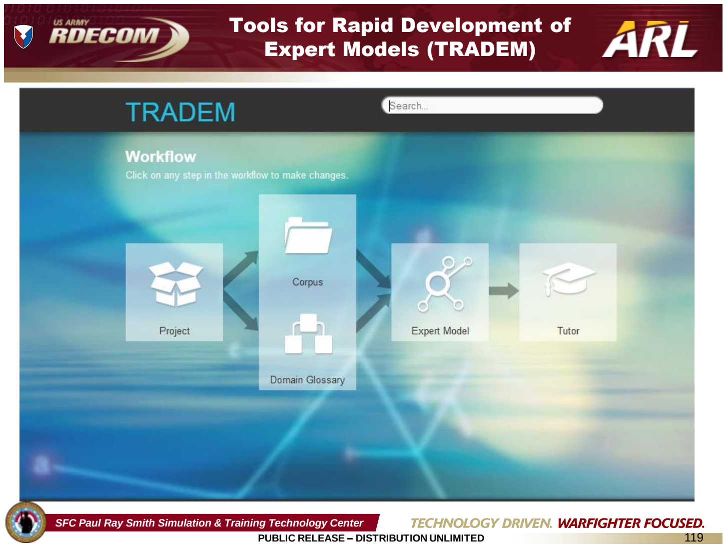
- Investigate and develop methods to automate expert model authoring by extracting rules, principles, tasks, standards, conditions and hierarchical relationships from text in field manuals and other text-based data sources through data mining techniques

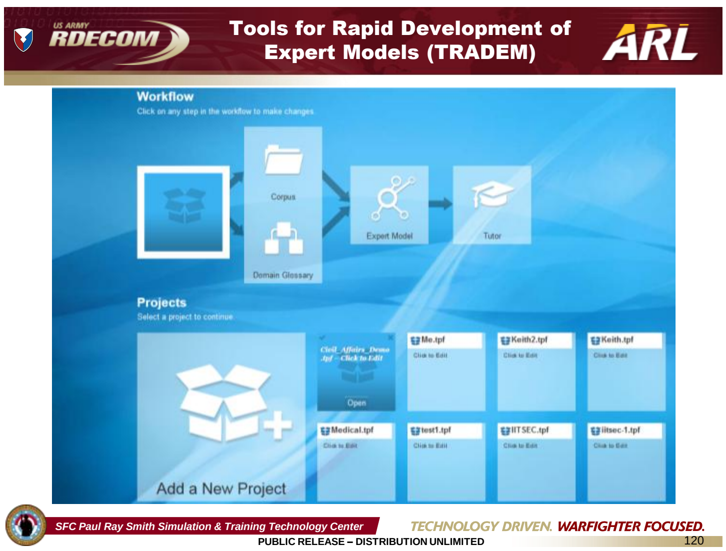


Authoring Reuse: Interoperability with External Environments

DOE's National Training & Education Resource (NTER)




US ARMY
RDECOM
Tools for Rapid Development of Expert Models (TRADEM)
ARL
TRADEM
Search...
Workflow
Click on any step in the workflow to make changes.
Project
Corpus
Domain Glossary
Expert Model
Tutor
SFC Paul Ray Smith Simulation & Training Technology Center
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
PUBLIC RELEASE – DISTRIBUTION UNLIMITED
119


US ARMY
RDECOM
Tools for Rapid Development of Expert Models (TRADEM)
ARL
Workflow
Click on any step in the workflow to make changes.
Corpus
Domain Glossary
Expert Model
Tutor
Projects
Select a project to continue.
Add a New Project
Me.tpf
Keith2.tpf
Keith.tpf
Open
Medical.tpf
test1.tpf
IITSEC.tpf
iitsec-1.tpf
SFC Paul Ray Smith Simulation & Training Technology Center
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
PUBLIC RELEASE – DISTRIBUTION UNLIMITED
120

