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Adaptive Training and Education Research at the US Army Research Laboratory: Bibliography (2016–2017)

by Robert A Sottolare

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by Robert A Sottolare

Human Research and Engineering Directorate, ARL

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1. Introduction

Adaptive training and educational instruction provides tailored experiences that are guided by computer-based intelligent tutoring systems. This report provides a comprehensive bibliography of publications produced from 2016 through 2017 under the direction of the US Army Research Laboratory's (ARL's) adaptive training and education research program. The bibliography includes references for journal articles, technical reports, and conference papers produced by ARL employees and contractors to support the development of the Generalized Intelligent Framework for Tutoring (GIFT) prototypes during this period to provide an open-source architecture for authoring, delivering, and evaluating adaptive instruction. In addition to the GIFT symposia, conference papers were produced and presented at a variety of technical venues that included, but were not limited to, the following organizations' conferences: Interservice/Industry Training, Simulation and Education, Artificial Intelligence in Education, Intelligent Tutoring Systems, Human Factors and Ergonomics, Applied Human Factors and Ergonomics, Augmented Cognition, Defense and Homeland Security Simulation, and Florida Artificial Intelligence Research Society. Contributors to these publications included members of US government agencies, academic institutions worldwide, and industry in the modeling, simulation, and training industrial base. References are arranged in reverse chronological order grouped by their year of publication.

2. Bibliography

2017 Publications

Special Issue on the Generalized Intelligent Framework for Tutoring (GIFT): Creating a Stable and Flexible Platform for Innovations in AIED Research

Abstract: The goal of this research was the development of a practical architecture for the computer-based tutoring of teams. This article examines the relationship of team behaviors as antecedents to successful team performance and learning during adaptive instruction guided by Intelligent Tutoring Systems (ITSs). Adaptive instruction is a training or educational experience tailored by artificially-intelligent, computer-based tutors with the goal of optimizing learner outcomes (e.g., knowledge and skill acquisition, performance, enhanced retention, accelerated

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environments). The core contribution of this research was the identification of behavioral markers associated with the antecedents of team performance and learning thus enabling the development and refinement of teamwork models in ITS architectures. Teamwork focuses on the coordination, cooperation, and communication among individuals to achieve a shared goal. For ITSs to optimally tailor team instruction, tutors must have key insights about both the team and the learners on that team. To aid the modeling of teams, we examined the literature to evaluate the relationship of teamwork behaviors (e.g., communication, cooperation, coordination, cognition, leadership/coaching, and conflict) with team outcomes (learning, performance, satisfaction, and viability) as part of a large-scale meta-analysis of the ITS, team training, and team performance literature. While ITSs have been used infrequently to instruct teams, the goal of this meta-analysis make team tutoring more ubiquitous by: identifying significant relationships between team behaviors and effective performance and learning outcomes; developing instructional guidelines for team tutoring based on these relationships; and applying these team tutoring guidelines to the Generalized Intelligent Framework for Tutoring (GIFT), an open source architecture for authoring, delivering, managing, and evaluating adaptive instructional tools and methods. In doing this, we have designed a domain-independent framework for the adaptive instruction of teams.

Keywords: Team tutoring. Teamwork. Taskwork. Adaptive instruction. Team-based instruction. Team learning. Team performance. Team satisfaction. Team viability. Collective. Collective training. Collaborative learning.

Citation: Sottolare, R.A., Graesser, A.C., Lester, J., & Baker, R. (2017). Special Issue on the Generalized Intelligent Framework for Tutoring (GIFT): Creating a Stable and Flexible Platform for Innovations in AIED Research. *International Journal of Artificial Intelligence in Education*. DOI: 10.1007/s40593-017-0149-9.

Reusing Evidence in Assessment and Intelligent Tutors

Abstract: Assessment design methodologies such as evidence-centered design (ECD) provide an approach for representing the “argument” underlying an assessment. Argument-based structures articulate the chain of reasoning connecting task-level data to the evidence required to support assessment claims about the student. Intelligent tutoring systems (ITSs) reflect similar underlying rationale, with decisions about how to update the student model and what to present to the student next, dependent on student performance (evidence). Although the concept of “evidence” is widely used within the assessment community, it is less well articulated in the ITS literature. In this chapter, we argue for the necessity of

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facilitate the use of evidence in ITSs. Explicitly representing evidence may provide a stronger theoretical basis for an ITS and facilitate the reuse of assessment components across ITSs. Furthermore, additions to the Generalized Intelligent Framework for Tutoring (GIFT) may support defining links from observable evidence to claims (number of links, types of evidence, types of observables, and properties) as well as mechanisms for quantifying evidence. Several examples illustrate how this approach facilitates reuse and handling of evidence in the areas of conversation-based assessment and GIFT-medical prototypes.

Keywords: Intelligent tutors. Concept of evidence. Generalized Intelligent Framework for Tutoring.

Citation: Zapata-Rivera, D., Brawner, K., Jackson, G. T., & Katz, I. R. –Reusing Evidence in Assessment and Intelligent Tutors. *Design Recommendations for Intelligent Tutoring Systems*, 125.

Affect Dynamics in Military Trainees using vMedic: From Engaged Concentration to Boredom to Confusion

Abstract: The role of affect in learning has received increasing attention from AIED researchers seeking to understand how emotion and cognition interact in learning contexts. The dynamics of affect over time have been explored in a variety of research environments, allowing researchers to determine the extent to which common patterns are captured by hypothesized models. This paper present an analysis of affect dynamics among learners using vMedic, which teaches combat medicine protocols as part of the military training at West Point, the United States Military Academy. In doing so, we seek both to broaden the variety of learning contexts being explored in order better understand differences in these patterns and to test the theoretical predictions on the development of affect over time.

Keywords: Affect dynamics. Emotion and cognition interaction. Military training.

Citation: Ocumpaugh, J., Andres, J. M., Baker, R., DeFalco, J., Paquette, L., Rowe, J., ... & Sottilare, R. (2017, June). Affect Dynamics in Military Trainees using vMedic: From Engaged Concentration to Boredom to Confusion. In *International Conference on Artificial Intelligence in Education* (pp. 238-249). Springer, Cham.

Generalized Intelligent Framework for Tutoring (GIFT) Cloud/Virtual Open Campus Quick Start Guide (Revision 1)

Abstract: This document serves as the quick-start guide for GIFT Cloud, the web-based application version of the Generalized Intelligent Framework for Tutoring (GIFT). GIFT is a modular, open-source framework for building, deploying, and managing adaptive training content. GIFT Cloud allows learners, authors, and researchers to access GIFT without downloading and installing software on a desktop or laptop computer. The purpose of this document is to provide an overview of the primary interfaces and basic functions of GIFT Cloud. Topics include establishing a GIFT Account, taking courses on GIFT Cloud, orienting the user to GIFT's authoring tools, and locating resources and providing feedback on GIFT Cloud. This document serves as a revision to ARL-CR-0796, to reflect recent developments to GIFT interfaces, processes, and terminology.

Keywords: Generalized Intelligent Framework for Tutoring. Virtual open campus. GIFT cloud. GIFT authoring tools.

Citation: Ososky, S. (2017). Generalized Intelligent Framework for Tutoring (GIFT) Cloud/Virtual Open Campus Quick Start Guide (Revision 1) (No. ARL-CR-0816). Army Research Lab, Orlando, FL.

Designing Adaptive Instruction for Teams: A Meta-analysis

Abstract: The goal of this research was the development of a practical architecture for the computer-based tutoring of teams. This article examines the relationship of team behaviors as antecedents to successful team performance and learning during adaptive instruction guided by Intelligent Tutoring Systems (ITSs). Adaptive instruction is a training or educational experience tailored by artificially-intelligent, computer-based tutors with the goal of optimizing learner outcomes (e.g., knowledge and skill acquisition, performance, enhanced retention, accelerated learning, or transfer of skills from instructional environments to work environments). The core contribution of this research was the identification of behavioral markers associated with the antecedents of team performance and learning thus enabling the development and refinement of teamwork models in ITS architectures. Teamwork focuses on the coordination, cooperation, and communication among individuals to achieve a shared goal. For ITSs to optimally tailor team instruction, tutors must have key insights about both the team and the learners on that team. To aid the modeling of teams, we examined the literature to evaluate the relationship of teamwork behaviors (e.g., communication, cooperation,

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coordination, cognition, leadership/coaching, and conflict) with team outcomes (learning, performance, satisfaction, and viability) as part of a large-scale meta-analysis of the ITS, team training, and team performance literature. While ITSs have been used infrequently to instruct teams, the goal of this meta-analysis make team tutoring more ubiquitous by: identifying significant relationships between team behaviors and effective performance and learning outcomes; developing instructional guidelines for team tutoring based on these relationships; and applying these team tutoring guidelines to the Generalized Intelligent Framework for Tutoring (GIFT), an open source architecture for authoring, delivering, managing, and evaluating adaptive instructional tools and methods. In doing this, we have designed a domain-independent framework for the adaptive instruction of teams.

Keywords: Team tutoring. Teamwork. Taskwork. Adaptive instruction. Team-based instruction. Team learning. Team performance. Team satisfaction. Team viability. Collective. Collective training. Collaborative learning.

Citation: Sottilare, R. A., Burke, C. S., Salas, E., Sinatra, A. M., Johnston, J. H., & Gilbert, S. B. (2017). Designing adaptive instruction for teams: A meta-analysis. *International Journal of Artificial Intelligence in Education*, 1-40.

Shared Mental Models in Support of Adaptive Instruction for Teams Using the GIFT Tutoring Architecture

Abstract: Teams and teamwork are ubiquitous in military and civilian organizations. Their importance to organizational success cannot be overstated. This article describes the relationship and effect of three concepts: Intelligent Tutoring Systems (ITSs), shared mental models, and teamwork. The nexus between these concepts is examined to determine its capability to support adaptive instruction of teams, defined here as collectives of interdependent individuals who must communicate and interact with each other in order to perform assigned tasks and missions. An assumption underlying this examination is that augmenting the mental modeling processes of ITS with the mental models shared by members of interdependent teams will allow the considerable and increasingly research-established capabilities of intelligent tutoring of individuals to be applied in training teams. Specifically, we reviewed the learning and performance literature to identify how shared mental models of cognition could be used to enhance the adaptive instruction of teams. Our goal is to develop a methodology to enhance training and educational options for institutions that provide adaptive team instruction at the point-of-need. Toward this end, we discuss the adaptation of the Generalized

Intelligent Framework for Tutoring (GIFT), an open source tutoring architecture, to accommodate team models and states. While this article makes a first step toward defining a process for team tutoring, challenges remain. Team tutors must have the ability to manage uncertainty and the dynamic nature of team interaction and communication in order to make effective and timely decisions that optimize team and team member performance.

Keywords: Adaptive instruction. Shared mental models. Collective tasks. Cognitive models. Affective models. Social models. Team tutoring. Collective tutoring.

Citation: Fletcher, J. D., & Sottolare, R. A. (2017). Shared Mental Models in Support of Adaptive Instruction for Teams Using the GIFT Tutoring Architecture. *International Journal of Artificial Intelligence in Education*, 1-21.

Enhancing the Experience Application Program Interface (xAPI) to Improve Domain Competency Modeling for Adaptive Instruction

Abstract: This paper describes methods for enhancing the experience application program interface (xAPI) to improve the assessment of domain competency modeling for adaptive instruction. xAPI is an e-learning software specification which allows individual learning experiences and achievements to be amassed in a Learning Record Store (LRS). Adaptive instruction includes tailored training or educational experiences usually delivered and guided by Intelligent Tutoring Systems (ITSs). ITSs can more effectively tailor or adapt instruction when they have more accurate models of the learner's prior knowledge or competency. This paper examines the potential effect of methods to more accurately model learner experiences and domain competency in an LRS. Specifically, we recommend five methods to improve xAPI statements by documenting: 1) achievement types; 2) experience duration; 3) experience source information; 4) domain learning and forgetting; and 5) assessment within learning experiences.

Keywords: Experience application program interface. Domain competency modeling. E-learning software application. Learning Record Store.

Citation: Sottolare, R. A., Long, R. A., & Goldberg, B. S. (2017, April). Enhancing the Experience Application Program Interface (xAPI) to Improve Domain Competency Modeling for Adaptive Instruction. In *Proceedings of the Fourth (2017) ACM Conference on Learning@ Scale* (pp. 265-268). ACM.

Challenges in Authoring, Instructional Management, and Evaluation Methods for Adaptive Instructional Systems

Abstract: Many Intelligent Tutoring Systems (ITSs) are highly effective learning tools and provide individual adaptive instruction in single, well-defined, cognitive task domains (e.g., mathematics, physics, or software programming). The adaptive instruction provided by ITSs intelligently tailors content, adapts the curriculum and guides the learner with the goal of optimizing learning. In his meta-analysis, VanLehn (2011) notes that ITSs have evolved to parity with expert human tutors. Although this is exciting news, ITSs remain expensive to author based on their complexity, their lack of reusable components, and the expert skillset required to design, create and update them. While it may be impractical at this time to develop ITSs for low density instructional domains (e.g., specialized fields with small populations of learners), the large number of potential learners in high density domains (e.g., high school mathematics) and their high degree of effectiveness help offset their initial authoring costs and demonstrate their potential. What if ITSs were easier to author in a broader range of task domains? What if their return on investment (ROI) made the authoring of even low density adaptive instructional domains cost effective?

This talk will focus on significant challenges and emerging solutions related to the development and adoption of adaptive instructional systems (AISs) which include: learner(s); ITSs to guide learning in a domain; and integrated environments (e.g., simulations, playgrounds, web pages, mobile applications, or serious games) all of which interact and influence each other with the goal of optimizing learning. To this end we have identified five challenges or barriers to the practical use of AISs:

- 1) reducing the time and skill required to author AISs;
- 2) optimizing adaptive instruction of individuals and teams to enhance learning;
- 3) building rapport and engagement with conversational agents;
- 4) supporting adaptive instruction in the classroom and distributed learning contexts, and
- 5) evaluating the true effectiveness of adaptive instructional tools and methods.

We discuss these challenges through the lens of the Generalized Intelligent Framework for Tutoring (GIFT; Sottolare, Brawner, Goldberg & Holden, 2012), an adaptive tutoring prototype architecture being developed with the goals of lowering the entry skill and reducing the time required to author adaptive instruction, automating the delivery of instruction, and automating the evaluation of AISs, components, tools, and methods.

Keywords: Challenges in authoring. Instructional management. Adaptive instructional systems. Evaluation methods. Instructional domain. Delivery of instruction.

Citation: Sottolare, R. A. (2017, April 28). *Challenges in Authoring, Instructional Management, and Evaluation Methods for Adaptive Instructional Systems*. Paper presented at American Education Research Association (AERA) Conference Technology, Instruction, Cognition & Learning Special Interest Group (AERA TICL SIG) Symposium on Intelligent Tutoring Systems, BIG DATA–Learning Analytics, and Automated Humanlike Tutoring: Similarities and Differences (pp. 1-6). San Antonio, TX: Army Research Lab.

Examining Motivational Feedback Sensor-Free Detected Frustration Within Game-Based Learning

Abstract: Social interactions, decision-making, perceptions, and learning are all influenced by affect. Frustration, anxiety, and fear in particular can draw cognitive resources away from successful task completion, causing the learner to focus on the source of the emotion instead. Serious games offer an ideal environment to investigate how feedback influences student affect and learning outcomes, particularly when feedback is delivered via computer system detection. This dissertation discusses the results of an experiment run in September 2015 to investigate which motivational feedback condition yields the most significant correlation to positive learning gains when a computer system intelligently generates and delivers feedback based on the detection of frustration while participants played the serious video game, vMedic, a combat casualty care simulation which includes triage tasks. Of the three motivational feedback conditions examined (self-efficacy, social-identity, and control-value), the self-efficacy motivational feedback interventions yielded positive, statistically significant learning gains when compared to the social identity and control-value feedback conditions, as well as the non-motivational feedback control condition, and the no feedback control condition.

