Instructional Management in the Generalized Intelligent Framework for Tutoring: 2018 Update

Benjamin Goldberg[1]
U.S. Army Research Laboratory[1]

INTRODUCTION

The Generalized Intelligent Framework for Tutoring (GIFT) serves as a flexible domain-agnostic architecture used to author, deliver, and evaluate computer-based tutoring systems. An end state objective of the GIFT program is to establish a set of defacto best practices that guide the development processes when building adaptive training solutions across military, industry, and academic domain applications. To drive this need, a research vector dedicated to instructional management functions was established. This research vector is used as a road-mapping function to establish capability needs and potential R&D paths to meet recognized gaps. Serving as a framing discussion, we provide an introduction to ongoing work described in the instructional management focused chapters to follow. In addition, we briefly describe new pedagogical functions being developed that have yet to be reported.

Instructional Management Research Vector

In 2015 members of the GIFT team published a research outline that examined specific goals and interests associated with instructional management in ITS type environments (Goldberg, Sinatra, Sottilare, Moss & Graesser, 2015). The authors identified the following dimensions as critical benchmarks in driving capability enhancements:

- Guidance and Scaffolding: focuses on identifying a set of pedagogical best practices that adhere to the tenets of learning and skill development. The challenge is identifying methods that generalize across domains and task environments, and providing tools flexible enough to create scaffolding that can be represented in domain-agnostic terms. Current research aims at creating logic to manage timing, specificity, and modality determinations of intervention content at the individual level.

- Social Dynamics and Virtual Humans: focuses on the social component of learning, and building tools and methods that adhere to the social cognitive tenets of how individuals interact to instill knowledge and solve problems (Bandura, 1986; Vygotsky, 1978). From an adaptive instructional management standpoint, social dynamics is concerned with: (1) using technology to replicate interactive discourses common in learning and operational settings, (2) using technology to create realistic and reactive virtual humans as training elements in a simulation or scenario, and (3) using technology to create social networks for the purpose of supporting peer-to-peer and collaborative learning opportunities.

- Metacognition and Self-Regulated Learning (SRL): focuses on instructional management practices that aim at building habits linked to successful regulation of learning practices and that promote metacognitive applications. This approach to instructional management varies from traditional guidance and scaffolding techniques as it focuses on behavior and application of strategy, rather than on task dependent performance. This research area is of interest as it is based around GIFT supporting SRL, and the efficacy of defining and modeling persistent metacognitive strategies that can be applied across domain applications. The goal is to embed instructional supports that promote situational awareness, and guide learners in planning, monitoring, and reflection based activities.

- Personalization (Occupational and Non-Cognitive Factors): focuses on the use of learner dependent information to personalize a training experience. This can involve personalizing content based on interests, with the goal of inducing a higher level of motivation when the context of a learning event is framed within a use case the learner cares about. In addition, the personalization dimension is also interested in identifying ways to automatically personalize training interactions based on occupational factors that are unique to their upcoming assignment or cur-rent job description. All of these instructional management practices require research to identify mechanisms for easily implementing personalization techniques, along with empirical evidence supporting their application for wide GIFT application.

The dimensions reviewed above provide a means for organizing and prioritizing efforts to enhance GIFT's current instructional management support. The dimensions should be ever evolving, as the needs and requirements of the end user is ever changing. To meet a near-term push to modernize the use of live, virtual and constructive simulations to train collective and team-oriented tasks across the Army, a major focus on instructional management research moving forward needs to be focused on team development and cohesion, as well as application of adaptive training applications in live environments through mobile device technologies. Each of these new problem spaces will be expanded upon as future programs mature.

In the remainder of this chapter, we present the 2018 current state of practice for instructional management in GIFT, as those piece parts are the ultimate methods rolled out to the community at large. Following, we review ongoing efforts and how they apply to future enhancements that aim to meet the goals of the overarching instructional management capability dimensions. We end the review with new instructional management efforts that are based on new training concepts centered on worked examples in game-based environments and mobile computing technologies.