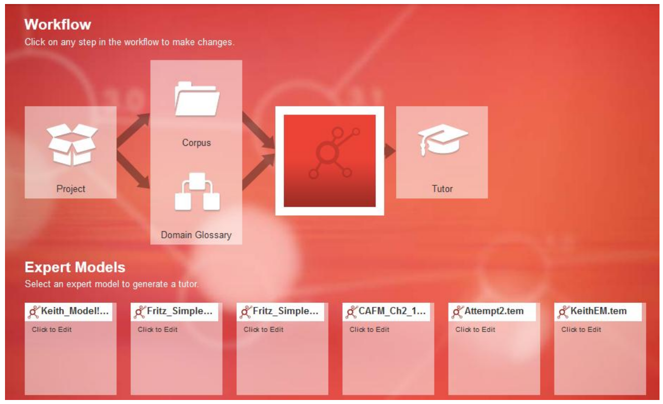
Tools for Rapid Development of Expert Models (TRADEM)

Tools for Rapid Development of Expert Models (TRADEM)

US ARMY RDECOM

Tools for Rapid Development of Expert Models (TRADEM)

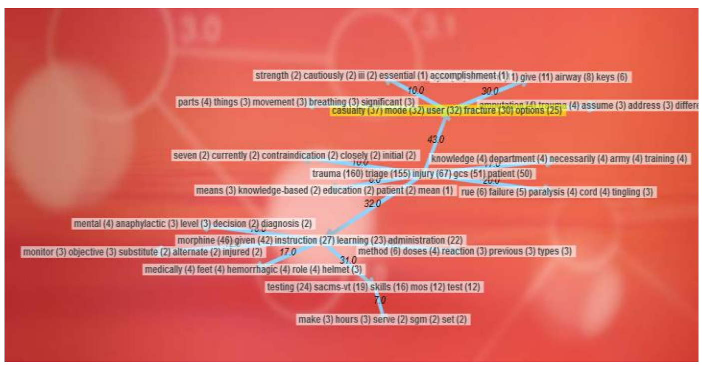
ARL



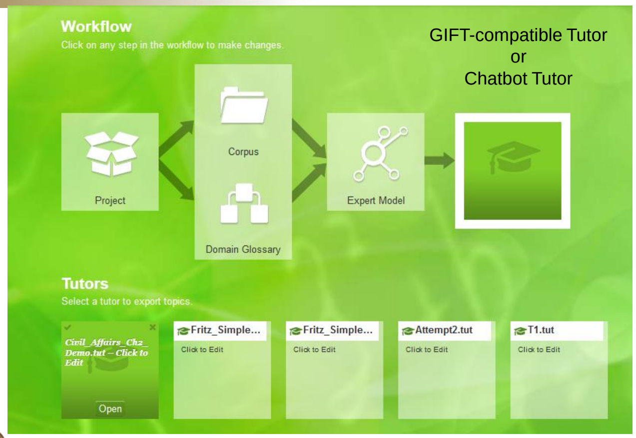
US ARMY RDECOM

Tools for Rapid Development of Expert Models (TRADEM)

ARL



Tools for Rapid Development of Expert Models (TRADEM)