Keywords: Motivational feedback. Affect. Social interactions. Decision making. Perceptions. Learning. Successful task completion. Self-efficacy motivational feedback.

Citation: DeFalco, J. A. (2017). Examining motivational feedback for sensor-free detected frustration within game-based learning (Doctoral dissertation, Columbia University).

Detecting and Addressing Frustration in a Serious Game for Military Training

Abstract: Tutoring systems that are sensitive to affect show considerable promise for enhancing student learning experiences. Creating successful affective responses requires considerable effort both to detect student affect and to design appropriate responses to affect. Recent work has suggested that affect detection is more effective when both physical sensors and interaction logs are used, and that context-sensitive design of affective feedback is necessary to enhance engagement and improve learning. In this paper, we provide a comprehensive report on a multi-part study that integrates detection, validation, and intervention into a unified approach. This paper examines the creation of both sensor-based and interaction-based detectors of student affect, producing successful detectors of student affect. In addition, it reports results from an investigation of motivational feedback messages designed to address student frustration, and investigates whether linking these interventions to detectors improves outcomes. Our results are mixed, finding that self-efficacy enhancing interventions based on interaction-based affect detectors enhance outcomes in one of two experiments investigating affective interventions. This work is conducted in the context of the GIFT framework for intelligent tutoring, and the TC3Sim game-based simulation that provides training for first responder skills.

Keywords: Affect detection. Motivational feedback. Game-based learning. GIFT.

Citation: DeFalco, J. A., Rowe, J. P., Paquette, L., Georgoulas-Sherry, V., Brawner, K., Mott, B. W., ... & Lester, J. C. (2017). Detecting and addressing frustration in a serious game for military training. *International Journal of Artificial Intelligence in Education*, 1-42.

Educational Data Mining Using GIFT Cloud

Abstract: Intelligent Tutoring Systems (ITS), like human instructors, make frequent decisions about what to present to the student. These decisions include what courses or content to present next, as well as what type of After Action Review (AAR) to present to the student after each course. Ideally, the AAR would be Adaptive (AAAR). In this work, we analyze the decisions of course content and presentation. We construct a student model which models the skill necessary, the effectiveness of each course at training each skill, and the relationship between in-scenario measures and student skill-level. If the student model is accurate and

represented mathematically, then decision-theory can be used by the ITS to select courses and course content.

Keywords: Educational data mining. GIFT cloud. Intelligent tutor systems. After actin review. Adaptive after actin review. Decision theory.

Citation: Carlin, A., Oster, E., Nucci, C., Kramer, D., & Brawner, K. (2017, July). Educational Data Mining Using GIFT Cloud. *In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5)* (p. 253). Robert Sottolare.

Establishing Ground Truth on Psychophysiological Models for Training Machine Learning Algorithms: Options for Ground Truth Proxies

Abstract: One of the core aspects of human-human interaction is the ability to recognize and respond to the emotional and cognitive states of the other person, leaving human-computer interaction systems, at their core, to perform many of the same tasks.

Keywords: Ground truth. Psychophysiological models. Training machine learning algorithms. Truth proxies.

Citation: Brawner, K., & Boyce, M. W. (2017, July). Establishing Ground Truth on Pyschophysiological Models for Training Machine Learning Algorithms: Options for Ground Truth Proxies. In *International Conference on Augmented Cognition* (pp. 468-477). Springer, Cham.

Expanding Authoring Tools to Support Psychomotor Training Beyond the Desktop

Abstract: Design Recommendations for Intelligent Tutoring Systems (ITSs) explores the impact of intelligent tutoring system design on education and training. Specifically, this volume examines “Authoring Tools and Expert Modeling Techniques.” The “Design Recommendations book series examines tools and methods to reduce the time and skill required to develop Intelligent Tutoring Systems with the goal of improving the Generalized Intelligent Framework for Tutoring (GIFT). GIFT is a modular, service-oriented architecture developed to capture simplified authoring techniques, promote reuse and standardization of ITSs along with automated instructional techniques and effectiveness evaluation capabilities for adaptive tutoring tools and methods.

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Keywords: Authoring tools. Support psychomotor training. Intelligent tutoring systems. System design on education and training. Design recommendations. Generalized Intelligent Framework for Tutoring.

Citation: Sottolare, R. A., Ososky, S. J., & Boyce, M. Expanding Authoring Tools to Support Psychomotor Training Beyond the Desktop. *Design Recommendations for Intelligent Tutoring Systems*, 347.

Creating a Team Tutor Using GIFT

Abstract: With the movement in education towards collaborative learning, it is becoming more important that learners be able to work together in groups and teams. Intelligent tutoring systems (ITSs) have been used successfully to teach individuals, but so far only a few ITSs have been used for the purpose of training teams. This is due to the difficulty of creating such systems. An ITS for teams must be able to assess complex interactions between team members (team skills) as well as the way they interact with the system itself (task skills). Assessing team skills can be difficult because they contain social components such as communication and coordination that are not readily quantifiable. This article addresses these difficulties by developing a framework to guide the authoring process for team tutors. The framework is demonstrated using a case study about a particular team tutor that was developed using a military surveillance scenario for teams of two. The Generalized Intelligent Framework for Tutoring (GIFT) software provided the team tutoring infrastructure for this task. A new software architecture required to support the team tutor is described. This theoretical framework and the lessons learned from its implementation offer conceptual scaffolding for future authors of ITSs.

Keywords: Team tutoring. GIFT. Architecture. Evaluation.

Citation: Gilbert, S. B., Slavina, A., Dorneich, M. C., Sinatra, A. M., Bonner, D., Johnston, J., ... & Winer, E. (2017). Creating a team tutor using GIFT. *International Journal of Artificial Intelligence in Education*, 1-28.

Motivation and Research in Architectural Intelligent Tutoring

Abstract: It is well-known that personalised and adaptive training, such as from a human tutor, is dramatically more effective than traditional classroom training (Bloom, 1984; VanLehn, 2011). Due to a variety of reasons, however, tutoring systems are not yet ubiquitous within the training market. The US Army Research Laboratory is working to address this problem and has recently published a series of research vector outlines, which guide research in the various areas. The research within the architectural vector naturally exists to support the other vectors and to investigate, standardise, componentise, and commodise the processes and functions of the various tutoring system aspects. This paper serves as an expansion and companion to the similarly named 2015 International Defense and Homeland Security Simulation Workshop paper and yet-to-be-published ARL architectural research plan, expanded in order to discuss the progress made to date, clarify the role of the architecture in the research, and discuss some of the advantages of a unified system as part of measuring training effectiveness and overall system improvement.

Keywords: Adaptive and predictive computer-based training. Intelligent tutoring systems. ITSs. Architectural components. Emerging standards.

Citation: Brawner, K., Sinatra, A. M., & Sottolare, R. (2017). Motivation and research in architectural intelligent tutoring. *International Journal of Simulation and Process Modelling*, 12(3-4), 300-312.

Team Tutoring in the Generalized Intelligent Framework for Tutoring: Current and Future Directions

Abstract: While the Generalized Intelligent Framework for Tutoring (GIFT) has been actively developed over the past few years, the majority of projects to date have focused on individual learners. A longterm goal of GIFT is to support team tutoring and provide simultaneous computer-based tutoring at the squad level.

Therefore, efforts in the Team Modeling vector have been examining the implications of extending GIFT to team tutoring, and have laid the groundwork for creating team tutors with GIFT.

Keywords: Team tutoring. Generalized Intelligent Framework for Tutoring. Team modeling.

Citation: Sinatra, A. M. (2017). Team Tutoring in the Generalized Intelligent Framework for Tutoring: Current and Future Directions.

Assessment in Intelligent Tutoring Systems in Traditional, Mixed Mode, and Online Courses

Abstract: As technology has continued to develop, there have been new and creative ways to use it in the classroom. Classes have transformed into learning environments that rely not only on the in-person instructor, but have many other resources easily available for students. At the college level, courses can vary between different modes of instruction: traditional in-person, mixed mode (classes with both an in-person and online component), and online. Students routinely bring laptops and tablets to class to both take notes and work on their assignments. Further, there are often computer labs available for students to use for assignments at universities. In some cases, these labs can be reserved for specific classes and provide all students with the opportunity to engage with a computer during class time. Even traditional in-person courses often have online materials available for students through learning management systems (LMSs) such as Blackboard or Webcourses. Students often engage in message board discussions with their classmates and download resources such as class PowerPoints from the sites. Grades are often times managed digitally and are available to students through logging into the system. Many LMSs also have built in assignment submission sections that in some cases can check the student submitted work against others for plagiarism. Many of these resources are used by instructors as they design and supplement their courses. These resources can be combined with in-class instruction to build a learning environment that provides students a self-regulated method of engaging with additional educational materials. In the case of mixed-mode or online course, the students heavily rely on these LMSs and primarily receive their instruction through engaging with the computer-based materials. In these types of classes, the instructor's goals when developing materials will be different than for in-person classes, such that the online materials will need to be deeper and more self-explanatory. In online and mixed-mode courses, the instructor moves from a lecturing capacity to a facilitator and subject-matter expert who engages with students when they turn in assignments, when they seek help and when they have questions. The online class environment is much more self-directed and requires the students to engage in self-regulated learning and be more aware of what knowledge that they have (metacognition), which does not necessarily come naturally to all students (Schraw, 1998).

Keywords: Intelligent tutor systems. Traditional course. Mixed course. Online course.

Citation: Sinatra, A. M., Ososky, S., & Sottolare, R. –Assessment in Intelligent Tutoring Systems in Traditional, Mixed Mode, and Online Courses. *Design Recommendations for Intelligent Tutoring Systems*, 5.

Recommendations for Use of Adaptive Tutoring Systems in the Classroom and in Educational Research

Abstract: The current paper and presentation provide background on the different uses of intelligent tutoring systems (ITSs) in context of course instruction, discusses specific instructor considerations that are associated with their use, and ways to use ITSs for educational research. Instructor considerations include the time necessary to plan prior to constructing an ITS, the process of constructing ITS lessons for use by students, the method in which students will interact with the ITS, approaches to incorporating ITS use into classes, and the information that instructors would find useful to be output from the ITS. Specifically, the Generalized Intelligent Framework for Tutoring (GIFT), an open-source, domain independent ITS framework will be discussed as an approach to creating adaptive tutoring content for classroom use. GIFT includes straightforward authoring tools for instructors and Subject Matter Experts (SMEs). These authoring tools are powerful, do not require a background in computer science to use, and result in fully adaptive computer-based lessons. Additionally, GIFT provides the flexibility for instructors to bring their pre-generated and already existing instructional material to the system and use it to create ITS lessons. The authoring tools allow the instructor to determine the path of their lesson and the components that their students will experience (i.e. surveys, quizzes, lesson materials, videos). The paper includes details about the development of an instructor dashboard in GIFT, ways for an instructor to use GIFT for educational research, and a discussion of general output information from ITSs that would be relevant to instructors.

Keywords: Intelligent tutoring systems. Classroom. Generalized Intelligent Framework for Tutoring. Educational research. Adaptive tutoring.

Citation: Sinatra, A. M., Ososky, S., Sottolare, R., & Moss, J. (2017, July). Recommendations for Use of Adaptive Tutoring Systems in the Classroom and in Educational Research. *In International Conference on Augmented Cognition* (pp. 223-236). Springer, Cham.

Future Directions for the Generalized Intelligent Framework for Tutoring (GIFT)

Abstract: Computerized assessment, with all of its promised affordances,¹ has been eagerly anticipated in the field of educational assessment for some time. The technology was embraced in high-stakes testing as soon as it was available, with punch cards being used for statistical processing, optical scanners processing multiple-choice answer sheets, and mainframe computers being brought into service to handle the huge amounts of data processing requirements of running an examination board. Yet, in 2017, we have not seen the revolution in forms of large-scale assessment that we all expected. There are some encouraging, notable developments, which we shall return to, but first, we recount the story so far to understand the issues that may have relevance for the Generalized Intelligent Framework for Tutoring (GIFT) in its venture into the field of computerized educational assessment in conjunction with intelligent tutoring.

Keywords: Generalized Intelligent Framework for Tutoring. Computerized assessments. Intelligent tutoring.

Citation: Baird, J. A., Sinatra, A. M., & Goodwin, G. (2017). Lessons CHAPTER21–Learned from Large-Scale E-Assessments: Future Directions for the Generalized Intelligent Framework for Tutoring (GIFT). *Design Recommendations for Intelligent Tutoring System-Volume 5: Assessment Methods*, 5, 249.

Analyzing Team Training Data: Aspirations for a GIFT Data Analytics Engine

Abstract: The primary questions for any training situation are, “How well did the trainees do? Are they trained enough?” And of course, there are secondary questions like, “Who did best/worst?” and “What were their major stumbling blocks?” If the trainees were running a footrace through an obstacle course, these questions would be relatively simple to answer. The measure of time to the finish line answers “how well” and “who did best/worst.” The number of stumbles on the obstacles could be counted as literal stumbling blocks. And a threshold based on previous performers could be used to answer whether they are trained enough. Unfortunately, real-world training scenarios are typically much more complex, and answering these simple questions can be quite challenging. This paper discusses some of these challenges, especially in a team training setting

Keywords: Team training data. Generalized Intelligent Framework for Tutoring. Data analytics engine. Team training setting.

Citation: Gilbert, S. B., Sinatra, A. M., MacAllister, A., Kohl, A., Winer, E., Dorneich, M. C., ... & Ouverson, K. M. (2017). *Analyzing Team Training Data: Aspirations for a GIFT Data Analytics Engine*. Industrial and Manufacturing Systems Engineering Conference Proceedings and Posters. 99.

An Updated Concept for a Generalized Intelligent Framework for Tutoring (GIFT)

Abstract: The purpose of this document is to provide users of the Generalized Intelligent Framework for Tutoring (GIFT) with a fundamental understanding of the function, goals/challenges, and research activities associated with the development of a largely domain-independent adaptive instructional capability for the US Army. While the design team for GIFT imagines capabilities beyond military training, the focus of our research is to solve the hard problems and break through barriers to the adoption of adaptive instruction as a practical tool for guiding military training. Adaptive instruction delivers content, offers feedback, and intervenes with learners based on tailored strategies and tactics with the goal of optimizing learning, performance, retention, and transfer of skills for both individual learners and teams. As of this year (2017) the concept that developed into the initial GIFT capability is five years old. So much has been accomplished over the last five years that the team saw the need to update the original GIFT concept document (Sottolare, Brawner, Goldberg, & Holden, 2012) by discussing research goals and their relationship to military requirements. The remainder of this introduction will focus on military motivation, tools to evaluate the effectiveness of candidate adaptive instructional technologies prior to integration in GIFT, and the economic motivation for a GIFT.

Keywords: Generalized Intelligent Framework for Tutoring. Fundamental understanding. Adaptive instruction.

Citation: Sottolare, R., Brawner, K., Sinatra, A., & Johnston, J. (2017). An Updated Concept for a Generalized Intelligent Framework for Tutoring (GIFT). *Orlando, FL: US Army Research Laboratory–Human Research & Engineering Directorate (ARL-HRED)*.

Operationalizing the C's of Teamwork in an Intelligent Tutoring System

Abstract: One of the difficulties in creating a team-focused intelligent tutoring system (ITS) is defining the measures used to assess the team's performance. While the team research literature offers nine C's of teamwork to consider, e.g., cooperation, communication, etc., it can also be difficult to implement these in real-world practice. This paper reviews the approach used in three team ITSs in which the C's were used, offering guidance for future implementation of team tutors.

Keywords: Intelligent tutoring system. Team research.

Citation: Bonner, D., Ouverson, K., Gilbert, S., Dorneich, M., Winer, E., Sinatra, A., ... & Kohl, A. (2017, September). Operationalizing the C's of Teamwork in an Intelligent Tutoring System. *In Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 61, No. 1, pp. 745-749). Sage CA: Los Angeles, CA: SAGE Publications.