2018 INSTRUCTIONAL MANAGEMENT PRACTICE IN GIFT

Enhancements to the Baselines

In the latest public release of GIFT, there have been many updates to the baseline that need to be noted. First, in an effort to extend the remedial capabilities of the Engine for Management of Adaptive Pedagogy (EMAP) to go beyond the passive delivery of new content and information, the previously reported ICAP activities framework was established in GIFT's Adaptive Courseflow object (Chi, 2009; Rowe, Pokorny, Goldberg, Mott & Lester, 2017). The ICAP-Inspired EMAP course-object now supports a configurable 'Remediation' phase (see Figure 1). In this block of the interface an author is tasked with configuring available content and feedback strategies dedicated for remediation purposes only. During this portion of the authoring experience, GIFT requires authors to specify metadata that corresponds with the concept that activity or content targets, and the classification of Constructive, Active or Passive determinations as they relate to Chi's specified activity levels.

This new remedial content addition is now available to all GIFT users. However, it must be noted that in its current state, selection of remedial content is managed by a policy set to randomly select among the ICAP configured resources. Ongoing work, which is reported below by Rowe et al. (2018), will establish the first set of data-driven policies within the domain of COunter-INsurgency (COIN) based on a probabilistic tutorial planning approach.

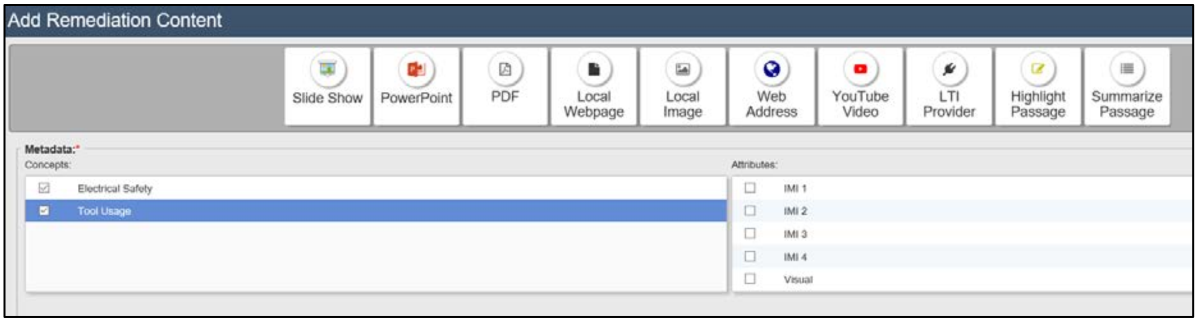

Figure 1. Remediation Content Configuration Interface in the ICAP-Inspired EMAP Course Object

GIFT Personalization and Management through Learning Tool Interoperability Standards

Next, to support efforts related to GIFT managing interaction across Massive Open Online Courses (MOOCs), development tasks were instituted to make the architecture compliant with the Learning Technology Interoperability (LTI) standards (IMS Global Learning Tools Interoperability Implementation Guide, 2012). The LTI specification establishes application programming interfaces with learning management systems. From this perspective, a learning management system is designated as an LTI consumer, while systems that provide learning activities themselves are considered LTI providers.

For GIFT, two instances of LTI integration were implemented. First, GIFT was established as an LTI provider, where a learning management system can direct a MOOC learner to a GIFTCloud configured lesson for adaptive pedagogical delivery. As an example, GIFT is utilized within a course managed by the site edX.org, where an established lesson incorporates GIFT lesson activities, with completion scores communicated back to edX following execution (Aleven et al., 2017). Next, GIFT was modified to serve as an LTI consumer, where GIFT can call upon LTI providers for support in lesson execution. In this instance, GIFT can now direct a learner to an LTI compliant application to support instruction or practice on specified concepts. As an example, GIFT can now direct a learner to a Cognitive Tutor application within the GIFT lesson flow, where learner and pedagogical modeling controls are handed to that LTI client. Following completion, a score is provided back to GIFT for tracking purposes.

One of the recognized shortfalls of this integration is the reported measure back. Currently, it is a value between 0 and 1, which is used to classify the performance for all assessments performed within that provider application. At the moment, that is not enough granularity to inform intended competency tracking functions GIFT's overall aim strives to support. With new development efforts to support GIFT as an LTI consumer, new pedagogical paradigms are now made available. Through these mechanisms, GIFT can now re-direct a learner to an LTI provider within the flow of a GIFT configured lesson, which makes GIFT the managing application that guides the ultimate experience. However, seeing as the data provided following an LTI provider interaction are not granular enough to inform complex competency modeling techniques, future research efforts examining how best to manage LTI oriented data feeds is needed.