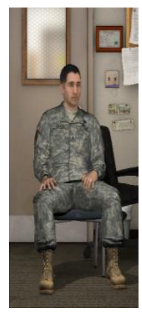


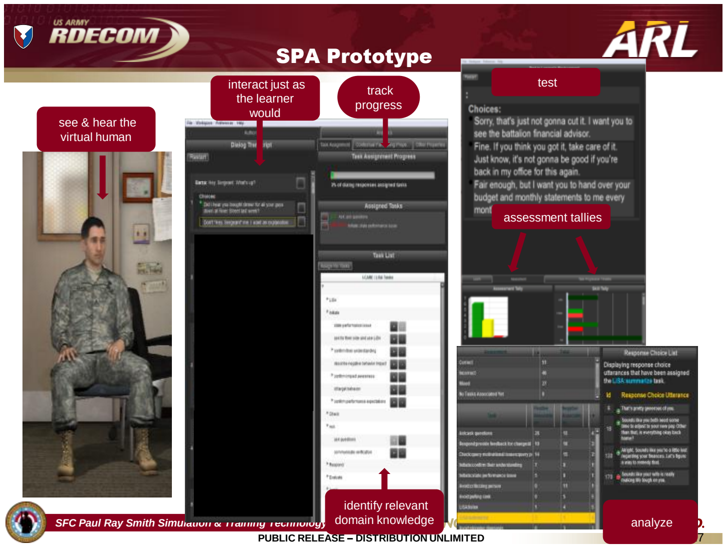
Situated Pedagogical Authoring

- What is it?
  - Providing ITS content in an environment that is as *similar to the learner's environment as possible*
  - think WYSIWYG

- Hypotheses: Situated authoring will enable authors to…
  - Gain competence with the authoring tool more quickly
  - Produce more *complete* and *pedagogically effective* intelligent tutoring content

  (than less situated authoring tools)

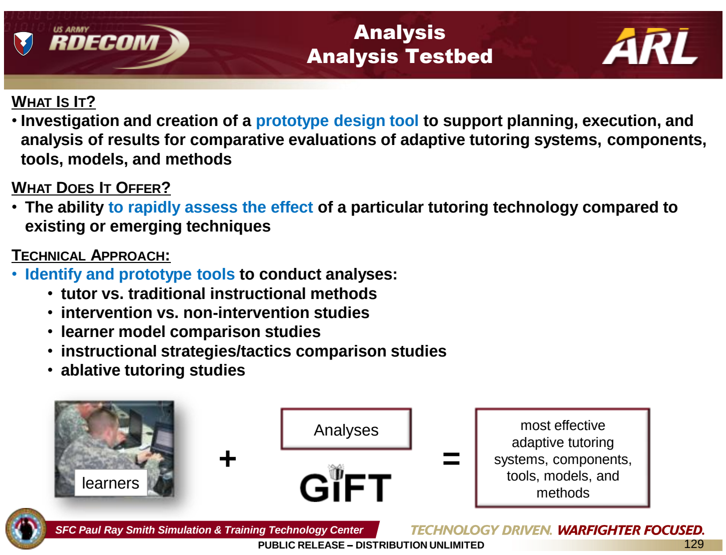




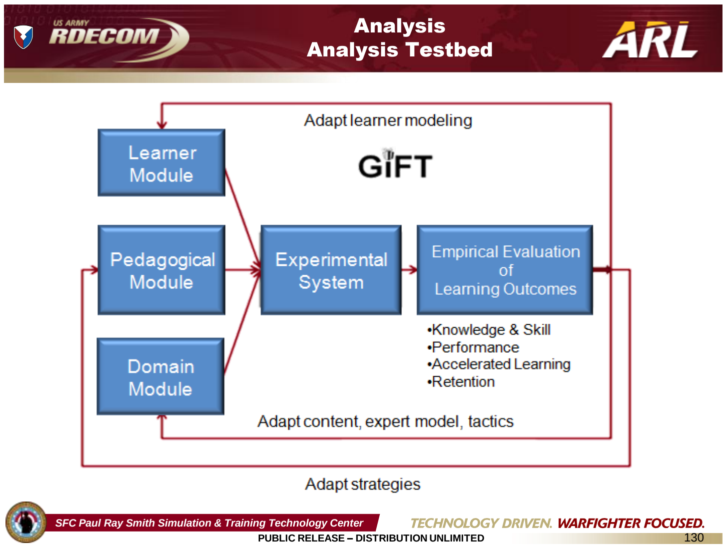
8. Analysis of Effect

An important part of ITS research is to determine the best (most effective) methods of learner modeling, instructional management (pedagogical strategies/recommendations), and domain modeling (e.g., expert modeling, assessment, and content and tactics presentation) to optimize outcomes (e.g., learning, performance, retention, competence).