The Future of Adaptive Tutoring: Wrangling Complexity across Domains, Applications, and Platforms

Abstract: The purpose of this panel is to discuss current directions in research and design of adaptive tutoring, and the need for a method to uniformly describe tutors within this growing field. Discussions will focus on the increasing complexity of individual tutors, as well as how tutors could be categorized through identification of relevant, constituent parts. A standardized taxonomy would provide the foundation for establishing a quantifiable metric of complexity, which could then be used to compare vastly distinct tutors to one another. Applications of such a metric also include evaluating tutor effectiveness with respect to learning outcomes, comparing capabilities / usability of different adaptive tutor authoring tools, and providing more accurate estimates of the time required to develop an hour of tutoring. Individual elements of tutoring to be discussed within the context of this framework include team tutoring, psychomotor tutoring, multi-platform architectures, personalized tutoring, and authoring complexity.

Keywords: Adaptive tutoring. Domains, applications and platforms. Standard taxonomy. Individual elements of tutoring.

Citation: Ososky, S., Dorneich, M., Gilbert, S. B., Goldberg, B., Johnson, C. I., & Sinatra, A. M. (2017, September). The Future of Adaptive Tutoring: Wrangling Complexity across Domains, Applications, and Platforms. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 61, No. 1, pp. 1985-1989). Sage CA: Los Angeles, CA: SAGE Publications.

Informing the Long-Term Learner Model: Motivating the Adult Learner (Phase 1)

Abstract: The United States (US) Army has valued training across a wide range of performance areas and has used a variety of platforms to instantiate the training seen as the best fit for the knowledge, skills, and abilities required for mission success. As the United States is coming out of wartime, an opportunity is available to consider the effectiveness and cost of training programs and platforms. The Army is developing a framework for providing personalized, on-demand, computer-based instruction under the Generalized Intelligent Framework for Tutoring (GIFT) program. Of particular interest for this effort is understanding the intersection of personality factors, motivation, and reinforcers that are relevant to informing the Long-Term Learner Model. The approach proposed is to use existing data as a starting point for identifying important correlates of the aforementioned concepts and evaluating their application within a learning/training environment. The goal is to develop a motivator capability that can be incorporated into GIFT. Phase 1 focused on the initial development of a Motivator Assessment Tool (MAT) and integration of the MAT in GIFT for purposes of validation. The focus for Phases 2 and 3 will be to refine the MAT based upon validation experiments and implement that version as an adapting strategy in GIFT for learning in a determined task. The expectation is that targeted motivator adaption strategy will increase the rate and retention of learning.

Keywords: Adaptive training. Military training. Human emotions. Instructions. Motivation. Thinking. Personality. Mental processes. Military personnel. Software tools.

Citation: Reinerman-Jones, L., Lameier, E., Biddle, E., & Boyce, M. W. (2017). *Informing the Long-Term Learner Model: Motivating the Adult Learner (Phase 1)* (No. ARL-TR-8160). US Army Research Laboratory Aberdeen Proving Ground United States.

Adaptive Training Across Simulations in Support of a Crawl-Walk-Run Model of Interaction

Abstract: In this paper we present a model of training interaction based on tenets of intelligent tutoring systems and skill development and acquisition. We present a Crawl-Walk-Run approach to training management that associates with the utility of complimentary simulation environments to build a set of skills across multiple exercises and scenarios. In addition, we highlight the role adaptive training technologies can play in this model of interaction, along with technologies being developed to support the authoring and configuration of these experiences. The work presented within is based on the Generalized Intelligent Framework for Tutoring (GIFT) and discusses the development of tools and methods to author and deliver adaptive training content grounded in skill development.

Keywords: Authoring. Gift wrap. Adaptive training. Assessment.

Citation: Goldberg, B., Davis, F., Riley, J. M., & Boyce, M. W. (2017, July). Adaptive Training Across Simulations in Support of a Crawl-Walk-Run Model of Interaction. In *International Conference on Augmented Cognition* (pp. 116-130). Springer, Cham.

Assessing Motivation to Individualize Reinforcement and Reinforcers for an Intelligent Tutor

Abstract: Personalized learning with technology is in full demand across all context. Learning occurs through motivation therefore, personalizing motivation is key to enhancing learning rate and retention for the learner. Supplying the intelligent tutors with key information not will advance the familiarity of individual's motivational factors and interest for individualizing motivation. Building this relationship stems from a streamlined Motivational Assessment Tool (MAT), aimed at assessing several motivation factors. The Motivation Assessment Tool is based on the interconnectedness of motivational factors with personality. The creation of the assessment allows the intelligent tutor to implement reinforcers that influence motivational level based off individual variances such as personality.

Keywords: Motivational factors. Intelligent tutor. Individualized motivation. Personality. Motivational Assessment Tool.

Citation: Lameier, E., Reinerman-Jones, L., Boyce, M. W., & Biddle, E. (2017, July). Assessing Motivation to Individualize Reinforcement and Reinforcers for an Intelligent Tutor. In *International Conference on Augmented Cognition* (pp. 175-184). Springer, Cham.

Using Assessment to Provide Application in Human Factors Engineering to USMA Cadets

Abstract: This paper discusses a collaboration between the Army Research Laboratory (ARL) and the United States Military Academy at West Point in teaching the fundamentals of human factors engineering through assessment and experimentation. To facilitate this, the cadets engage in a year-long capstone project where an ARL scientist serves as a mentor, often in conjunction with departmental faculty. This paper discusses a five-phase teaching process to assist in training the fundamentals of research. The five phases are: 1. Identification of research questions and background research. 2. The development of research protocols and their associated training, 3. The selection and understanding of appropriate assessment techniques, 4. The coordination and execution of data collection, and 5. Statistical analysis and reporting. This process uses an existing research experiment at ARL focusing on the impact of different types of display surfaces to support military tactical decision-making to serve as a case study. The research experiment used a hybrid of two research platforms: the Augmented Reality Sandtable (ARES) and the Generalized Intelligent Framework for Tutoring (GIFT). An examination of the process as well as perspectives from the cadets assisting with the Perspectives from The ARL/USMA research and the cadets assisting with the research. These perspectives can help with the development of other similar programs aimed at combining research laboratories and academic institutions.

Keywords: Military tactics. Assessment. Capstone. Augmented reality sandtable. Generalized Intelligent Framework for Tutoring. Cadets. USMA.

Citation: Boyce, M. W., Rowan, C. P., Baity, D. L., & Yoshino, M. K. (2017, July). Using Assessment to Provide Application in Human Factors Engineering to USMA Cadets. In *International Conference on Augmented Cognition* (pp. 411-422). Springer, Cham.

The GIFT 2017 Architecture Report

Abstract: The first version of the Generalized Intelligent Framework for Tutoring (GIFT) was released to the public in May of 2012. One year later the first symposium of the GIFT user community was held at the Artificial Intelligence and Education conference in Memphis Tennessee. Since then the GIFT development team has continued to gather feedback from the community regarding recommendations on how the GIFT project can continue to meet the needs of the user community and beyond. This current paper invites and encourages members of the GIFT user community to continue to share their feedback, research findings and technology innovations with the development team and with one another in order to strengthen the power, usability and flexibility of the GIFT project. As a follow up to the “GIFT 2015 Report Card and State of the Project” (Brawner & Ososky, 2015), and GIFT 2016 Community Report, the feature requests and responses have been broken out among a number of papers discussing research vectors. This paper discusses the ongoing architectural working and changes in support of the various sets of projects.

Keywords: Generalized Intelligent Framework for Tutoring. Architecture Report. Architectural working. Changes in support.

Citation: Brawner, K., Heylmun, Z., & Hoffman, M. (2017, July). The GIFT 2017 Architecture Report. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 3). Robert Sottolare.

The 2017 Overview of the GIFT Authoring Experience

Abstract: One of the primary goals of the Generalized Intelligent Framework for Tutoring (GIFT) is to reduce the time and skill required to create adaptive training. Achieving those goals within the GIFT platform is enabled by a set of authoring tools and associated resources, known collectively as the Authoring Experience. The current paper will discuss the state of the GIFT Authoring Experience, as well as how feedback and data from the community is informing user-centered design efforts within the GIFT authoring tools.

Keywords: Generalized Intelligent Framework for Tutoring. Authoring experience. Time and skill. Authoring tools.

Citation: Ososky, S. (2017, July). The 2017 Overview of the GIFT Authoring Experience. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 39). Robert Sottolare.

Focused Authoring for Building GIFT Tutors In Specialized Domains: A Case Study Of Psychomotor Skills Training

Abstract: As expressed in the Army Learning Model (ALM), psychomotor skills are foundational to many of the competencies that compose the U.S. Army's vision for 21st Century Soldier Competencies. Training psychomotor skills is being addressed in part through the use of sophisticated intelligent tutoring systems (ITS) that tailor and adapt instruction during simulations, and promising ITS investments have been made in numerous domains including marksmanship and tactical combat casualty care. However, current ITS authoring tools tend to lack generalization and are limited in scope. The process to develop ITS thus remains time-consuming and costly. For the Army to successfully realize the ALM vision, creating ITS that target psychomotor skills must be an affordable, replicable, and reusable process.

Keywords: Generalized Intelligent Framework for Tutoring. Case study. Psychomotor skills training. Simulations.

Citation: Bell, B., Brown, D., Goldberg, B., & Goldberg, B. S. (2017, July). Focused authoring for building GIFT tutors in specialized domains: a case study of psychomotor skills training. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 51). Robert Sottolare.

Development of an Integrated, User-Friendly Authoring Tool for Intelligent Tutoring Systems

Abstract: The Generalized Intelligent Framework for Tutoring (GIFT) is a modular suite of capabilities aimed at overcoming the challenges associated with authoring and delivering computer-based instruction via an intelligent tutoring system (Sottolare, Brawner, Goldberg, & Holden, 2012). One of the goals for GIFT development is to create an integrated, user-friendly authoring experience that can be used across training applications. Human proof, with teammate Design Interactive, is currently developing the second-generation GIFT Wrap prototype, a software application that allows training developers to configure the real-time, automated delivery of instructional content triggered by assessing state changes within the training application's learning environment (e.g., entity location within

Approved for public release; distribution is unlimited.

a virtual environment) and/or learner (e.g., progress toward concept mastery, changes in cognitive workload). This ongoing research and development effort is focused on the design and implementation of the user interface that guides users through the set-up of tutoring events. Integration with ARES (Augmented Reality Sandtable) served as the first use case. ARES, which can be used as a tactical training and mission rehearsal platform, provided the context for demonstrating GIFT Wrap's utility for defining real-time assessments directly within existing training scenarios. The following sections briefly describe the previous version of GIFT Wrap, provide a detailed discussion of development efforts to date, and present concepts for extending the capability to other training applications as well as live training environments.

Keywords: User friendly authoring tool. Intelligent tutoring systems. Generalized Intelligent Framework for Tutoring. GIFT wrap prototype. Augmented Reality Sandtable.

Citation: Davis, F. C., Riley, J. M., & Goldberg, B. S. (2017, July). Development of an Integrated, User-Friendly Authoring Tool for Intelligent Tutoring Systems. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 77). Robert Sottolare.

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

Abstract: The function of an intelligent tutoring system (ITS) is to adapt or tailor training to an individual learner. As with a human tutor, this requires the ITS to have some “knowledge” of the learner (i.e., a learner model). The ITS uses and updates the learner model as the learner progresses through the material. For example, if the learner masters some concept, the learner model must be updated to reflect this. On the other hand if the learner has difficulty with a concept, the ITS needs to be able to understand where deficiencies lie in order to prescribe the appropriate remediation. Understanding why the learner might have had difficulty with a particular concept is no simple task as the list of reasons could be quite extensive. Perhaps the learner lost focus during the presentation of a key piece of information, lacks some key prerequisite knowledge, or has a low aptitude for the domain. The list could go on and on. All of these possible explanations require assessment of the learner. As can be seen from the above example, assessments can include information about the learner's background, experiences, traits, and aptitudes, as well as measures of the learner's affect, behavior, and performance

during the training session. The more completely the learner model represents the learner, the better the ITS will be able to effectively adapt training.

Keywords: Learner models. Generalized Intelligent Framework for Tutoring. Tailor training. Individual learner. Intelligent tutor system.

Citation: Goodwin, G. A. (2017, May). Learner Models in the Generalized Intelligent Framework for Tutoring: Current Work and Future Directions. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 89). Robert Sottolare.

Multi-Level User Modeling in GIFT to Support Complex Learning Tasks

Abstract: Open-ended computer-based learning environments (OELEs) are user-centered. They present users with complex problems to solve, and a set of tools and resources that support the problem-solving task. While problem solving, users typically explore multiple solution approaches, and assess their evolving solutions to make sure they are making progress toward their learning and problem-solving goals. In general, OELEs focus on developing users' (1) cognitive skills, (2) metacognitive processes and (3) problem solving strategies that go beyond the acquisition of domain-specific cognitive skills (Hannafin et al., 1994). These environments make high cognitive demands on users, and promote the development of strategies and metacognitive processes that can support planning, monitoring, and self-evaluation processes.

Keywords: Generalized Intelligent Framework for Tutoring. Multi-level user modeling. Complex learning tasks. Open-ended computer-based learning environments.

Citation: Rajendran, R., Mohammed, N., Biswas, G., Goldberg, B. S., & Sottolare, R. A. (2017, July). Multi-level User Modeling in GIFT to Support Complex Learning Tasks. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 99). Robert Sottolare.

Pedagogical Management in Support of a Generalized Framework for Intelligent Tutoring

Abstract: A current goal associated with the development of the Generalized Intelligent Framework for Tutoring (GIFT) is providing a set of tools for training practitioners to rapidly build adaptive instructional materials based on an interplay of knowledge acquisition and skill development. To accommodate this guiding requirement, an instructional management research vector was devised as a means to coordinate resources and efforts to meet the needs of end users. While the science surrounding intelligent tutoring system (ITS) development is multidisciplinary, a guiding assumption is that targeted GIFT developers in the military community will be subject matter experts (SMEs) within their respected fields, but lack many of the technical disciplines that go into ITS development. Accordingly, it is also safe to assume these SME developers will also require assistance in authoring training content that adheres to learning science principles. As such, authoring workflows and ITS methods must be developed to compensate for the skills a GIFT user lacks when creating a lesson or course.

Keywords: Generalized Intelligent Framework for Tutoring. Pedagogical management. Tools for training practitioners. Intelligent tutor systems. Subject matter experts.

Citation: Goldberg, B. (2017, July). Pedagogical Management in Support of a Generalized Framework for Intelligent Tutoring. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 139). Robert Sottolare.

Developing a Pattern Recognition Structure to Tailor Mid-Lesson Feedback

Abstract: The Generalized Intelligent Framework for Training (GIFT) has the potential to increase the micro-adaptive individualization of many training systems by overlaying adaptive feedback to learners during training sessions. For example, GIFT can augment a particular scenario in a first-person infantry simulation without needing to change the scenario itself, by displaying feedback messages in the tutor user interface (TUI) when particular learner experiences are observed. Feedback that GIFT delivers in the TUI can be as effective as feedback embedded directly in the system (Goldberg & Cannon-Bowers, 2015)

Keywords: Pattern recognition structure. Tailor mid-lesson feedback. Generalized Intelligent Framework for Tutoring. Training systems. Tutor user interface.

Citation: Folsom-Kovarik, J. T., & Boyce, M. W. (2017, May). Developing a Pattern Recognition Structure to Tailor Mid-Lesson Feedback. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 149). Robert Sottolare.

Integrating the Outer Loop: Validated Tutors for Portable Courses and Competencies

Abstract: The Generalized Intelligent Framework for Tutoring (GIFT) is a broad and flexible framework for developing and delivering training. GIFT currently provides support for best practices and most effective pedagogy in the tutoring context, however, it is limited in providing support in the course development process. In this paper, we present the GIFT Structural Equation Modeling (GIFT-SEM) module for doing rapid analysis and validation of the concepts and concept models used to guide training development. We believe this is one piece of a suite of validation tools that will be used to allow GIFT authors to identify and share effective pedagogy, concept models, sequencing, and learning resources. This validation suite will provide the evaluation necessary to integrate GIFT tutors into synthetic training environments (Dumanoir, 2015) and larger service oriented architecture (SOA) ecosystems. Additionally, validated tutors and pedagogy allow authors to learn from each other's work, share validated training throughout the GIFT ecosystem, leverage near and far transfer of learning, and validate external resources within their domain

Keywords: Validated tutors. Portable courses. Competencies. Generalized Intelligent Framework for Tutoring. GIFT Structural Equation Modeling. Validation suite. Synthetic training environments. Service orientated architecture.