Enhancements Still Under Development

Establishing Policies in the ICAP-Inspired Engine for Management of Adaptive Pedagogy

With an infrastructure in place to support the ICAP-Inspired EMAP instance described above, the next step is establishing data-driven policies that will dictate run-time pedagogical decisions. To support this development task, experimentation using the Amazon Mechanical Turk platform is being prepared. This will enable the collection of a data set that will ultimately be used to generate a set of simulated students based on the distribution properties of the collected data points. This will enable replicating multiple instances of learner interactions to garner enough data to establish valid policies to inform the ICAP remediation determinations. The methodology to build the simulated student data set is described in last year's GIFTsym proceedings (Rowe, Pokorny, Goldberg, Mott & Lester, 2017), with a breakdown of the testbed development to support this effort described in this year's proceedings (Rowe et al., 2018). Following the creation of policy specifications, a reinforcement learning backend will be established to enable policy weight adjustments as evidence is collected on the utility of specified remedial materials.

NEW INSTRUCTIONAL MANAGEMENT EFFORTS

As an extension to last year's update at the 2017 GIFTsym, this section is used to present new efforts currently being worked in the GIFT program that have not yet been reported upon. Each effort is currently in the early stages of implementation, with future experimentation planned across each capability. What is important to note as a grounding function is that each project presented is being applied within the domain of Land Navigation. The domain was selected due the amount of content and scenarios available to train the knowledge, skills, and abilities (KSAs) associated with land navigation execution, as well as excellent support from Subject Matter Experts (SMEs) that will guide assessment and remediation policies.

For initial implementation, the following mechanisms are being researched: (1) using structured interviews in GIFT to facilitate scaffolded worked examples as it relates to procedural tasks that incorporate discrete inputs required to execute a task (e.g., plan a route from one point on a map to another), (2) using mobile app technologies and cloud-computing to guide self-regulated training exercises by blending the physical environment with didactic instruction and personalized assessments (e.g., conducting terrain association exercises), and (3) using metacognitive modeling techniques to track learner competencies across disparate training applications and using persistent models to drive feedback interventions. Each project will be explained in more detail below.

Scaffolded Worked Examples across Procedural Tasks

Worked examples provide a means to guide novice learners through procedural activities, where each step within that activity can be discretely defined for the purpose of guiding execution. In this instance, a system can provide the solution path to a defined problem, with directed engagement with students at specific steps within that process for the purpose of assessing understanding and correcting errors and misconceptions. This pedagogical approach has proven effective across many domains, most of which provide well-defined procedural tasks that require consistent execution to obtain an appropriate solution (Durlach & Spain, 2012). From this perspective, GIFT's survey authoring system is being used as a basis to establish structured interviews for the purpose of using worked example instructional methods. These interviews associate with a set of procedurally related questions that are commonly applied across a set of tasks. For each question, a specific concept or sub-concept can be targeted, with contextualized responses based on the scenario that serve as the assessment criteria. With this framework in place, specific steps within a solution path can be remediated, where focused interventions address direct misconceptions and impasses that result from the learner's input to a step.

As an example in the domain of land navigation, scenarios are designed in a game-based environment to train all concepts associated with dead-reckoning procedures (i.e., navigating from one point to another using a compass and a map). Trainees are responsible for locating points on a map, determining an azimuth to guide the direction by which they walk, determining an estimated distance, and identifying land features to help them orient as they walk. If the learning objective of the training event is to provide multiple opportunities to apply dead-reckoning procedures, then each discrete task can have an associated structured interview that can guide that interaction. Each task requires the same steps, with each input having new contextualized responses based on where they are on the map and where they are supposed to go. Once these interviews are in place, new logic can be established to infer a confidence state in a learner's ability to provide the correct response on each step within the interview. With a high confidence rating, GIFT has the ability to adapt the pedagogical approach by modifying the complexity of the task. Rather than prompt the trainee for inputs on the required steps, the task can re-orient and instruct the trainee to navigate to the next point with a specified time constraint, thus increasing the difficulty and leaving the trainee to execute on their own accord.