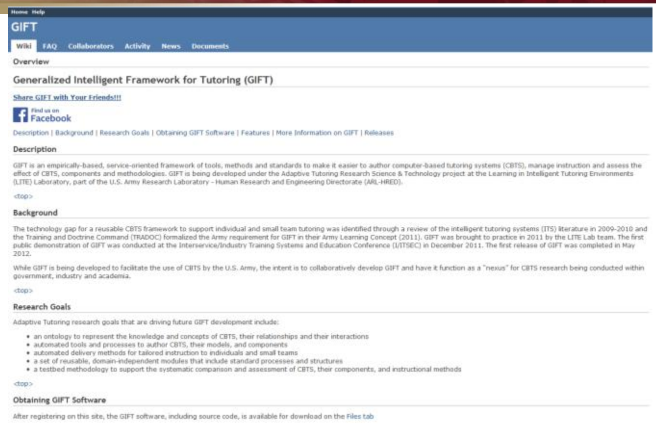
How might this research and analysis be enabled?



The analysis test bed within GIFT allows for scientific evaluation of each element and subelements of a tutoring system design. The test-bed methodology shown in Slide 130 is based on Hanks et al.'s (1993) test-bed approach. Effect sizes analyzed using this test bed are based on Cohen's *d* (1992).



GIFT available at www.GIFTtutoring.org



Home Help

GIFT

Wiki FAQ Collaborators Activity News Documents

Overview

Generalized Intelligent Framework for Tutoring (GIFT)

Share GIFT with Your Friends!!!

Find us on Facebook

Description | Background | Research Goals | Obtaining GIFT Software | Features | More Information on GIFT | Releases

Description

GIFT is an empirically-based, service-oriented framework of tools, methods and standards to make it easier to author computer-based tutoring systems (CBTS), manage instruction and assess the effect of CBTS, components and methodologies. GIFT is being developed under the Adaptive Tutoring Research Science & Technology project at the Learning in Intelligent Tutoring Environments (LITE) Laboratory, part of the U.S. Army Research Laboratory - Human Research and Engineering Directorate (ARL-HRED).

<top>

Background

The technology gap for a reusable CBTS framework to support individual and small team tutoring was identified through a review of the intelligent tutoring systems (ITS) literature in 2009-2010 and the Training and Doctrine Command (TRADOC) formalized the Army requirement for GIFT in their Army Learning Concept (2011). GIFT was brought to practice in 2011 by the LITE Lab team. The first public demonstration of GIFT was conducted at the Interservice/Industry Training Systems and Education Conference (I/ITSEC) in December 2011. The first release of GIFT was completed in May 2012.

While GIFT is being developed to facilitate the use of CBTS by the U.S. Army, the intent is to collaboratively develop GIFT and have it function as a "nexus" for CBTS research being conducted within government, industry and academia.

<top>

Research Goals

Adaptive Tutoring research goals that are driving future GIFT development include:

- an ontology to represent the knowledge and concepts of CBTS, their relationships and their interactions
- automated tools and processes to author CBTS, their models, and components
- automated delivery methods for tailored instruction to individuals and small teams
- a set of reusable, domain-independent modules that include standard processes and structures
- a testbed methodology to support the systematic comparison and assessment of CBTS, their components, and instructional methods

<top>

Obtaining GIFT Software

After registering on this site, the GIFT software, including source code, is available for download on the Files tab

Demo of GIFT Tools

Thank you for your attention!

Questions?

Bibliography

Anderson JR, Corbett AT, Koedinger KR, Pelletier R. Cognitive tutors: lessons learned. The Journal of the Learning Sciences. 1995;4:167–207.

Anderson LW, Krathwohl DR. A taxonomy for learning, teaching and assessing: a revision of bloom's taxonomy of educational objectives: complete edition. New York (NY): Longman; 2001.