Citation: Robson, E., Ray, F., Sinatra, A. M., & Sinatra, A. M. (2017, July). Integrating the outer loop: Validated tutors for portable courses and competencies. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 161). Robert Sottolare.

Toward Simulated Students for Reinforcement Learning-Driven Tutorial Planning in GIFT

Abstract: A critical feature of intelligent tutoring systems (ITSs) is their capacity to guide and scaffold student learning. Tutorial planners leverage contextual information to determine how pedagogical feedback, hints, and prompts should be tailored to learners at run-time (Woolf, 2008). Recent years have witnessed growing interest in applying reinforcement learning (RL) to devise tutorial planners. RL provides a data-driven framework for creating tutorial planners from observations of student behavior and learning outcomes. RL techniques introduce the potential for ITSs that can automatically refine and improve their pedagogical methods over time. RL methods account for the inherent uncertainty in how learners respond to different types of tutorial strategies and tactics, and they produce models that can be automatically induced to optimize measures of student learning. Recent work on reinforcement learning-based tutorial planning has outlined a path for devising pedagogical models across a broad range of learning environments and educational domains (Chi, VanLehn, Litman, & Jordan, 2011; Rowe & Lester, 2015; Williams et al., 2016).

Keywords: Reinforcement learning-driven tutor planning. Generalized Intelligent Framework for Tutoring. Intelligent tutoring systems. Student learning.

Citation: Rowe, J., Pokorny, B., Goldberg, B., Mott, B., & Lester, J. (2017). Toward Simulated Students for Reinforcement Learning-Driven Tutorial Planning in GIFT. In Proceedings of R. Sottolare (Ed.) 5th Annual GIFT Users Symposium. Orlando, FL.

Expanding Domain Modeling in GIFT

Abstract: The purpose of this paper is to update users of the Generalized Intelligent Framework for Tutoring (GIFT; Sottolare, Brawner, Goldberg, & Holden, 2012; Sottolare, Brawner, Sinatra, & Johnston, 2017, in press) on new and emerging capabilities to represent a broader variety of task domains in Intelligent Tutoring Systems (ITSs) in support of adaptive instruction. Adaptive instruction delivers content, offers feedback, and intervenes with learners based on tailored strategies and tactics with the goal of optimizing learning, performance, retention, and transfer of skills for both individual learners and teams. GIFT is a tutoring architecture that has evolved over the last five years with three primary goals: 1) reduce the time and skill required to author ITSs, 2) automate best practices of instruction in the policy, strategies, and tactics of tutoring, and 3) provide a testbed

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to assess the effectiveness of adaptive instructional tools and methods with respect to learning, performance, retention, and transfer of skills. Another overarching goal for GIFT has been to adapt ITSs to provide instruction in militarily-relevant training and educational domains

Keywords: Generalized Intelligent Framework for Tutoring. Domain modeling. Intelligent tutoring system. Task domains. Adaptive instruction. Military-relevant training. Educational domains.

Citation: Sottolare, R. A. (2017, May). Expanding Domain Modeling in GIFT. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 185). Robert Sottolare.

Modeling Training Efficiency and Return on Investment for Adaptive Training

Abstract: Adaptive training promises more effective training by tailoring content to each individual. Where nonadaptive training may be just right for one segment of the student population, there will be some students that find it too easy while others find it too difficult. Another, often ignored benefit of adaptive training, is improved training efficiency by minimizing the presentation of unnecessary material to learners. One implication of this is that intelligent, adaptive training should require less time to train a population of learners to a given level of proficiency than non-adaptive training. The gains in efficiency should be a function of several factors including learner characteristics (e.g., aptitude, reading ability, prior knowledge), learning methods employed by the adaptive training system, course content (e.g., difficulty and length, adaptability), and test characteristics (e.g., difficulty, number of items). This paper describes the development of a predictive model for training efficiency based on those factors and how it could be integrated into the Generalized Intelligent Framework for Tutoring (GIFT) architecture. How this model supports return on investment decisions for authors is also discussed.

Keywords: Modeling training efficacy. Adaptive training. Generalized Intelligent Framework for Tutoring architecture. Investment decisions.

Citation: Goodwin, G. A., Kim, J. W., & Niehaus, J. (2017, July). Modeling Training Efficiency and Return on Investment for Adaptive Training. In Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5) (p. 229). Robert Sottolare.

A Data Analytics Framework to Support Training Effectiveness Evaluation

Abstract: As the Generalized Intelligent Framework for Tutoring (GIFT) framework becomes more pervasive as a research tool, the ability to evaluate student performance will be a critical consideration in its adoption. Having a common method for evaluating learner performance and course data in a simple user-intuitive way will aid course evaluators, instructional designers, and content managers to better assess the effectiveness of a course. In order to produce accurate measurement of learner performance within an intelligent tutoring system, a robust data analytics framework must include the ability to analyze course performance data, learner attributes, and learning strategies. Given the minimal amount of existing intelligent tutoring data, a tool for generating synthetic data would enhance the ability to build models and conduct robust experiments. This data can be used to establish and validate analytic findings, and develop baselines against which to compare observed performance. This paper introduces a data authoring tool and demonstrates its use.

Keywords: Data analytics framework. Training effectiveness evaluation. Generalized Intelligent Framework for Tutoring. Learner performance. Intelligent tutoring systems. Observed performance. Data authoring tool.

Citation: Weerasinghe, C., Dillon, C., Cummings, P., Smith, M., & Long, R. (2017, July). A Data Analytics Framework to Support Training Effectiveness Evaluation. In *Proceedings of the 5th Annual Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym5)* (p. 241). Robert Sottolare.

Challenges for Assessing and Tutoring Collective Skills

Abstract: Computer-based intelligent tutoring systems (ITSs) rely on assessment of learner behavior, and indeed, ITSs cannot accurately function without an “understanding” of the specific learner. As a result, it is of critical importance to understand what can and cannot be assessed automatically, given various learning environments and learning objectives, as this will impact ITS functionality. Here, we define an assessment as the result of applying a formula to data (a measurement), and then comparing the score on the measurement to an expert behavior (the assessment). Assessment is especially challenging in environments focused on collective tasks (i.e., those that require organized team or unit performance for accomplishment; Department of the Army, 2012), in which many

of the key behaviors of interest involve coordination and communication between human and/or synthetic actors (broadly referred to as collective skills here)

Keywords: Assessing and tutoring collective skills. Computer based intelligent tutoring systems. Team performance. Collective tasks.

Citation: Ayers, J., Bink, M. L., & Diedrich, F. J. Challenges for Assessing and Tutoring Collective Skills. *Design Recommendations for Intelligent Tutoring Systems*, 287.

Lessons Learned from Large-Scale E-Assessments: Future Directions for the Generalized Intelligent Framework for Tutoring (GIFT)

Abstract: Computerized assessment, with all of its promised affordances,¹ has been eagerly anticipated in the field of educational assessment for some time. The technology was embraced in high-stakes testing as soon as it was available, with punch cards being used for statistical processing, optical scanners processing multiple choice answer sheets, and mainframe computers being brought into service to handle the huge amounts of data processing requirements of running an examination board. Yet, in 2017, we have not seen the revolution in forms of large-scale assessment that we all expected. There are some encouraging, notable developments, which we shall return to, but first, we recount the story so far to understand the issues that may have relevance for the Generalized Intelligent Framework for Tutoring (GIFT) in its venture into the field of computerized educational assessment in conjunction with intelligent tutoring.

Keywords: Generalized Intelligent Framework for Tutoring. Large scale E assessments. Computerized assessment. Intelligent tutoring.

Citation: Baird, J. A., Sinatra, A. M., & Goodwin, G. Lessons Learned from Large-Scale E-Assessments: Future Directions for the Generalized Intelligent Framework for Tutoring (GIFT). *Design Recommendations for Intelligent Tutoring Systems*, 249.

Assessing Individual Learner Performance in MOOCs

Abstract: Massive open online courses (MOOCs) have emerged as a prominent mode of online education, but the quality of assessments in MOOCs remains inconsistent. There has been a consistent gap between the state of the art in assessment and the state of the practice in both MOOCs and other forms of educational technology. Improving the quality of assessment has the potential to improve their usefulness for certification, formative feedback, and learning. In this chapter, we discuss this gap and efforts to improve assessment in MOOCs. There are several potential directions for improving assessments in MOOCs, including improving the psychometric properties of simple assessment types, such as multiple-choice and fill-in-the-blank questions; creating richer assessment experience through more student interaction and more engaging experiences (e.g., games, and simulations), through leveraging help resources to see how students perform with some degree of support; and using more powerful technology such as automated essay scoring to better assess students. We discuss both existing efforts and ways that research in other communities can be incorporated into MOOC platforms

Keywords: Individual learner performance. Massive open online courses.

Citation: Baker, R. S., Mitros, P., Goldberg, B., & Sottolare, R. A. Assessing Individual Learner Performance in MOOCs. *Design Recommendations for Intelligent Tutoring Systems*, 85.

Principles of Assessment in the Generalized Intelligent Framework for Tutoring (GIFT)

Abstract: The challenges of assessing human performance have been around for centuries, long before the advent of the Generalized Intelligent Framework for Tutoring (GIFT). This section focuses on a discussion of principles of assessment and on how those principles should be applied in the context of GIFT delivered training. While concepts like reliability and validity are discussed, the goal of this section is not simply to provide a review of basic psychometric terms and methods. Rather, the authors have focused more on applying lessons learned from their respective experiences and disciplines to make recommendations on the development and design of GIFT. The chapters examine quite a range of topics from the somewhat philosophical (e.g., understanding the reasons and goals of assessment) to the very practical (e.g., developing an instructor dashboard to make student performance measures more accessible to instructors). Key themes that run

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through these chapters include understanding how evidence and data can be used to automatically support the validation of assessments in GIFT, creating a standardized method for implementing assessments in GIFT, and providing transparency of assessments to users of GIFT.

Keywords: Generalized Intelligent Framework for Tutoring. Principle assessment.

Citation: Goodwin, G., Principles of Assessment in the Generalized Intelligent Framework for Tutoring. *Design Recommendations for Intelligent Tutoring Systems*, 183.

Assessment of Individual Learner Performance in Psychomotor Domains

Abstract: The goal of training is to support the learner to achieve the learning objectives, i.e., reducing the task completion time, reducing errors, and increasing accuracy. Performance characterized by such speed and accuracy can be evaluated by interpreting the learner behavior – that is, as one of the classic models, Fitts’ law provides a way to assess a regularity of a simple psychomotor task, such as tapping or pointing (Fitts, 1954). Based on the Fitts’ model, researchers have investigated the coordination of physical human movement and information processing. The model has been used and expanded to predict the time to position and move around a mouse cursor in the human-computer interaction area (e.g., MacKenzie, 1992).

Keywords: Individual learner performance. Psychomotor domains. Performance. Psychomotor tasks.

Citation: Kim, J. W., Sottilare, R. A., Goodwin, G., & Hu, X. Assessment of Individual Learner Performance in Psychomotor Domains. *Design Recommendations for Intelligent Tutoring Systems*, 319.

Coordinating Evidence Across Learning Modules Using Digital Badges

Abstract: No matter how successful a learning module or intervention such as an intelligent tutoring system (ITS) is at producing learning, the fruits of those efforts cannot be employed efficiently without a suitable means for representing and conveying which learners possess which skills. Who will know to hire or promote this more knowledgeable individual, if there is no clear sign that they are more accomplished? Digital badges are digital artifacts that function as markers of achievement. Often described as building on the combined traditions found within

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Scouting (e.g., Boy Scouts or Girl Scouts) and online gaming (e.g., Xbox Live Achievements, PlayStation Network Trophies), badges are issued to an individual when the individual meets specific criteria embedded in program-relevant activities (Ostashewski & Reid, 2015).

Keywords: Learning modules. Digital badges. Intelligent tutoring system. Digital badges. Markers of achievement.

Citation: Higashi, R., Schunn, C., Nguyen, V., & Ososky, S. J. Coordinating Evidence Across Learning Modules Using Digital Badges. *Design Recommendations for Intelligent Tutoring Systems*, 53.

Cognitive Assessment as Service in the Generalized Intelligent Framework for Tutoring (GIFT)

Abstract: In current and earlier volumes of the series, more detailed analyses of ITSs have been presented. In general, an ITS has been considered as an integrated collection of more complicated models and processes (Sottolare, Graesser, Hu & Holden, 2013; Sottolare, Graesser, Hu & Goldberg, 2014; Sottolare, Graesser, Hu & Brawner, 2015; Sottolare, Graesser, Hu, Olney, Nye & Sinatra, 2016). With the limited space and restricted focus of the current chapter, we focus only on the evaluative component of ITSs (step D of the outline sequence), especially, we consider such component in the context of the General Intelligent Framework for Tutoring (GIFT). For the purpose of illustration, we consider two types of learner's responses: categorical responses (such as multiple choices) and natural language responses. For each of these two types of response types, we present theory-based assessment models, implemented as standalone software service following the best practice of service-oriented architecture (SOA). We argue that such web services can be used to serve GIFT and as an example of cognitive assessment web service for GIFT.

Keywords: Cognitive assessment. Generalized Intelligent Framework for Tutoring. Intelligent tutoring system. Service-orientated architecture.

Citation: Hu, X., Xu, S., Sottolare, R., & Albert, D. Cognitive Assessment as Service in the Generalized Intelligent Framework for Tutoring (GIFT). *Design Recommendations for Intelligent Tutoring Systems*, 295.

Toward Systematic Assessment of Human Performance Interventions in the US Army: An Assessment Process Framework

Abstract: The purpose of this chapter is to present some of the ideas emerging from the UMMPIREE effort. Specifically to present a definition of assessment and a framework that depicts steps regarding how assessment should be accomplished. The framework is applied to assessing human performance in technologically augmented learning environments such as intelligent tutoring systems (ITSs), specifically the Generalized Intelligent Framework for Tutoring (GIFT).

Keywords: Systematic assessment. Human performance intervention. Intelligent tutoring system. US army.

Citation: Orvis, K. L., Freeman, J. T., Beaubien, J. M., Burford, C. W., Johnston, J. H., Reinerman-Jones, L., & Teo, G. –Toward Systematic Assessment of Human Performance Interventions in the US Army: An Assessment Process Framework. *Design Recommendations for Intelligent Tutoring Systems*, 225.

Assessment of Forgetting

Abstract: Most efforts to educate individuals in a domain conclude with efforts to assess the effectiveness of the educational activities. During education research, the assessment activity tends to focus on the performance of the students and what that reflects on the quality of the educational intervention. After a quality educational intervention has been deployed, the focus of assessment turns to the individual students. In both cases, there are multiple considerations in collecting, analyzing, and interpreting the results of assessments.

Keywords: Assessment. Forgetting. Education research. Student performance.

Citation: Pavlik Jr, P. I., Maass, J. K., & Kim, J. W. Assessment of Forgetting. *Design Recommendations for Intelligent Tutoring Systems*, 203.

Motivating Individual Differences in an Intelligent Tutoring System

Abstract: A key ingredient of achievement, engagement, and learning is motivation. Motivated trainees believe, value, focus on learning, manage a task or time more efficiently, and persist. The flip-side results in disengagement, procrastination, anxiety, loss of control, negative thoughts, failure, or a complete shutdown. The benefits to properly assessing and individually motivating learners are saving lives, reducing cost, saving time, and increasing retention. The challenge is determining a goodness of fit for each individual that is measured by an increase in effort, attention, goal attainment, learning outcomes, and retention within an intelligent tutor. Traditionally, trainers develop relationships that paint a clear picture of the individual's motivation, but class size restricts individualization. Intelligent tutors have the potential to assess in real time, plan, and implement individualized motivational strategies to a task lacking luster.