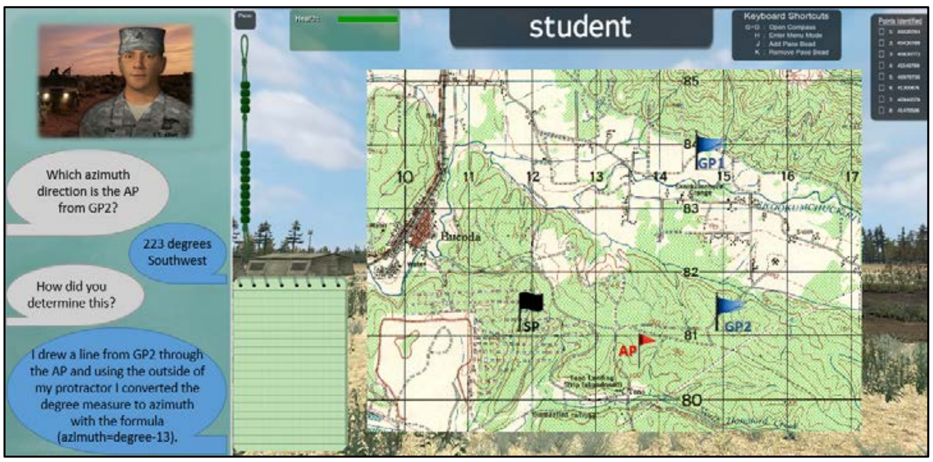

Figure 2. Sample Question from GIFT Worked Example Structured Interview

This new instructional management concept has led to some structural changes to GIFT's Domain Knowledge File (DKF), as well as to the survey authoring system. To support direct numeric inputs that orient with map grid points, azimuth directions, and estimated distances, GIFT can now deliver a survey with an open numeric input response with configurable assessments based on exact inputs, or inputs that fall within a defined range. Next, GIFT's concept structure in the DKF will be leveraged to associate a specific question with a specific sub-concept so that remediation and feedback can be contextualized on the procedure step that scores below-expectation. In addition, new pedagogical logic will need to be developed that can adjust the conditions and standards of a defined DKF Task, based on the outcomes of the tasks completed before it. In this example, observing effective execution of two tasks in a row under the scaffolded worked example can lead to a pedagogical shift to increase the complexity by removing the help functions.

Live Training with Mobile Intelligent Tutoring Functions

Another effort being worked with land navigation serving as a guiding domain is the first development of a GIFT mobile application. In this instance, GIFT is leveraging real-time positional and movement data to trigger training events in a live environment through the delivery of contextualized content, tasks and assessments (Goldberg & Boyce, 2018). The notion here is to extend the training space into the actual operational environment and embedding structured learning activities that utilize the elements of the space they are occupying. As an example, the first mobile application being developed is to support an exercise called a Terrain Walk. During this exercise, a trainee completes a specified course where designated spots along the path are used to train directed concepts that associate with land navigation fundamentals. In the traditional sense a Terrain Walk is completed by a live instructor with a group of trainees. To support a self-regulated delivery approach, the idea is to replace the instructor with a smart phone, where each trainee receives a personalized experience.