Army Training and Doctrine Command (US). The United States Army learning concept for 2015. Fort Monroe (VA): Army Training and Doctrine Command (US); 2011.

Baker RSJd, Gowda SM, Wixon M, Kalka J, Wagner AZ, Salvi A, Aleven V, Kusbit G, Ocumpaugh J, Rossi L. Sensor-free automated detection of affect in a cognitive tutor for algebra. In: Proceedings of the 5th International Conference on Educational Data Mining; 2012 Jun 19–21; Chania, Greece; p.126–133.

Bloom BS. The 2 sigma problem: the search for methods of group instruction as effective as one-to-one tutoring. Educational Researcher. 1984;13(6):6.

Brawner KW. Modeling learner mood in realtime through biosensors for intelligent tutoring improvements. [doctoral dissertation]. [Orlando (FL)]: University of Central Florida; 2013.

Brawner K, Goldberg B. Realtime monitoring of ECG and GSR signals during computer-based training. In: Proceedings of the Intelligent Tutoring Systems (ITS) Conference; 2012; Chania, Crete, Greece.

Brawner K, Holden H, Goldberg B, Sottilare R. Recommendations for modern tools to author tutoring systems. In: Proceedings of the Interservice/Industry Training Systems & Education Conference; 2012 Dec; Orlando, FL.

Carroll M, Kokini C, Champney R, Fuchs S, Sottilare R, Goldberg B. Assessing trainee states in intelligent tutoring systems: using low cost sensors for affective and cognitive state modeling. Interservice/Industry Training Systems & Education Conference; 2011 Dec; Orlando, FL.

Cohen J. Quantitative methods in psychology: a power primer. Psychological Bulletin. American Psychological Association, Inc. 1992;112(1):155–159.

Cohen PA, Kulik JA, Kulik CLC. Educational outcomes of tutoring: a meta-analysis of findings. American Educational Research Journal. 1982;19:237–248.

Dillon TJ. Questioning and teaching: a manual of practice. New York (NY): Teachers College Press; 1988.

Fletcher JD, Sottilare R. Shared mental models and intelligent tutoring for teams. In: Sottilare R, Hu X, Graesser A, Holden H, editors. Design recommendations for intelligent tutoring systems: learner modeling, volume I. Adelphi (MD): Army Research Laboratory (US); 2013.

Goldberg B. Explicit feedback within game-based training: examining the influence of source modality effects on interaction. [doctoral dissertation]. [Orlando (FL)]: University of Central Florida; 2013.

Goldberg B, Brawner K. Efficacy of measuring engagement during computer-based training with low-cost electroencephalogram (EEG) sensor outputs. Proceedings of Human Factors and Ergonomics Society Annual Meeting (HFES2012); 2012; Boston, MA.

Goldberg B, Brawner KW, Sottilare R, Tarr R, Billings DR, Malone N. Use of evidence-based strategies to enhance the extensibility of adaptive tutoring technologies. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference; I/ITSEC. 2012; Orlando, FL.

Goleman D. Emotional intelligence. New York (NY): Bantam Books; 1995.

Graesser AC, D'Mello S. Emotions during the learning of difficult material. In: Ross BH, editor. Psychology of learning and motivation. New York (NY): Academic Press; 2012. Volume 57; Chapter 5; p. 183–225. ISSN 0079-7421, ISBN 978012-3942937, 10.1016/B978-0-12-394293-7.00005-4.

Graesser AC, McNamara DS. Self-regulated learning in learning environments with pedagogical agents that interact in natural language. Educational Psychologist. 2010;45:234–244.

Graesser AC, Person NK. Question asking during tutoring. American Educational Research Journal. 1994;31:104–137.

Hanks S, Pollack ME, Cohen PR. Benchmarks, test beds, controlled experimentation, and the design of agent architectures. AI Magazine. 1993;14 (4).