Keywords: Individual differences. Intelligent tutoring system. Intelligent tutors. Motivation.

Citation: Reinerman-Jones, L., Lameier, E., Biddle, E., & Boyce, M. Motivating Individual Difference in an Intelligent Tutoring System. *Design Recommendations for Intelligent Tutoring Systems*, 331.

Assessment in Intelligent Tutoring Systems in Traditional, Mixed Mode, and Online Courses

Abstract: As technology has continued to develop, there have been new and creative ways to use it in the classroom. Classes have transformed into learning environments that rely not only on the in-person instructor, but have many other resources easily available for students. At the college level, courses can vary between different modes of instruction: traditional in-person, mixed mode (classes with both an in-person and online component), and online. Students routinely bring laptops and tablets to class to both take notes and work on their assignments. Further, there are often computer labs available for students to use for assignments at universities. In some cases, these labs can be reserved for specific classes and provide all students with the opportunity to engage with a computer during class time.

Keywords: Assessment of courses. Intelligent tutoring systems. Traditional course. Mixed course. Online course. Performance differences.

Citation: Sinatra, A. M., Ososky, S., & Sottolare, R. –Assessment in Intelligent Tutoring Systems in Traditional, Mixed Mode, and Online Courses. *Design Recommendations for Intelligent Tutoring Systems*, 235.

Introduction to Assessments Methods & GIFT

Abstract: This book is the fifth in a planned series of books that examine key topics (e.g., learner modeling, instructional strategies, authoring, domain modeling, assessment, impact on learning, team tutoring, machine learning, and potential standards) in intelligent tutoring system (ITS) design through the lens of the Generalized Intelligent Framework for Tutoring (GIFT) (Sottolare, Brawner, Goldberg & Holden, 2012; Sottolare, Brawner, Sinatra, & Johnston, 2017). GIFT is a modular, service-oriented architecture created to reduce the cost and skill required to author ITSs, manage instruction within ITSs, and evaluate the effect of ITS technologies on learning, performance, retention, transfer of skills, and other instructional outcomes. Along with this volume, the first four books in this series, Learner Modeling (ISBN 978-0-9893923-0-3), Instructional Management (ISBN 978-0-9893923-2-7), Authoring Tools (ISBN 978-0-9893923-6-5) and Domain Modeling (978-0-9893923-9-6) are freely available at www.GIFTtutoring.org and on Google Play. This introduction begins with a description of tutoring functions, provides a glimpse of assessment best practices, and examines the motivation for standards in the design, authoring, instruction, and evaluation of ITS tools and methods. We introduce GIFT design principles and discuss how readers might use this book as a design tool. We begin by examining the major components of ITSs.

Keywords: Generalized Intelligent Framework for Tutoring. Assessment methods. Introduction to GIFT.

Citation: Sottolare, R. A., Graesser, A. C., Hu, X., & Goodwin, G. A. Introduction to Assessment Methods & Gift. *Design Recommendations for Intelligent Tutoring Systems*, 1.

Understanding Competency Assessment Methodologies Applied to Adaptive Instruction in Intelligent Tutoring Systems

Abstract: The first goal of this chapter is to provide the reader with a basic understanding of competence, competency assessment methods, and their relationship to processes leading to knowledge and skill acquisition during adaptive instruction. The second goal is to introduce the chapters in this section of the book and define each chapter's importance to competency assessment and the design of Intelligent Tutoring Systems (ITSs). Let's begin by defining competence and competency. In terms of learning, competence is an "ability or skill" or "the ability to do something successfully or efficiently" (Merriam-Webster, 2017). The goal of adaptive instruction is to guide the learner in developing competence in one or more domains.

Keywords: Assessment methodologies. Adaptive instruction. Intelligent tutoring systems. Introduction to ITSs.

Citation: Sottolare, R. Understanding Competency Assessment Methodologies Applied to Adaptive Instruction in Intelligent Tutoring Systems. *Design Recommendations for Intelligent Tutoring Systems*, 17.

Resting Evidence in Assessment and Intelligent Tutors

Abstract: Assessment design methodologies such as evidence-centered design (ECD) provide an approach for representing the "argument" underlying an assessment. Argument-based structures articulate the chain of reasoning connecting task-level data to the evidence required to support assessment claims about the student. Intelligent tutoring systems (ITSs) reflect similar underlying rationale, with decisions about how to update the student model and what to present to the student next, dependent on student performance (evidence). Although the concept of "evidence" is widely used within the assessment community, it is less well articulated in the ITS literature. In this chapter, we argue for the necessity of formalizing the concept of evidence and for implementing tools and services that facilitate the use of evidence in ITSs. Explicitly representing evidence may provide a stronger theoretical basis for an ITS and facilitate the reuse of assessment components across ITSs. Furthermore, additions to the Generalized Intelligent Framework for Tutoring (GIFT) may support defining links from observable evidence to claims (number of links, types of evidence, types of observables, and properties) as well as mechanisms for quantifying evidence. Several examples illustrate how this approach facilitates reuse and handling of evidence in the areas of conversation-based assessment and GIFT-medical prototypes

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Keywords: Evidence in assessment. Intelligent tutors. Evidence centered design. Intelligent tutoring systems. Generalized Intelligent Framework for Tutoring. Conversation based assessment. GIFT medical prototypes.

Citation: Zapata-Rivera, D., Brawner, K., Jackson, G. T., & Katz, I. R. Reusing Evidence in Assessment and Intelligent Tutors. *Design Recommendations for Intelligent Tutoring Systems*, 125.

Using Mobile Technology to Generate Learning Content for an Intelligent Tutoring System

Abstract: With the release of the “Army Learning Concept for 2015,” the Army signaled a need to change the way it trained. One goal was to reduce the amount of lecture-based classes, and move towards “...more engaging technology-delivered instruction that will be used as part of a blended learning approach, distributed to the workforce for job-related sustainment learning, and as performance support applications.” As a result, a repository of learning modules will be needed to support career progression, assignment-oriented learning, operational lessons, and performance support. In addition, intelligent tutors, generated with the Generalized Intelligent Framework for Tutoring (GIFT), will tailor the learning experience to the individual learner.

Our research examined effective ways for guiding users, e.g. subject matter experts, instructional systems designers, etc. in the development of reusable learning objects (RLOs) to support adaptive learning. RLOs are small “chunks” of instructional content which are associated with learning objectives. The research included studying the common structure of RLOs and defining approaches for creating RLOs via easy-to-use, guided user interactions. In addition, a prototype authoring system was developed to provide a robust set of capabilities for quick and easy development of effective RLOs, leveraging the capability of mobile devices to create rich, multi-media assets. The resulting Android-based mobile app: 1) guides users through the development of instructionally sound RLOs and lessons that are created from sequencing multiple RLOs; 2) provides support for including multimedia assets such as video, audio, still imagery, and text to convey knowledge, 3) supports the development of embedded assessments within RLOs, and 4) saves/packages the instructional content in a sharable format (as a sharable content object). This paper discusses the user needs analysis, requirements definition, authoring tool prototype, exemplar training content development, and results from preliminary usability and instructional system design evaluations.

Keywords: Intelligent tutoring systems. Learning content generation. Mobile.

Citation: Long, R. A., Riley, J. M., & Padron, C. K. (2017, July). Using Mobile Technology to Generate Learning Content for an Intelligent Tutoring System. In *International Conference on Augmented Cognition* (pp. 199-209). Springer, Cham.

2016 Publications

GIFT Cloud: Improving Usability of Adaptive Tutor Authoring Tools Within a Web-Based Application

Abstract: GIFT Cloud is the recently released web-based application version of GIFT, an open-source computer-based tutoring architecture that supports authoring, deployment, and evaluation of intelligent tutoring system technologies. This paper presents the GIFT Cloud Authoring Tools, through the lens of usability. Each major element within the authoring tools is described, along with usability design considerations that were made in order to reduce occurrence of error, to organize information, and to support end-user goals. The initial release of GIFT Cloud supports an iterative design approach, informed by user data and feedback, with an overall goal of making tutor authoring practical for subject matter experts without computer programming or instructional design knowledge. As such, lessons learned from this release, as well as plans for future research and usability improvements, are discussed.

Keywords: Authoring. GIFT. Intelligent tutoring system. User data. Feedback.

Citation: Ososky, S., Brawner, K., Goldberg, B., & Sottilare, R. (2016, September). GIFT Cloud: Improving usability of adaptive tutor authoring tools within a web-based application. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 60, No. 1, pp. 1389-1393). Sage CA: Los Angeles, CA: SAGE Publications. DOI: 10.1177/1541931213601320

The Effects of Self-Reference and Context Personalization on Task Performance During Adaptive Instruction

Abstract: An advantage of computer-based instruction is that student entered information can be saved and used throughout learning. Self-reference (tying information to the self) has been shown to have a positive impact on memory and learning. This study evaluates the impact of including self-reference and familiar popular culture names during the assessment phase of adaptive instruction. Participants engaged with a computer-based tutorial about solving logic grid puzzles and were assessed by completing additional puzzles. The assessment puzzles included the participant's and friends' names (self-reference), popular culture names, or generic names. Participants in the popular culture condition spent significantly less time solving the standard puzzle than those in the generic condition, with no difference in percentage correct. The inclusion of popular culture names may have facilitated more efficient task performance while maintaining quality of performance. It is envisioned that this strategy can be implemented in computer-based adaptive instruction to improve task efficiency.

Keywords: Computer-based instruction. Self-reference. Adaptive instruction. Task efficiency.

Citation: Sinatra, A. M., Sottilare, R. A., & Sims, V. K. (2016, September). The effects of self-reference and context personalization on task performance during adaptive instruction. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 60, No. 1, pp. 398-402). Sage CA: Los Angeles, CA: SAGE Publications.

Agent-Based Practices for an Intelligent Tutoring System Architecture

Abstract: The Generalized Intelligent Framework for Tutoring (GIFT) project is partially an effort to standardize the systems and processes of intelligent tutoring systems. In addition to these efforts, there is emerging research in agent-driven systems. Agent-based systems obey software and messaging communication protocols and accomplish objectives to the original system, but have different architectural structure. This paper describes the upcoming research changes for GIFT, from a module-driven system to an agent-driven system, the reasons for wanting to do so, the advantages of the change, some initial technical approaches

which encapsulate current functionality, and the types of research that this change will enable in the future.

Keywords: Intelligent tutoring systems. Agent based systems. eLearning. mLearning. Software-as-a-service.

Citation: Brawner, K., Goodwin, G., & Sottolare, R. (2016, July). Agent-Based Practices for an Intelligent Tutoring System Architecture. In *International Conference on Augmented Cognition* (pp. 3-12). Springer International Publishing.

Examining the Influence of Heartbeat on Expert Marksman Performance

Abstract: Marksmanship training in the US Army follows a process that all marksmen must learn, understand, and experience to improve their shot. This standard can be broken down into key factors over which a marksman has control and needs to develop to improve his or her marksmanship. For that reason, in this technical note we examine the role of the heartbeat as observed from expert marksmen. The influence of the heartbeat is categorized into 3 different areas: 1) if expert marksmen time the shot on a heartbeat, 2) if they fire between heartbeats, or 3) if they simply ignore their heartbeat during marksmanship. The data support that expert marksmen ignore their heartbeat when firing. Because of this evaluation of expert behavior, we determine the heartbeat to be a nonfactor in marksmanship training.

Keywords: Training. Heart rate. Marksmanship. Instructions. Behavior. Performance human.

Citation: Goris, T., & Brawner, K. (2016). *Examining the Influence of Heartbeat on Expert Marksman Performance* (No. ARL-TN-0754). US Army Research Laboratory Aberdeen Proving Ground United States.

Modelling a Learner's Affective State in Real Time to Improve Intelligent Tutoring Effectiveness

Abstract: This paper introduces, describes, and evaluates real-time models of affective states of individual learners interacting with Intelligent Tutoring Systems. Computer-based instructors, like human instructors, should use affective information for adapting instruction. This requires an accurate representation of individual learner state during tutoring; however, models described in the literature

are generalized and constructed offline. Such total population models have faced validation difficulty with individuals, while individualized models have had difficulties with offline creation and online use. The simultaneous creation and utilization of an individualized model from sensor-based physiological measurements presents an attractive alternative. We present and evaluate approaches for building affective models during the tutoring session which address the difficulties present in real-time data streams. Additionally, this work examines the impact of occasional direct user query on model quality. The results indicate that individualized real-time model construction is comparable to offline equivalents, yet can be successfully applied in tutoring settings.

Keywords: Affective learner state. Real-time systems. Computer-managed instruction. Artificial intelligence. Intelligent tutoring systems.

Citation: Brawner, K. W., & Gonzalez, A. J. (2016). Modelling a learner's affective state in real time to improve intelligent tutoring effectiveness. *Theoretical Issues in Ergonomics Science*, 17(2), 183-210.

Considerations for Immersive Learning in Intelligent Tutoring Systems

Abstract: Research has examined the benefits and retractors of immersing the learner in an environment. Immersive computer-based training environments are costly to construct and may not always lead to significant learning or transfer benefits over other methods. The current paper presents a brief review of presence and immersion research in computer-based learning and adaptive tutoring. The Generalized Intelligent Framework for Tutoring (GIFT) is an open source domain-independent framework for creating intelligent tutoring systems (ITS). GIFT offers flexibility, and can be interfaced with training applications ranging from highly immersive computer-based learning environments (e.g., TC3Sim, VBS2) to less immersive mediums such as PowerPoint. The capabilities of GIFT that can be used to create immersive adaptive tutoring are discussed. Additionally, the use of GIFT to run and generate experimental studies to examine the impact of immersion is highlighted. Finally, recommendations are given on how to provide more opportunities to integrate immersive environments into GIFT.

Keywords: Immersion. Intelligent tutoring systems. Generalized Intelligent Framework for Tutoring. Presence.

Citation: Sinatra, A. M. (2016, July). Considerations for Immersive Learning in Intelligent Tutoring Systems. In *International Conference on Augmented Cognition* (pp. 76-84). Springer International Publishing.

A Review of Self-Reference and Context Personalization in Different Computer-Based Educational Domains

Abstract: A goal of instruction is for a student to not only learn the material and be able to recall it immediately afterwards, but also to be able to retain it for future use. Additionally, it is preferable for the material to be taught in such a way that the student can use what was learned and then apply or transfer it to new situations. Human memory and learning have been extensively studied, resulting in mnemonics and general strategies that assist in memory across different domains of instruction. One such strategy is linking information to knowledge that the student already has and that is important to them. This strategy can include linking information to the self, to people that the individual knows, or simply customizing the materials to include mention of topics that are of interest to the individual or group of students. There appears to be significant benefits to employing all of these approaches; however, they are often lumped together in the literature, and the different domains in which they may or may not be beneficial have not been acknowledged.

Many different domains, topics, and areas of instruction include materials, examples, and practice problems with wording that can be adjusted to make it specific to different students or interest areas. In many classes, whether they are lecture-based, web-based, large or small, it is often difficult to retain student interest and motivation throughout. However, there are different approaches that can be used to draw student attention and personalize the materials that they receive in order to keep them more interested in the topic. Referencing the self and context personalization (changing the wording of student materials to be contextually consistent with student interests) has been shown to have positive impacts on student outcomes. Self-reference and context/interest personalization techniques offer benefits to memory and performance without requiring large adjustments to learning materials. This chapter reviews research and approaches to self-reference, context personalization, interest personalization, and the impacts that they have on learning and retention in different domains. It has been assumed that these strategies will work between learning domains; however, research has focused primarily on mathematics. The domains of instruction are examined and recommendations are made for using this strategy in intelligent tutoring systems (ITSs).

Keywords: Intelligent tutoring systems. Computer-based education. Self-reference. Memory. Performance.