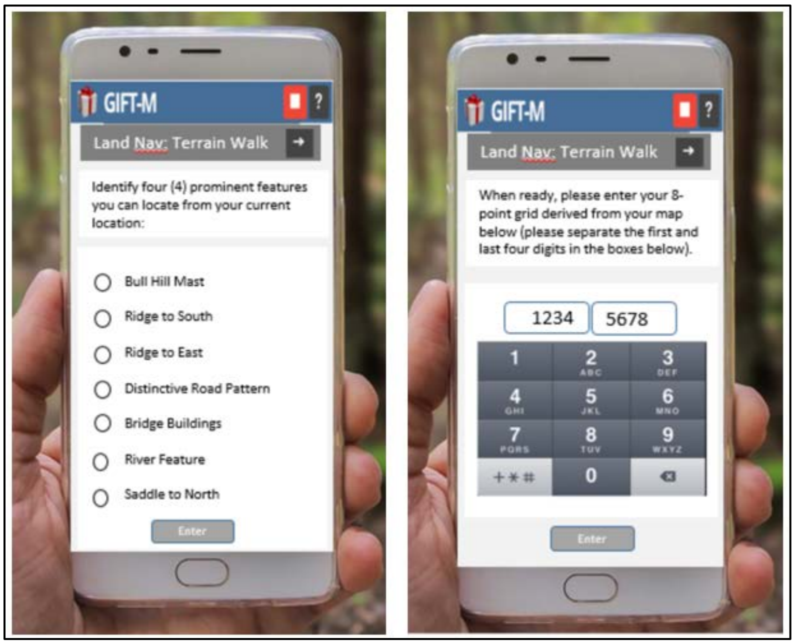

Figure 3. GIFT Mobile App Example Interactions for Terrain Walk

To support this implementation, GIFT has been configured to consume cellular network traffic data to monitor the exact location of an individual as they navigate through an environment. With this new data type, GIFT's DKF can be configured to use location data to inform task start triggers that associate with a task, the concepts linked to that task, and its respective assessments used to infer performance and competency. When a trigger is recognized, GIFT can now deliver content, task directions, and deliver assessments through survey items (see Figure 3). The DKF applies timing functions to guide the delivery of content and items to assist in making the user experience an enjoyable one. Following completion of the first iteration of the GIFT Mobile App to support a Terrain Walk, there will be a designated data collection this summer at the United States Military Academy.

Metacognitive Training across a Network of Simulations

The third new effort using land navigation as a guiding function is extending the learner modeling techniques in GIFT to support metacognitive training across a network of training environments. This approach is based on prior work aiming to establish a hierarchical approach to learner modeling that focused on cognitive skills, cognitive strategies, and metacognitive abilities (Rajendran, Mohammed, Biswas, Goldberg & Sottilare, 2017). This approach was originally developed within the domain of COIN using the game UrbanSim. Now, the learner model framework is being re-applied to land navigation, where approach will manage interactions across three distinct training events that focus on a crawl/walk/run modeling of training (Goldberg, 2017). In this example, the hierarchical student model will be used to infer KSAs as trainees interact with a virtual sand table to learn terrain association concepts, interact with a virtual game to rehearse dead-reckoning procedures, and interact on a live land navigation course. This approach requires the first implementation of a persistent learner model that can track experiences across a number of scenarios and lessons and use those recorded experiences to personalize future interactions through GIFT supported pedagogical functions. This effort is just starting, with much to share in future reporting.

FUTURE CONSIDERATIONS

As mentioned above in the introduction, team intelligent tutoring is a desired capability moving forward across the Department of Defense. With that said, a majority of the instructional management functions built in GIFT as of now are dedicated to the individual learner. Future research is required to implement pedagogical approaches to managing team interactions across the planning, execution, and review phases of a training exercise. Currently, there is much written on how to monitor and measure team development (Sottilare et al., 2017), but there is little contribution to the literature on instructional management techniques that associate with technology-based interventions. To this end, a pedagogical framework is required to associate with feedback and scenario adaptations that are based on team and task structures. Current chapters in the soon-to-be released GIFT Recommendations books will explore some notional theoretical approaches, with sports psychology playing a role in their instantiation.

CONCLUSION

In this chapter, we present current and future instructional management functions that are being built into GIFT. This review covers the last twelve months of development, with the introduction of new capabilities being rolled into the publicly available baseline, while future capabilities reviewed are being developed to support data collections and future extensions to be included in subsequent releases. With GIFT continually evolving to include more AI driven methods, future enhancements to GIFT's instructional management functions will continue to mature that focus on data-driven agent methods, as well as exploring new approaches to manage team structures.

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ABOUT THE AUTHORS

Dr. Benjamin Goldberg *is an adaptive training scientist at the Army Research Laboratory's Human Research and Engineering Directorate. He leads research focused on instructional management within ARL's Learning in Intelligent Tutoring Environments (LITE) Lab and is a co-creator of the Generalized Intelligent Framework for Tutoring (GIFT).*