Holden H. Understanding the interaction behavior of pedagogical agents' emotional support and competency on learner outcomes and agent perceptions. In: Proceedings of the Intelligent Tutoring Systems (ITS) 2012 Conference; 2012; Chania, Crete, Greece.

Holden H, Goldberg B. Student expectations and tutor acceptance: the impact on student affect (mood) and future usage intentions. international defense & homeland security simulation workshop. In: Proceedings of the I3M Conference. 2011 Sep; Rome, Italy.

Holden H, Sottilare R, Goldberg B, Brawner K. Effective learner modeling for computer-based tutoring of cognitive and affective tasks. In: Proceedings of the Interservice/Industry Training Systems & Education Conference; 2012 Dec; Orlando, FL.

Honey MA, Hilton M, editors. Learning science through computer games and simulations. Washington (DC): National Academies Press; 2011.

Hunt E, Minstrell J. A cognitive approach to the teaching of physics. In: McGilly K, editor. Classroom Lessons. Cambridge (MA): MIT Press; 1994. p. 51–74.

Kim Y. Desirable characteristics of learning companions. International Journal of Artificial Intelligence in Education. 2007;17(04):371–388.

Kim Y, Baylor AL, Shen E. PALS Group. Pedagogical agents as learning companions: the impact of agent affect and gender. Journal of Computer-Assisted Learning. 2007;23(03):220–234.

Kim Y, Xu B, Sharif A. Pedagogical agents rendering social context to an online learning environment MathGirls. International Transactions on Systems Science and Applications. 2008;4(2):99–106.

Kokini C, Carroll M, Ramirez-Padron WX, Hale K, Sottilare R, Goldberg B. Quantification of trainee affective and cognitive state in real-time. In: Proceedings of Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC2012). 2012; Orlando, FL.

Krathwohl DR, Bloom BS, Masia BB. Taxonomy of educational objectives: handbook II: affective domain. New York (NY): David McKay Co.; 1964.

Lepper MR, Drake M, O'Donnell-Johnson TM. Scaffolding techniques of expert human tutors. In: Hogan K, Pressley M, editors. Scaffolding student learning: instructional approaches and issues. New York (NY): Brookline Books; 1997. p. 108–144.

Lepper M, Woolverton M. The wisdom of practice: lessons learned from the study of highly effective tutors. In: Aronson J, editor. Improving academic achievement: impact of psychological factors on education. New York (NY): Academic Press; 2002. p. 135–158.

Lesgold AM, Lajoie S, Bunzo M, Eggan G. Sherlock: a coached practice environment for an electronics trouble shooting job. Pittsburgh (PA): University of Pittsburgh, Learning Research and Development Center; 1988.

Mehrabian A. Pleasure-arousal-dominance: a general framework for describing and measuring individual differences in temperament. Current Psychology. 1996;14:261–292.

Merrill D, Reiser B, Ranney M, Trafton J. Effective tutoring techniques: a comparison of human tutors and intelligent tutoring systems. The Journal of the Learning Sciences. 1992;2(3):277–305.

Murray T. Authoring intelligent tutoring systems: an analysis of the state of the art. International Journal of Artificial Intelligence in Education. 1999;10(1):98–129.

Murray T. An overview of intelligent tutoring system authoring tools: updated analysis of the state of the art. In: Murray T, Blessing S, Ainsworth S, editors. Authoring tools for advanced technology learning environments. Dordrecht (The Netherlands): Kluwer Academic Publishers; 2003. p. 491–545.

Ocumpaugh J, Baker RSJd, Rodrigo MMT. Baker-Rodrigo observation method protocol (BROMP) 1.0. Training Manual Ver. 1.0. New York (NY): EdLab, Teachers College, Columbia University; 2012.

Person NK, Graesser AC. The Tutoring Research Group. Fourteen facts about human tutoring: food for thought for ITS developers. AI-ED 2003 Workshop Proceedings on Tutorial Dialogue Systems: With a View Toward the Classroom; 2003; Sydney, Australia. p. 335–344.