Citation: Sinatra, A. M. (2016). A Review of Self-Reference and Context Personalization in Different Computer-Based Educational Domains. *Design Recommendations for Intelligent Tutoring Systems*, 107.

Exploring the Diversity of Domain Modeling for Training and Educational Applications

Abstract: Domain models represent the knowledge within a task domain in order to facilitate instruction. This knowledge may be visual (e.g., text, graphic) or verbal and represents domain content to be presented to the learner during instruction, feedback provided by the tutor, and other communications initiated by the tutor (e.g., hints, prompts, questions, assertions). The goal of this chapter is to explore assorted domain models as they are applied within intelligent tutoring systems (ITSs) during adaptive instruction. Domains may be defined per the various taxonomies in the literature: cognitive (Bloom, 1956), affective (Krathwohl, Bloom & Masia, 1964), psychomotor (Simpson, 1972), or social (Soller, 2001), but most instructional domains are a mixture of two or more of these taxonomies.

Within the Generalized Intelligent Framework for Tutoring (GIFT), the domain model specifies concepts (also known as learning objectives) and their associated methods of measurement and sources for data to determine whether learners have met the standards for a concept. The GIFT domain model also has data structures that allow the author to specify the tutor actions (e.g., ask the learner a question or change the challenge level of the environment) in response to conditions identified within the environment and the learner. The authored tutor actions are linked to strategies (plans) recommended by the pedagogical model.

Keywords: Domain modeling. GIFT. Learning objectives. Pedagogical model. Intelligent tutoring systems.

Citation: Sinatra, A. M., & Sottolare, R. A. (2016). Exploring the Diversity of Domain Modeling for Training and Educational Applications. *Design Recommendations for Intelligent Tutoring Systems*, 161.

The Hidden Challenges of Team Tutor Development

Abstract: This paper describes the unexpected challenges of team tutor development such as the task and logistics. Previously, a research team from Iowa State University (ISU) working with the U.S. Army Research Laboratory (ARL) developed the reconnaissance (Recon) task for simple team tutoring with the Generalized Intelligent Framework for Tutoring (GIFT) (Bonner et al., 2015; Gilbert et al., 2015). Considerations were included for the testing environment such as audio-based team interactions, initialization of the scenario simultaneously, and the inclusion of eyetracking and screen capture technology. Throughout the process of tutor development, several computational challenges have been encountered such as the implementation of team rules, determination of the appropriate amount of feedback, and the use of participants' behavior history as input to the tutor. Our descriptions of these challenges should forewarn future developers of team tutors. We also suggest enhancements to GIFT to aid this process.

Keywords: Team tutor. Behavior. GIFT. Testing environments. Evetracking. Screen capture technology. Audio-based interactions. Scenario initialization.

Citation: Bonner, D., Slavina, A., MacAllister, A., Holub, J., Gilbert, S. B., Sinatra, A. M., ... & Winer, E. H. (2016). The hidden challenges of team tutor development.

Generalized Intelligent Framework for Tutoring (GIFT) Cloud/Virtual Open Campus Quick-Start Guide

Abstract: This document serves as the quick-start guide for GIFT Cloud, the web-based application version of the Generalized Intelligent Framework for Tutoring (GIFT). GIFT is a modular, open-source framework for building, deploying, and managing adaptive training content. GIFT Cloud allows learners, authors, and researchers to access GIFT without downloading and installing software on a desktop or laptop computer. The purpose of this document is to provide an overview of the primary interfaces and basic functions of GIFT Cloud. Topics include establishing a GIFT Account, taking courses on GIFT Cloud, orienting the user to GIFTs tools, and locating resources and providing feedback on GIFT Cloud.

Keywords: Computeraided instruction. Training management. Application software. User manuals. Adaptive training.

Citation: Ososky, S. (2016). Generalized Intelligent Framework for Tutoring (GIFT) Cloud/Virtual Open Campus Quick-Start Guide. Oak Ridge Associated Universities Oak Ridge United States.

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Sensor-Free or Sensor-Full: A Comparison of Data Modalities in Multi-Channel Affect Detection

Abstract: Computational models that automatically detect learners' affective states are powerful tools for investigating the interplay of affect and learning. Over the past decade, affect detectors--which recognize learners' affective states at run-time using behavior logs and sensor data--have advanced substantially across a range of K-12 and postsecondary education settings. Machine learning-based affect detectors can be developed to utilize several types of data, including software logs, video/audio recordings, tutorial dialogues, and physical sensors. However, there has been limited research on how different data modalities combine and complement one another, particularly across different contexts, domains, and populations. In this paper, we describe work using the Generalized Intelligent Framework for Tutoring (GIFT) to build multi-channel affect detection models for a serious game on tactical combat casualty care. We compare the creation and predictive performance of models developed for two different data modalities: 1) software logs of learner interactions with the serious game, and 2) posture data from a Microsoft Kinect sensor. We find that interaction-based detectors outperform posture-based detectors for our population, but show high variability in predictive performance across different affect. Notably, our posture-based detectors largely utilize predictor features drawn from the research literature, but do not replicate prior findings that these features lead to accurate detectors of learner affect.

Keywords: Models. Affective behavior. Intelligent tutoring systems. Games. Medical services. Comparative analysis. Computer software. Diaries. Interaction. Human posture. Observation. Measurement equipment. Training. Military personnel. Technology uses in education. Physiology. Coding. Statistical analysis. Regression (statistics).

Citation: Paquette, L., Rowe, J., Baker, R., Mott, B., Lester, J., DeFalco, J., ... & Georgoulas, V. (2016). Sensor-Free or Sensor-Full: A Comparison of Data Modalities in Multi-Channel Affect Detection. *International Educational Data Mining Society*.

Effect of Topography on Learning Military Tactics-Integration of Generalized Intelligent Framework for Tutoring (GIFT) and Augmented Reality Sandtable (ARES)

Abstract: This report discusses the findings of a research project that integrated the Generalized Intelligent Framework for Tutoring and the Augmented Reality Sandtable (ARES) for the assessment of military tactics. An experiment involving 19 Reserve Officers Training Corps cadets from a large southeastern university assessed performance, physiological, and experiential data in a between-subjects design. The conditions consisted of a 2-D map displayed on either a flat or contoured surface, both of which leveraged the projection technology of ARES. Results of the study did not indicate significant differences between time on task, accuracy, or electrodermal activity, but a larger sample size is needed to verify findings. Preference between conditions was more prevalent in support of ARES; however, individuals that preferred the flat condition discussed issues with the ARES condition being more difficult to precisely measure, consistent with the findings in the literature. This study is being refined for a follow-on experiment to be conducted at the United States Military Academy at West Point.

Keywords: Military tactics. Adaptive training. Topography. Workload. Virtual reality. Learning. Mental processes. Simulations.

Citation: Boyce, M. W., Reyes, R. J., Cruz, D. E., Amburn, C. R., Goldberg, B., Moss, J. D., & Sottolare, R. A. (2016). Effect of Topography on Learning Military Tactics-Integration of Generalized Intelligent Framework for Tutoring (GIFT) and Augmented Reality Sandtable (ARES) (No. ARL-TR-7792). Army Research Lab Aberdeen Proving Ground Maryland Aberdeen Proving Ground United States.

Electrodermal Activity Analysis for Training of Military Tactics

Abstract: This study examined the differences in the electrodermal activity (EDA) of 19 ROTC cadets viewing a 2D or 3D perspective display. Skin conductance responses (SCRs) were analyzed using a multistep visual analytic process and coded according to participant and condition. Results show non-significant differences SCRs between conditions, however since it is only an initial study, more research needs to be done before definitive conclusions can be made. Future investigations involving mixed method research design are discussed with a specific emphasis on user engagement and workload. The results of this initial study will be incorporated into future research with the United States Military Academy at West Point.

Approved for public release; distribution is unlimited.

Keywords: Electrodermal activity. Military tactics. Skin conductance responses. Research design. User engagement. Workload. West Point.

Citation: Boyce, M. W., Goldberg, B., & Moss, J. D. (2016, September). Electrodermal Activity Analysis for Training of Military Tactics. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 60, No. 1, pp. 1339-1343). Sage CA: Los Angeles, CA: SAGE Publications.

Elements of Adaptive Instruction for Training and Education

Abstract: This paper discusses critical elements of adaptive instruction in support of training and education. Modeling and assessing learners and teams, optimizing adaptive instructional methods, applying domain modeling outside of traditional training and educational domains, automating authoring processes, and assessing the learning effect of instruction are among the challenges reviewed.

Keywords: Adaptive instruction. Intelligent tutoring systems. Learner modeling. Domain modeling. Authoring tools. Learning effect.

Citation: Sottilare, R. A., & Boyce, M. W. (2016). Elements of Adaptive Instruction for Training and Education. In Schmorow, D. D., & Fidopiastis, C. M. (Eds.). (2016). Foundations of Augmented Cognition: Neuroergonomics and Operational Neuroscience: 10th International Conference, AC 2016, Held as Part of HCI International 2016, Toronto, ON, Canada, July 17-22, 2016, Proceedings (Vol. 9744). Springer.

Interpretative Phenomenological Analysis for Military Tactics Instruction

Abstract: This experiment determined how 19 Army Reserve Officer Training Corps (ROTC) cadets rationalize military tactics decisions using two different displays through qualitative data analysis. Interpretative Phenomenological Analysis (IPA) was used to understand platoon and squad level decision-making to help influence the development of adaptive training systems. IPA is a process through which the participant experience is analyzed through a dual interpretation methodology, where participants provide meaning of their world, followed by an empirical assessment to categorize and define the participants' perspectives of their experiences. The tactical questions covered topics that would typically be covered in a military science junior level class. Results include the importance of terrain elevation differences between friendly and enemy forces, as well as the importance

of cover and concealment and distance. The findings from this experiment are currently being developed into a large scale assessment in collaboration with the United States Military Academy at West Point.

Keywords: Interpretative phenomenological analysis. Military population. Qualitative research. Experiential learning. Decision-making.

Citation: Boyce, M. W., Cruz, D., & Sottolare, R. (2016). Interpretative Phenomenological Analysis for Military Tactics Instruction. In *Advances in Human Factors, Business Management, Training and Education* (pp. 623-634). Springer International Publishing.

Automated Detection of Cognitive and Metacognitive Strategies for Learner Modeling in GIFT

Abstract: Promoting students' learning of cognitive and metacognitive strategies that may generalize across domains is increasingly seen as an important component of intelligent tutoring systems (ITSs), especially those that support open-ended complex problem solving and decision making. Such open-ended learning environments (OELEs) allow learners to make choices in their approach to developing, monitoring, and managing their evolving solution paths (Segedy, Kinnebrew & Biswas, 2015). To be successful, learners have to become adept at employing cognitive, metacognition and self-regulation processes and strategies in developing their solutions (Butler & Winne, 1995; Kinnebrew, Segedy & Biswas, 2016; Zimmerman & Schunk, 2001). Such processes and strategies typically encompass information acquisition, situation awareness, plan development and refinement taking into account resource limitations and trade-offs, solution monitoring, evaluation, and, finally, reflection.

In this paper, we present our work on modeling students learning about counterinsurgency (COIN) operations with UrbanSim (McAlinden, et al., 2009), a turn-based game environment, where users take on the role of a battalion commander to deal with fictional counterinsurgency scenarios. We track student problem solving and analyze student performance using the extensions of the GIFT tracking and learner modeling capabilities that we are implementing to develop metacognitive tutoring in GIFT. The analysis of turn-by-turn student performance is a first step toward analyzing students' metacognitive and problem solving processes. The data we analyze in this paper are data logged by UrbanSim collected

in a study conducted with Reserve Officers' Training Corps (ROTC) officers-in-training at a major U.S. University. We analyze students' operations in the context of the state of the simulation. We present our analysis methods, and discuss how the results will help us define learner models that capture students cognitive and metacognitive processes.

Keywords: Cognitive strategies. Metacognitive strategies. Self-regulation. Learner modeling. GIFT. UrbanSim. Intelligent tutoring system. Open-ended learning environments.

Citation: Tscholl, M., Biswas, G., Goldberg, B. S., & Sottolare, R. A. (2016). Automated Detection of Cognitive and Metacognitive Strategies for Learner Modeling in GIFT. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 15).

Elements of a Learning Effect Model to Support an Adaptive Instructional Framework

Abstract: This paper describes the evolution of a learning effect model (LEM; Sottolare, 2012; Sottolare, Ragusa, Hoffman & Goldberg, 2013) to guide adaptive instruction within the Generalized Intelligent Framework for Tutoring (GIFT; Sottolare, Brawner, Goldberg & Holden, 2012), an open-source architecture for authoring, delivering, guiding, and evaluating tailored, computer-based instruction for individual learners and teams of learners. Effect models may be used to demonstrate the relationship between the learner, the computer-based tutor, and the instructional environment and how they influence each other during adaptive instruction.

The GIFT LEM is focused on how these relationships facilitate desirable learning outcomes (e.g., knowledge and skill acquisition, performance, retention, and transfer of skills from training to the work environment). The LEM discussed in this paper began as a set of strategies (plans) and tactics (actions) used by a GIFT-generated tutor to drive tailored training experiences in real-time. The LEM has since evolved to encompass real-time and long-term models of both individual learners and teams of learners plus required knowledge, learning objectives, tailored learning events, and measures of learning and performance. This paper provides a detailed breakout of elements and processes that compose the LEM and a description of their function in the process of adaptive instruction.

Keywords: Learner effect model. Adaptive instruction. GIFT. Open-sourced architecture. Computer-based instruction. Individual learners. Team learning. Models. Instructional environment.

Citation: Sottolare, R. (2016, July). Elements of a Learning Effect Model to Support an Adaptive Instructional Framework. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 7).

Motivational Feedback Messages as GIFT Interventions to Frustration

Abstract: Determining how to effectively respond to learner affect is important not only in face-to-face learning environments (Pekrun, Goetz, Titz & Perry, 2002), but also within the field of intelligent tutoring systems (ITSs) (Goldberg et al., 2012). This requires not only tools to accurately identify affect, but also developing a suite of accompanying interventions that can respond to learner affect (D’Mello, Lehman & Graesser, 2011).

In an effort to help learners regulate their affective states, some computer tutoring systems researchers have used interventional feedback messages to motivate the learner through a frustrated state (Robison, McQuiggan & Lester, 2009). However, these researchers have noted that where frustration has been detected and feedback delivered, learners do not always respond positively to these interventions, but rather may react negatively to feedback provided by the system (Robison, McQuiggan & Lester, 2009). This has given rise to the need to take a closer examination of the design of motivational feedback messages delivered to learners in a frustrated state to determine the most effective approach for addressing learner frustration via interventional feedback messages.

Within this context, then, the gap addressed by this current work is an effort in determining what kind of motivational feedback messages delivered within an ITS effectively addresses the affective state of frustration within a simulation-based training game and promotes learning gains. Three theories of motivation were targeted to design feedback messages: 1) theory of control-value (Pekrun, Elliot & Maier, 2006); 2) theory of social identity (Tajfel & Turner, 1979); and 3) theory of self-efficacy (Bandura, 1977). These theories are distinct from each other in the way they target either a person’s sense of what they value (control-value theory), who they are (social identity theory), and what a person believes they can achieve (self-efficacy theory).

Keywords: Motivation. Learner affect. Intelligent tutoring systems. Frustration. Feedback. Affective state. Theories of motivation.

Citation: DeFalco, J. A., Georgoulas-Sherry, V., Paquette, L., Baker, R. S., Rowe, J., Mott, B., & Lester, J. Motivational Feedback Messages as GIFT Interventions to Frustration. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 25).

The Use of Social Media for Creating and Improving Learning Content

Abstract: The US Army trains and educates over a half million individuals per year in a course-based, throughput-oriented system. Much of the Army's web-based instruction is in the form of static PowerPoint presentations, with little tailoring to individual soldier needs. With the ever-changing landscape of full spectrum operations, today's soldiers are facing ill-structured problems and have little time for the ideal levels of reflection and repetition needed to promote critical thinking, adaptability, and mastery of complex skills. Additionally, the current time frame for updating courses (3 to 5 years) does not support the modern Army's fast-paced learning needs.