Person NK, Kreuz RJ, Zwaan RA, Graesser AC. Pragmatics and pedagogy: conversational rules and politeness strategies may inhibit effective tutoring. Cognition and Instruction. 1995;13(2):161–188.

Rose CP, Jordan PW, Ringenberg M, Siler S, Vanlehn K, Weinstein A. Interactive conceptual tutoring in Atlas-Andes. In: Moore JD, Redfield C, Johnson WL, editors. Artificial intelligence in education: AI-Ed in the wired and wireless future. Washington (DC): IOS; 2001. p. 256–266.

Simpson E. The classification of educational objectives in the psychomotor domain: the psychomotor domain. Vol. 3. Washington (DC): Gryphon House; 1972.

Soller A. Supporting social interaction in an intelligent collaborative learning system. International Journal of Artificial Intelligence in Education. 2001;12(1):40–62.

Sottilare R. Considerations in the development of an ontology for a generalized intelligent framework for tutoring. International defense & homeland security simulation workshop. In: Proceedings of the I3M Conference; 2012 Sep; Vienna, Austria.

Sottilare R. Characterizing an adaptive tutoring learning effect chain for individual and team tutoring. In: Proceedings of the Interservice/Industry Training Systems & Education Conference; 2013 Dec; Orlando, FL.

Sottilare R. Future concepts for learner modeling. In: Sottilare R, Hu X, Graesser A, Holden H, editors. Design recommendations for intelligent tutoring systems: learner modeling, volume I. Army Research Laboratory (US); 2013.

Sottilare R, Gilbert S. Considerations for tutoring, cognitive modeling, authoring and interaction design in serious games. Authoring Simulation and Game-Based Intelligent Tutoring workshop at the Artificial Intelligence in Education Conference (AIED); 2011 Jun; Auckland, New Zealand.

Sottilare R, Goldberg B. Designing adaptive computer-based tutors to accelerate learning and facilitate retention. Journal of Cognitive Technology: Contributions of Cognitive Technology to Accelerated Learning and Expertise. 2012;17(1):19–34.

Sottilare R, Goldberg S. Research gaps for adaptive computer-based tutoring systems. In: Best C, Galanis G, Kerry J, Sottilare R, editors. Fundamental issues in defence simulation & training. London (UK): Ashgate Publishing; 2013.

Sottilare R, Goldberg B, Brawner K, Holden H. A modular framework to support the authoring and assessment of adaptive computer-based tutoring systems (CBTS). In: Proceedings of the Interservice/Industry Training Systems & Education Conference; 2012 Dec; Orlando, FL.

Sottilare R, Holden H, Brawner K, Goldberg B. Challenges and emerging concepts in the development of adaptive, computer-based tutoring systems for team training. In: Proceedings of the Interservice/Industry Training Simulation & Education Conference; 2011 Dec; Orlando, FL.

Sottilare R, Holden H, Goldberg B, Brawner K. The generalized intelligent framework for tutoring (GIFT). In: Best C, Galanis G, Kerry J, Sottilare R, editors. Fundamental issues in defence simulation & training. London (UK): Ashgate Publishing; 2013.

Sottilare R, Proctor M. Passively classifying student mood and performance within intelligent tutoring systems (ITS). Educational Technology Journal & Society. 2012;15(2):101–114.

VanLehn K. The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. Educational Psychologist. 2011;46(4):197–221.

VanLehn K, Lynch C, Schulze K, Shapiro JA, Shelby R, Taylor L, et al. The Andes physics tutoring system: lessons learned. International Journal of Artificial Intelligence and Education. 2005;15(3):147–204.

Vygotsky LS. Mind in society: the development of higher psychology processes. Cambridge (MA): Harvard University Press; 1978.

Woolf BP. A roadmap for education technology. Arlington (VA): National Science Foundation; 2010. Report No.: 0637190.

1 (PDF) DEFENSE TECHNICAL
INFORMATION CTR
DTIC OCA

2 (PDF) DIRECTOR
US ARMY RESEARCH LAB
RDRL CIO LL
IMAL HRA MAIL & RECORDS MGMT

1 (PDF) GOVT PRINTG OFC
A MALHOTRA

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM D
T DAVIS
BLDG 5400 RM C242
REDSTONE ARSENAL AL 35898-7290

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRS EA DR V J RICE
BLDG 4011 RM 217
1750 GREELEY RD
FORT SAM HOUSTON TX 78234-5002

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM DG J RUBINSTEIN
BLDG 333
PICATINNY ARSENAL NJ 07806-5000

1 (PDF) ARMY RSCH LABORATORY – HRED
ARMC FIELD ELEMENT
RDRL HRM CH C BURNS
THIRD AVE BLDG 1467B RM 336
FORT KNOX KY 40121

1 (PDF) ARMY RSCH LABORATORY – HRED
AWC FIELD ELEMENT
RDRL HRM DJ D DURBIN
BLDG 4506 (DCD) RM 107
FORT RUCKER AL 36362-5000

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM CK J REINHART
10125 KINGMAN RD BLDG 317
FORT BELVOIR VA 22060-5828

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM AY M BARNES
2520 HEALY AVE
STE 1172 BLDG 51005
FORT HUACHUCA AZ 85613-7069

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM AP D UNGVARSKY
POPE HALL BLDG 470
BCBL 806 HARRISON DR
FORT LEAVENWORTH KS 66027-2302

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM AT J CHEN
12423 RESEARCH PKWY
ORLANDO FL 32826-3276

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM AT C KORTENHAUS
12350 RESEARCH PKWY
ORLANDO FL 32826-3276

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM CU B LUTAS-SPENCER
6501 E 11 MILE RD MS 284
BLDG 200A 2ND FL RM 2104
WARREN MI 48397-5000

1 (PDF) ARMY RSCH LABORATORY – HRED
FIRES CTR OF EXCELLENCE
FIELD ELEMENT
RDRL HRM AF C HERNANDEZ
3040 NW AUSTIN RD RM 221
FORT SILL OK 73503-9043

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM AV W CULBERTSON
91012 STATION AVE
FORT HOOD TX 76544-5073

1 (PDF) ARMY RSCH LABORATORY – HRED
RDRL HRM DE A MARES
1733 PLEASONTON RD BOX 3
FORT BLISS TX 79916-6816

8 (PDF) ARMY RSCH LABORATORY – HRED
SIMULATION & TRAINING
TECHNOLOGY CENTER
RDRL HRT COL G LAASE
RDRL HRT I MARTINEZ
RDRL HRT T R SOTTILARE
RDRL HRT B N FINKELSTEIN
RDRL HRT G A RODRIGUEZ
RDRL HRT I J HART
RDRL HRT M C METEVIER
RDRL HRT S B PETTIT
12423 RESEARCH PARKWAY
ORLANDO FL 32826

1 (PDF)	ARMY RSCH LABORATORY – HRED HQ USASOC RDRL HRM CN R SPENCER BLDG E2929 DESERT STORM DRIVE FORT BRAGG NC 28310
1 (PDF)	ARMY G1 DAPE MR B KNAPP 300 ARMY PENTAGON RM 2C489 WASHINGTON DC 20310-0300

<u>ABERDEEN PROVING GROUND</u>

12 (PDF)	DIR USARL RDRL HR L ALLENDER P FRANASZCZUK RDRL HRM P SAVAGE-KNEPSHIELD RDRL HRM AL C PAULILLO RDRL HRM B J GRYNOVICKI RDRL HRM C L GARRETT RDRL HRS J LOCKETT RDRL HRS B M LAFIANDRA RDRL HRS C K MCDOWELL RDRL HRS D A SCHARINE RDRL HRS E D HEADLEY RDRL HRT T R SOTTILARE

INTENTIONALLY LEFT BLANK.