In pursuit of more powerful training tools, the US Army Research Laboratory (ARL) has sponsored research resulting in the Generalized Intelligent Framework for Tutoring (GIFT; Sottolare, Brawner, Goldberg & Holden, 2012; Sottolare, Holden, Goldberg & Brawner, 2013), an open source architecture to lower the skills and time needed to author, deliver, and evaluate adaptive instruction. To enhance the content authoring and management capabilities of GIFT and other instructional frameworks, ARL has sponsored research into a Social Media Framework (SMF) that enables organizations to crowd-source and crowd-vet new learning content and improvements to existing courses. The research questions we seek to answer in our current research include the extent to which the SMF and GIFT can: (a) promote critical thinking, collaboration, adaptability, effective communication, and problem solving; (b) help close the gap between formal training and operational application of the training to missions in the field; (c) reduce the time required to locate and use learning resources; (d) reduce the time required to incorporate feedback from the field into formal instruction; and (e) reduce instructor workload, while maximizing the efficacy of the instructor's time.

Keywords: Social media. Learner content. Web-based instruction. Soldiers. GIFT. Open source architecture. Adaptive instruction. Training. Social Media Framework.

Citation: Long, R. A., Boland, I. T., & Silverglate, D. The Use of Social Media for Creating and Improving Learning Content. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 37).

The GIFT 2016 Community Report

Abstract: The first version of the Generalized Intelligent Framework for Tutoring (GIFT) was released to the public in May 2012 (Sottolare, Brawner, Goldberg & Holden). One year later, the first symposium of the GIFT user community was held at the Artificial Intelligence and Education conference in Memphis, Tennessee. Since then, the GIFT development team has continued to gather feedback from the community regarding recommendations on how the GIFT project can continue to meet the needs of the user community and beyond. This paper continues the conversation with the GIFT user community in two important ways. First, it invites and encourages members of the GIFT user community to continue to share their feedback, research findings, and technology innovations with the development team and with one another in order to strengthen the power, usability, and flexibility of the GIFT project. This year, the title of the current paper has been updated to reflect the emphasis on the GIFT community. Second, as a follow up to the “GIFT 2015 Report Card and State of the Project” (Brawner & Ososky, 2015), this paper briefly describes how the GIFT development team is addressing features requested in previous GIFT Symposium meetings and serves as documentation for the next major project direction.

The research and technology innovation efforts presented in the current document include those that are informed by the GIFT user community, and only represent a fraction of the overall research, development, and implementation work associated with GIFT. We invite the reader to review the other chapters in this volume, publications on GIFTTutoring.org, and other references described below, to get a sense of the total body of work on the GIFT project. Major themes in this current, 2016 GIFT community discussion include user experience improvements for authors and researchers, functionality supporting experimentation with GIFT, and the alpha release of GIFT Cloud as an enabling technology.

Keywords: GIFT. Feedback. Recommendations. GIFT community. Innovation. Research. Development. Implementation. Improvements.

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Citation: Ososky, S., & Brawner, K. (2016, July). The GIFT 2016 Community Report. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 63).

Using GIFT Wrap to Author Domain Assessment Models with Native Training Applications

Abstract: A generalized tool to build tutors helps to facilitate authoring across domains, however it decreases the likelihood that the authoring experience will be well guided with context sensitive help when necessary. For example, a course designer creating a course on counter insurgency and another creating a course on crowd control would benefit from course creation interfaces tailored for each domain to help guide them through the authoring process. However, since it is currently inconceivable to develop an authoring environment for all domains and user roles, an alternative solution is needed that can provide the domain familiarity while still offering a generalized approach. This paper provides an insight into ongoing development on the next generation GIFT authoring tool called GIFT Wrap. GIFT Wrap aims to merge the abstract nature of authoring domain assessment models with the native training applications that subject-matter experts are familiar with. This connection will diminish the learning curve associated with authoring for an ITS.

Keywords: Generalized tool. Tutors. Authoring. Modeling domains. GIFT Wrap. Training applications. Intelligent tutoring systems.

Citation: Hoffman, M., Markuck, C., & Goldberg, B. (2016, July). Using GIFT Wrap to Author Domain Assessment Models with Native Training Applications. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 75).

Extending GIFT with a Reinforcement Learning-Based Framework for Generalized Tutorial Planning

Abstract: In this paper, we describe our recent work on a modular reinforcement learning framework for tutorial planning in the Generalized Intelligent Framework for Tutoring (GIFT; Sottolare, Brawner, Goldberg & Holden 2012). We focus on inducing tutorial planning models directly from learner data to support a broad range of tutorial interventions, which share a generalized encoding of instructional strategies and tactics across multiple learning environments. This work is part of a collaborative project between North Carolina State University (NCSU), Intelligent

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Automation, Inc. (IAI), and the U.S. Army Research Laboratory (ARL) to investigate generalizable data-driven tutorial planning that operates across multiple training environments. We are investigating modular reinforcement learning-based tutorial planning in the domain of counterinsurgency and stability operations (COIN) training, with a focus on adaptive hypermedia and simulation-based learning environments. We describe the initial design and development of a generalized tutorial planner, whose design is inspired by Chi's ICAP framework (2009), which differentiates between passive, active, constructive, and interactive forms of learning. In addition, we describe a pilot study that was conducted with university ROTC cadets, which was designed to test the impact of ICAP-inspired tutorial interventions on learning outcomes during COIN training. We conclude with a discussion of design recommendations for GIFT to facilitate reinforcement learning-based tutorial planning induced from simulated- and human-student data.

Keywords: Learning-based framework. Generalized tutorial. GIFT. Learner data. Tutorial planning models. Generalized encoding. Instructional strategies. Tactics. Multiple learning environments.

Citation: Rowe, J., Frankosky, M., Mott, B., Lester, J., Pokorny, B., Peng, W., & Goldberg, B. (2016, July). Extending GIFT with a Reinforcement Learning-Based Framework for Generalized Tutorial Planning. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4)* (p. 87).

Integrating an Interoperable Competency Model with GIFT using the Experience API (xAPI)

Abstract: A robust student model is key to successful intelligent tutoring. Traditionally, student models are specific to the intelligent tutoring system (ITS) in which they reside, and are not reusable across different educational technologies. As the U.S. Army works toward the goal of maintaining persistent representations of an individual learner and integrating Soldier training across multiple systems, student models should be flexible to support their use across multiple training platforms. Work on automating student model generation from systems could provide a means to extend the capability of the Generalized Intelligent Framework for Tutoring (GIFT) and allow an ecosystem of ITSs and tools to create common value.

In this paper, we describe our work to create such a learner model which we call an Interoperable Competency Model (ICM) that can be used by GIFT. This model incorporates xAPI performance data from training delivered both within and

outside of GIFT, to model learner competencies. An ICM database exists outside of GIFT to facilitate the data being accessed, updated, and used by multiple training systems. In this way, GIFT can effectively cooperate with other training systems within a learning ecosystem to develop learner competencies. This might take the form of providing programmed or remedial training, providing diagnosis of learner problems, recommending training to learners and instructors, or providing predictions of skill acquisition and/or retention.

Keywords: Student model. Competency model. GIFT. Experience API. Intelligent tutoring systems. Reusability. Interoperable competency model. Performance data. Training.

Citation: Goodwin, G., Medford, A., Diaz, G., Murphy, J., Twitchell, M., & Blink, M. J. (2016, July). Integrating an Interoperable Competency Model with GIFT using the Experience API (xAPI). In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 99).

An Adaptive AAR Capability for GIFT

Abstract: The US Army Research Laboratory (ARL) seeks to improve the capability for customized feedback within GIFT, in support of the ALM vision. In this paper, we report on progress in developing an Adaptive After-Action Review (AAR) Module that is grounded in the well-validated theory of deliberate practice, which suggests that expertise grows best when the learner focuses study and practice on specific, deficient knowledge and skills, and receives feedback concerning the efficacy of their performance (Ericsson, Krampe, & Tesch-Romer, 1993). The AAR model will improve the learner's competence on specific competencies. It is based on a domain-general mathematical approach, and contains adjustable parameters that will be adjusted by looking across instances in which feedback has been applied and assessing the impact of that feedback on learning. This model will address both components of the deliberate practice formula, as it will focus study on specific competencies and optimize feedback that drives learning and improves performance. The Module will plug into the GIFTarchitecture, making it simpler for ITS developers to dynamically optimize feedback for users of GIFT-based ITSs.

The Adaptive AAR Module is designed to support the delivery of AAR during self-guided learning and in classroom instruction. Initially, we are developing our technology to interact with Newton's Playground (Zhao, W., M. Ventura, et al.,

2015) in the physics tutoring domain. The capability within will be generic, and in future work will be expanded to other domains.

Keywords: Customized feedback. GIFT. Adaptive after-action review. Feedback. Domain. Model. Self-guided learning. Newton's Playground.

Citation: Carlin, A., Kramer, D., Nucci, C., Oster, E., Freeman, J., & Brawner, K. (2016, July). An Adaptive AAR Capability for GIFT. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 111).

From Concept to Publication-A Successful Application of Using GIFT from the Ground Up

Abstract: The idea for this paper comes from the desire to help people who are unfamiliar with, or novices using the Generalized Intelligent Framework for Tutoring (GIFT, Sottolare, Brawner, Goldberg, & Holden, 2012) understand how GIFT can effectively gather and collect data without large amounts of programming or intelligent tutoring experience. By providing guidance for building an assessment for an experiment, a potential author can give GIFT a try without intimidation. This paper serves as a companion to previous papers on experimentation and GIFT (Goldberg & Cannon-Bowers, 2015; Sinatra, 2014) as well as papers discussing the authoring process using GIFT (Brawner & Ososky, 2015). Sinatra (2014) discusses GIFT from the perspective of a research psychologist. She explains the use of the Course Authoring Tool (CAT), the creation of surveys using the Survey Authoring System (SAS), and the exporting of data using the Event Reporting Tool (ERT) to collect data. Brawner & Ososky (2015) discuss the ongoing development with GIFT as a result of user requirements or feature requests. The paper discusses GIFT as a content manager, where it assists in the interaction with the Augmented REality Sandtable (ARES, Amburn, Vey, Boyce & Mize, 2015).

Keywords: GIFT. Authoring. Experiment assessment. Survey Authoring System. Event Reporting Tool. Data collection. User requirements. Content management. ARES.

Citation: Boyce, M. W. From Concept to Publication-A Successful Application of Using GIFT from the Ground Up. In Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4) (p. 125).

The Updated Research Psychologist's Guide to GIFT

Abstract: DON'T PANIC. Those two words were made famous by the book *The Hitchhiker's Guide to the Galaxy* (Adams, 1979), as their being on the cover was one of reasons that the fictitious guide had sold more copies than the *Encyclopedia Galactica* (it was also slightly cheaper). Those classic words were also included at the beginning of my original *Research Psychologist's Guide to GIFT* paper (Sinatra, 2014) that was presented at GIFTSym2. Having "Don't Panic" at the top of the page is meant to serve as a reminder that even though things can seem overwhelming at times when using software such as the Generalized Intelligent Framework for Tutoring (GIFT; Sottolare, Brawner, Goldberg & Holden, 2012), there are documents like this one that include explanations on how to easily and efficiently use GIFT. In a world filled with movie sequels and prequels this guide serves as a sequel of sorts to the original *Research Psychologist's Guide to GIFT*. However, it does not necessarily replace it. The information provided in it is still helpful, however, many changes have occurred in the past 2 years and the current work provides information about how to use updated features in GIFT, and considerations that should be made as a result of the changes. This guide itself will be tightly coupled with the releases surrounding it, GIFT 2015-2X, GIFT Cloud/GIFT Virtual Open Campus, and the soon to be released GIFT 2016-1. Perhaps the current guide is a middle piece of a trilogy (or a series of trilogies), and hopefully future editions will cover the new advancements that are made with GIFT over time.

Keywords: Research psychology. Ease. Effectiveness. User capabilities. GIFT.

Citation: Sinatra, A. M. *The Updated Research Psychologist's Guide to GIFT*. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4)* (p. 135).

Designing the User Experience of the GIFT Cloud Authoring Tools

Abstract: This paper presents a new user experience for the authoring tools associated with the web-based version of the Generalized Intelligent Framework for Tutoring (GIFT; Sottolare, Brawner, Goldberg & Holden, 2012), known as GIFT Cloud. The new user experience endeavors to provide user interfaces (UI) and interaction paradigms that are more congruent with human mental models of adaptive tutor authoring, compared to the system representation model upon which prior versions of the authoring tools were more closely associated.

Based on a flowchart-interaction metaphor, the new authoring tools will allow authors to take an object oriented approach to sequencing course content. The new design is intended to be learnable and efficient for authors without computer programming or instructional design experience. This current paper will describe the evolution of the GIFT authoring tools, articulate the vision for the new authoring experience, and discuss the principles upon which the new design is based. This work is intended to benefit novice and intermediate users of the GIFT authoring tools, and will be of value to researchers and practitioners interested in developing or managing adaptive training content using GIFT.

Keywords: User experience. Authoring tools. GIFT. User interfaces. Adaptive tutor authoring. Adaptive training content.

Citation: Ososky, S. (2016, July). Designing the User Experience of the GIFT Cloud authoring tools. In *Proceedings of the 4th Annual GIFT Users Symposium*.

Scaling Across Domains and the Implications for GIFT

Abstract: Currently, the Generalized Intelligent Framework for Tutoring (GIFT) adapts training in a somewhat closed system. That is, current GIFT applications are only concerned with modeling the learner and do main within the confines of a single block of training delivered exclusively through the GIFT framework. While this approach has been advantageous from the point of view of providing experimental control while exploring GIFT’s utility and effectiveness, it only partially addresses what we know to be the “real world” requirements of an adaptive training system. Adaptive training systems like GIFT will be expected to function within a rich ecosystem of training events and include classroom lectures, group discussions, and hands-on training, as well as simulation, gaming, other computer-based training, and training out comes. A single course might easily include all of these forms of training, while GIFT may be responsible for only a subset. For GIFT to be most effective in such an environment, it will have to be able to model the learner and domain at a higher level and not just for the specific blocks of training that it is responsible for delivering.

Language training and marksmanship training are real-world examples of the type of training described above. Neither language proficiency nor marksmanship expertise develops through training in single applications or over short periods of time. Rather, both require hundreds of hours of deliberate practice after mastering the basics. Training for both includes lecture, computer-based training, and live practice. While technology has been shown to help language learning (Zhao, 2003) and marksmanship training (Chung et al., 2011), studies are typically isolated to a single application over a short period of time (although there are some exceptions,

notably Adair-Hauck, Willingham-McLain & Youngs, 2000; Green & Youngs, 2001; Spain et al., 2013). This chapter explores the challenges of scaling the domain model to encompass an entire course, specifically through the examination of these two training domains.

Keywords: Scaling. Domain model. Adaptive application. Training. Course examination. Learner model. High level domain.

Citation: Brawner, K. W., Goodwin, G., & Regan, D. (2016). Scaling Across Domains and the Implications for GIFT. *Design Recommendations for Intelligent Tutoring Systems*, 97.

Domain Modeling in a Psychomotor World: A Marksmanship Use Case

Abstract: Recent technological advancements have extended computer-based training and education practices beyond the traditional desktop environment and into domains requiring physical interaction to conduct tasks. In this chapter, we examine a psychomotor use case as it relates to domain modeling within the Generalized Intelligent Framework for Tutoring (GIFT), and present considerations to address when developing any system of this nature. GIFT is a domain-independent architecture developed for the purpose of building adaptive training functions and intelligent tutoring systems (ITSs) across an array of tasks and a conceivably unlimited set of knowledge, skills, and abilities (KSAs). A current objective is to apply GIFT tools and methods in an Army-valued skill domain that incorporates psychomotor components of task execution and KSA development (Sottolare, Sinatra, Boyce & Graesser, 2015). The intention is to broaden ITS modeling techniques beyond the traditional cognitive dimensions of learning. In this instance, individuals are reliant upon knowledge and skills associated with psychomotor functions rather than cognitive application used to solve problems. From an adaptive training and ITS perspective, this new psychomotor paradigm requires a shift in how the domain space is modeled to associate this new type of input for informing assessment. Rather than modeling and monitoring steps toward solving a problem and identifying misconceptions and impasses along the way, the psychomotor use case focuses on behavior and its inherent influence on performance; specifically, what nuances of a task are dictated by variations in patterns of behavior and what strategies can be enacted to assist an individual in acquiring the ability to replicate a desired behavior across multiple trials. The end-state goal is to enhance training systems to support physical skill development through deliberate practice techniques (Ericsson, 2006, 2014) pedagogically managed by ITS assessment and feedback methods.

Keywords: Domain modeling. Psychomotor. Marksmanship. Intelligent tutoring system. Assessment. Feedback. Training.

Citation: Goldberg, B., & Amburn, C. Domain Modeling in a Psychomotor World: A Marksmanship Use Case. *Design Recommendations for Intelligent Tutoring Systems*, 195.

Defining the Ill-Defined: From Abstract Principles to Applied Pedagogy

Abstract: Attempts to define ill-defined domains in intelligent tutoring system (ITS) research has been approached a number of times (Fournier-Viger, Nkambou & Nguifo, 2010; Lynch, Ashley, Pinkwart & Alevén, 2009; Mitrovic & Weerasinghe, 2009; Jacovina, Snow, Dai & McNamara, 2015; Woods, Stensrud, Wray, Haley & Jones, 2015). Related research has tried to determine levels of ill-definedness for a domain (Le, Loll & Pinkwart, 2013). Despite such attempts, the field has not yet converged on common guidelines to distinguish between well- versus ill-defined domains. We argue that such guidelines struggle to converge because a domain is too large to meaningfully categorize: every domain contains a mixture of well- and ill-defined tasks. While the co-existence of well- and ill-defined tasks in a single domain is nearly universally agreed upon by researchers, this key point is often quickly buried by an extensive discussion about what makes certain domain tasks ill defined (e.g., disagreement about ideal solutions, multiple solution paths).

In this chapter, we first take a step back to consider what is meant by a domain in the context of learning. Next, based on this definition, we map out the components that are in a learning domain, since each component may have ill-defined parts. This leads into a discussion about the strategies that have been used to make ill-defined domains tractable for certain types of pedagogy. Examples of ITS research that applies these strategies are noted. Finally, we conclude with practical how-to considerations and open research questions for approaching ill-defined domains.

Keywords: Ill-defined domains. Intelligent tutoring systems. Learning domain. Pedagogy. Learning tasks. Authoring.

Citation: Nye, B. D., Boyce, M. W., & Sottilare, R. A. (2016). Defining the Ill-Defined: From Abstract Principles to Applied Pedagogy. *Design Recommendations for Intelligent Tutoring Systems*, 19.

A Review of Self-Reference and Context Personalization in Different Computer-Based Educational Domains

Abstract: A goal of instruction is for a student to not only learn the material and be able to recall it immediately afterwards, but also to be able to retain it for future use. Additionally, it is preferable for the material to be taught in such a way that the student can use what was learned and then apply or transfer it to new situations. Human memory and learning have been extensively studied, resulting in mnemonics and general strategies that assist in memory across different domains of instruction. One such strategy is linking information to knowledge that the student already has and that is important to them. This strategy can include linking information to the self, to people that the individual knows, or simply customizing the materials to include mention of topics that are of interest to the individual or group of students. There appears to be significant benefits to employing all of these approaches; however, they are often lumped together in the literature, and the different domains in which they may or may not be beneficial have not been acknowledged.

Many different domains, topics, and areas of instruction include materials, examples, and practice problems with wording that can be adjusted to make it specific to different students or interest areas. In many classes, whether they are lecture-based, web-based, large or small, it is often difficult to retain student interest and motivation throughout. However, there are different approaches that can be used to draw student attention and personalize the materials that they receive in order to keep them more interested in the topic. Referencing the self and context personalization (changing the wording of student materials to be contextually consistent with student interests) has been shown to have positive impacts on student outcomes. Self-reference and context/interest personalization techniques offer benefits to memory and performance without requiring large adjustments to learning materials. This chapter reviews research and approaches to self-reference, context personalization, interest personalization, and the impacts that they have on learning and retention in different domains. It has been assumed that these strategies will work between learning domains; however, research has focused primarily on mathematics. The domains of instruction are examined and recommendations are made for using this strategy in intelligent tutoring systems (ITSs).

Keywords: Self-reference. Context personalization. Computer-based education. Memory and learning. Interest personalization. Mathematics. Intelligent tutoring systems.

Citation: Sinatra, A. M. (2016). A Review of Self-Reference and Context Personalization in Different Computer-Based Educational Domains. *Design Recommendations for Intelligent Tutoring Systems*, 107.

Introduction to Domain Modeling & GIFT

Abstract: This introduction begins with a description of tutoring functions, provides a glimpse of domain modeling best practices, and examines the motivation for standards in the design, authoring, instruction, and evaluation of ITS tools and methods. We introduce GIFT design principles and discuss how readers might use this book as a design tool. We begin by examining the major components of ITSs

Keywords: Learner modeling. Instructional strategies. Authoring. Domain modeling. Assessment. Impact on learning. Team tutoring. GIFT. Design tool. Learning. Performance. Retention. Transfer.

Citation: Sottolare, R. A., Graesser, A. C., Hu, X., Olney, A., Nye, B., & Sinatra, M. (2016). Introduction to Domain Modeling & Gift. *Design Recommendations for Intelligent Tutoring Systems*, 1.

A Process for Adaptive Instruction of Tasks in the Psychomotor Domain

Abstract: In order to maximize transfer of skills from the training environment to the work environment, we advocate closer alignment of learner experiences in the training environment with those expected in the work environment. This implies that psychomotor tasks will benefit from greater transfer if the training includes physical as well as cognitive elements represented in the work environment. Toward this end, cognitive and physical measures should be modeled after successful or expert performers and essential stressors should be represented in the training environment to promote realism and learning. Adequate measures for assessment and appropriate feedback mechanisms to support psychomotor tasks should be represented in ITS domain models. By doing this, the ITS can then more effectively align training and optimize transfer.

Sottolare and LaViola (2015) described an adaptive system prototype to extend training beyond the desktop in support of a land navigation psychomotor task using smart glasses to assess progress, augment reality, and provide feedback to the learner. Sottolare, Hackett, Pike, and LaViola (2016, in review) described a similar adaptive system for training hemorrhage control tasks using smart glasses and pressure sensors to assess the appropriate application of tourniquets and pressure bandages. This chapter expands on these concepts to examine interaction design for

GIFT-based tutors to provide generalized adaptive instruction across the breadth of tasks in the psychomotor domain while maximizing opportunities for transfer.

Keywords: Training environment. Learner experience. Adaptive instruction. Psychomotor domain. Intelligent tutoring system. Land navigation. Feedback. Interaction design. Transfer optimization.

Citation: Sottolare, R. A., & LaViola, J. (2016). A Process for Adaptive Instruction of Tasks in the Psychomotor Domain. *Design Recommendations for Intelligent Tutoring Systems*, 185.

Making Static Lessons Adaptive through Crowdsourcing & Machine Learning

Abstract: How can instructors turn static text into adaptive components that can be perpetually enhanced? This chapter discusses how the goals of instructors and researchers in the learning sciences can be advanced by integrating crowdsourcing and design ideas from human-computer interaction (HCI) with machine learning algorithms that provide automatic optimization. The approach is illustrated by describing a system that instructors can use as a plugin to improve text components of instruction. It is called the Adaptive Explanation Improvement System (AXIS) and was first reported in Williams, Kim, Rafferty, Maldonado, Gajos, Lasecki & Heffernan (2016a).

AXIS lets an instructor designate an existing static explanation to be turned into an adaptive, data-driven component that tests out different explanations and improves over time. Each component asks learners to explain why an answer to a problem is correct, which promotes reflection and understanding (Williams & Lombrozo, 2010), as is well established in education as the self-explanation effect (Chi et al., 1989; 1994; Lombrozo, 2006). At the same time, learners' explanations can be collected and then presented to help future students learn, given the importance of high quality explanations (Renkl, 1997). The instructor then indicates how explanations should be compared (e.g., based on learner ratings or on learner performance on a related problem), and AXIS applies a machine learning algorithm automatically analyze and use the data being collected to choose better explanations for future students. For example, in a computer science class, one might want to determine what explanation of a sorting algorithm is most clear to learners, as measured by students' rating of the helpfulness of the explanation. If learners are provided with the opportunity to rate the explanation that was provided to them, their responses can be used to select better explanations for future learners.

The original paper (Williams et al., 2016a) provides the technical details of the system design and algorithm. The current chapter is intended to provide a higher-level overview of how the approach is relevant to instructors and researchers outside of HCI and machine learning. In that vein, we begin with a brief overview of relevant work.

Keywords: Static lessons. Adaptive training. Crowdsourcing. Machine learning. Data-driven. Human-computer interaction. Machine learning algorithms. Automatic optimization. Learner performance.

Citation: Williams, J. J., Kim, J., Glassman, E., Rafferty, A., & Lasecki, W. S. (2016). Making Static Lessons Adaptive through Crowdsourcing & Machine Learning. *Design Recommendations for Intelligent Tutoring Systems*, 127.

Intelligent Tutoring Authoring Tools to Access Training Effectiveness

Abstract: Intelligent Tutoring Systems (ITS) hold the potential to unlock a new era of adaptive learner-centric training, but much of the current research focuses on learner-tutor interactions. Alternatively, this paper describes ongoing research to support training effectiveness evaluations from the tutor authoring perspective. The Army Research Laboratory's Generalized Intelligent Framework for Tutoring (GIFT) is being extended to explore training effectiveness within an ITS. The resulting prototype operationalizes this framework to support the rapid, high-level, visually intuitive analysis of effectiveness at a user-selected level of granularity and to then offer a mechanism to delve deeper and explore individual factors to ultimately identify areas for improvement. A statistical engine is included to identify factors that contribute significantly to training effectiveness and to support experimentation and sensitivity analysis.

An Army marksmanship course was chosen as a test case since it relies on multiple training delivery techniques and includes non-traditional factors such as trigger pressure that are external to the GIFT environment. The research focuses on using the Experience Application Programming Interface (xAPI) formatted data to combine disparate data sources, to support integration of multiple perspectives and provide interoperability with other data systems. This paper will describe the architecture and integrated tool-set that allows course authors and administrators to more accurately assess training effectiveness and prioritize targeted improvements, as well as sample applications.

Keywords: Intelligent Tutoring Systems. Data Analytics.

Citation: Long, R., Smith, M., Dass, S., Dillon, C., & Silverman, J. Intelligent Tutoring Authoring Tools to Assess Training Effectiveness.

Data Analytics: Techniques and Applications to Transform Army Learning

Abstract: Data analytics is the scientific process of transforming data into insight for making better decisions and is used in industry to improve organizational decision-making and in the sciences to verify or disprove existing models or theories. Current data analytic models have begun to make an impact on the way that courses are designed, run, and evaluated, although little progress has been made towards the design of a structured method to categorize and implement data measurements as they relate to the Army Learning Model (ALM) goals. The following paper describes ongoing work with the U.S. Army Research Laboratory to examine data analytics as it relates to the design of courses, evaluation of individual and group performances, and the ability to tailor the learning experience to achieve optimal learning outcomes. This paper describes: a) the methodology for research and evaluation; b) the fields of Learning Analytics and Educational Data Mining; c) data analytics methods and techniques relevant to learning systems; and d) a framework for applying data analytic methods and techniques for learning via three illustrative use cases. Ultimately, the goal of this paper will be to provide a vision for successful application of these techniques within the Army learning community and higher education.

Keywords: Data analytics. Army Learning Model goals. Group performance. Learning analytics. Educational Data Mining.

Citation: Long, R., Smith, M., Dass, S., Dillon, C., & Hill, K. Data Analytics: Techniques and Applications to Transform Army Learning.

Architecture for Multi-Domain Adaptive Training

Abstract: Adaptive Training is intelligently tailored, computer-guided experiences for individuals and units focused on optimizing training performance, training efficiency, deep learning, and transfer of skills to the operational environment. Training “adaptation” is multi-faceted. For the trainee, the delivery of training must adapt to individual trainee needs and to the organizational groupings of trainees (e.g., an Army unit). Training must be adaptively tailored to trainee state (cognitive, affective, psychomotor, social, etc.) and to trainee task performance. Adaptations might be determined and delivered in real time during training events or determined through assessment of learner data over extended time and delivered periodically

(non-real time). Adaptations may seek to inform and optimize instructional strategies both during training and off-line (between training sessions). Training content adaptations might be automated, semi-automated, or human (instructor)-driven. From a "training systems" life cycle perspective, the adaptation approaches must seek to optimize training over learner lifecycles through optimal blending of training types and modalities (e.g., computer-based, tutor-based, game-based, simulation-based, Live, Virtual, Constructive (LVC), etc.).

A central barrier that impedes increased use of adaptive training is the amount of time and the high cost required to build and maintain these complex training applications. This paper describes an ontology-driven Multi-domain Adaptive Training (MAT) approach for adaptive training application integration and management that targets this challenge. The MAT approach is founded on the observation that inter-domain ontology mappings may be used to drive multi-domain adaptive training application information exchange requirements. The paper will describe: (i) the MAT application integration method; (ii) a conceptual architecture for providing automation support for the MAT method; (iii) an initial reference ontology for adaptive training applications and the use of this ontology for enabling adaptive training application integration; and (iv) an illustrative multi-domain adaptive training application integration example. The Generalized Intelligent Framework for Tutoring (GIFT) is used as a unifying framework for demonstrating the methods described in this paper.

Keywords: Adaptive training. Training performance. Training efficiency. Multi-domain Adaptive Training. Generalized Intelligent Framework for Tutoring.

Citation: Long, R., Benjamin, P., Wu, C.K., Fernandes, R., & Li, B. Architecture for Multi-Domain Adaptive Training.

List of Symbols, Abbreviations, and Acronyms

2-D	2-dimensional
AAR	after-action review
AAAR	adaptive after-action review
AERA	American Education Research Association
AIS	adaptive instructional system
ALM	Army learning model
ARES	Augmented REality Sandtable
ARL	US Army Research Laboratory
AXIS	Adaptive Explanation Improvement System
CAT	course authoring tool
COIN	counterinsurgency
ECD	evidence-centered design
EDA	electrodermal activity
ERT	event reporting tool
GIFT	Generalized Intelligent Framework for Tutoring
GIFTSym5	GIFT users' symposium
HCI	human-computer interaction
IAI	Intelligent Automation, Inc
ICM	interoperable competency model
IPA	interpretative phenomenological analysis
ISU	Iowa State University
ITS	intelligent tutoring system
KSAs	knowledge, skills, and abilities
LEM	learning effect model
LMSs	learning management systems

LRS	learning record store
LVC	live, virtual, constructive
MAT	motivational assessment tool
MOOCs	massive open online courses
NCSU	North Carolina State University
OELEs	open-ended learning environments
Recon	reconnaissance
RL	reinforcement learning
RLO	reusable learning object
ROI	return on investment
ROTC	Army Reserve Officer Training Corps
SAS	survey authoring system
SCRs	skin conductance responses
SEM	structural equation modeling
SME	subject matter expert
SMF	social media framework
SOA	service-oriented architecture
TICL SIG	Technology, Instruction, Cognition & Learning Special Interest Group
TUI	tutor user interface
UI	user interfaces
xAPI	experience application program interface

1 DEFENSE TECHNICAL
(PDF) INFORMATION CTR
DTIC OCA

2 DIR ARL
(PDF) IMAL HRA
RECORDS MGMT
RDRL DCL
TECH LIB

1 GOVT PRINTG OFC
(PDF) A MALHOTRA

1 ARL
(PDF) RDRL HR
R A SOTTILARE