The Development of a Testbed to Assess an Intelligent Tutoring System for Teams

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Abstract. Work has been ongoing to develop an Intelligent Tutoring System (ITS) for teams. As part of this work, we are developing a flexible, scalable, military-based set of collaborative team tasks that can serve as a "testbed" to exercise various aspects of a team ITS architecture.Warfighting teams are a core part of any operation as individual soldiers combine their skill sets and plan, coordinate and act as one entity to accomplish assigned objectives. The team ITS test bed presented in this paper uses simple team tasks to train soldiers on basic functions including observation, target detection, target identification, communication within the team and decision making under stress. The testbed allows for manipulation of various dimensions of tutor feedback, learner workload, and team size. The testbed enables researchers to systematically evaluate the effectiveness of different types of feedback on militarily-relevant training tasks.

Keywords: Team Tutoring, Team Training, Intelligent Tutoring Systems (ITSs), Generalized Intelligent Framework for Tutoring (GIFT)

1 Introduction

Work has been ongoing to develop Intelligent Tutoring Systems (ITSs) to support tailored, guided learning experiences for teams conducting collaborative tasks [1-3]. As part of this work, we have been developing a flexible, scalable, militarily-relevant set of collaborative team tasks that can serve as "testbed" to exercise various aspects of a team ITS architecture. This paper focuses on the development of a generic testbed and an effective implementation of an ITS for training team tasks which can serve as a model for future ITSs. While work has been previously conducted in this area (see section 2), the work which is described in this paper differs as it attempts to remove humans from the tutor role completely, seeks to encourage proper performance while learners are performing several sub-tasks within a larger one, and accomplish both goals while simultaneously applying them to two or more individual learners concurrently within a collaborative team setting.

There is a need for effective team training in the military to match the tasks conducted by military teams in the operational environment. It is important that tailored training be easy to distribute while minimizing cost [4]. Tailored training through the convergence of ITSs and Virtual Reality (VR) training (e.g., serious games and virtual simulations) is emerging to become part of the Army's plan for the 21st Century soldier competencies [4,5]. VR can simulate a combat zone and allow inexperienced soldiers to learn how to react to high-stress situations without exposure to actual harm. In a virtual environment, random events can occur by the trainer's design, which mimic events such as sniper attacks, improvised explosive devices (IEDs), and hostile civilian environments. The goal for the military application of VR is not only to expose soldiers to a broad spectrum of potential environments, but also effectively train soldiers by providing tailored instruction and feedback [5]. The result is more efficient training and shorter time to reach competency.

An ITS is a computerized learning environment that incorporates content from a specific domain (e.g. military training) to provide instruction through the use of feedback and immediate interaction based on an individual learner's rate of comprehension [6]. ITSs attempt to play the role of a trainer or instructor in a training simulation. However, capturing the expertise of a human trainer is difficult. The most crucial element in training is the experience of the trainer, usually a Non-Commissioned Officer (NCO), which is shared with soldiers [7]. Beyond individual training, the military trains teams of soldiers to work together to accomplish mission goals. Military teams are capable of achieving goals that cannot be accomplished by an individual warfighter alone. Thus, the trainer is responsible for enhancing the performance and learning of multiple soldiers.

A human trainer is most effective when giving one-on-one training or tutoring [8]. The goal of ITS development was to find a tutor that was just as effective as one-to-one tutoring as it is the most effective form of education. Students who receive one-to-one tutoring perform better than those who receive conventional group education [9]. Most students have the potential to reach a high level of learning and human one-to-one tutoring allows them the opportunity to reach their potential. However, only until recently, ITS's were solely focused on individual tutoring [10]. The challenge is to make ITS training effective for teams. Developing and testing ITS for effective team training is vital to the success of military operations. Due to the increasing complexity of missions which include specific tasks, the timing and characteristics of feedback that teams receive during training is crucial to understanding a tutor's effectiveness in addition to its development [3].

Development of a Team ITS will extend an existing individual (or one-to-one) authoring architecture to small groups. Our goal is to develop an architecture for authoring team ITSs using VR and the authoring capabilities of the General Intelligent Framework for Tutoring (GIFT) [11]. This will require a test bed to assess the effectiveness of the tutor. The testbed needs to be flexible and scalable so that it can be adapted to explore different teaming variables, such as the elements and dimensions of team-based feedback [2, 12].

To develop a team training testbed, the collaborative team task of joint reconnaissance ("recon") was chosen based on its ability to test various dimensions of feedback, and its scalability with respect to workload and team size. The next section describes related work that informed the development of the testbed. The subsequent section details the generic Recon Task Testbed developed to exercise a team tutoring architecture. Finally, an initial implementation is described that tests two of the many dimensions of feedback: public vs. private, and team vs. individual feedback.

2 Related Work

Several areas of research informed the development of the Recon Task Testbed. Team training in the military and the development of individual ITSs has formed the basis of the collaborative tasks included within the Testbed. Research on the types of feedback in training scenarios was reviewed extensively. Finally, the authoring tool that is being extended from individuals to team tutors is briefly introduced. This research supports U.S. Army training objectives [5].

One of the goals for the Army is to maintain a tactical edge over potential threats through the ability to learn faster [5]. In order for teams to learn faster it is necessary for their training to be adaptive. The military is headed towards more effective training by becoming less dependent on lengthy PowerPoint slides for soldier comprehension [5]. When using an excess of PowerPoint slides to present important information students will be less engaged and unlikely to grasp material [13]. When the time comes to apply the material in field training, the learner's earlier low engagement may reflect performance. With VR training, students can be exposed to material and apply it simultaneously.

Applying VR with an ITS has been explored in previous work [4,14]. ITSs have been more effective for learning than traditional training which takes place in classrooms [6]. It reduces the time required for learning and in some cases is less costly than conventional learning. ITSs such as SimStudent predict future behavior from students by looking at previous behavioral patterns and therefore can reduce learning time [15]. It has been difficult to successfully apply what works in individual ITSs to a Team ITS [10]. Team training requires a higher expenditure of flexibility and energy in regards to authoring ITSs in addition to the human trainer. Some tutors have been created in order to assist human trainers with facilitating collaborative learning and team training such as the Advanced Embedded Training System (AETS) [16]. With AETS, the workload for the human trainer required for successful tactical team training was reduced [16].

Teams are usually made up of individuals who differ in competency, content comprehension, and skill levels. Also, team interaction is another factor which individual tutors do not have to consider. Work from Suh and Lee address the complexities of team collaborative work through an asynchronous text system called the Extensible Collaborative learning Agent (ECOLA) [17]. In their work, they go on to describe challenges such as complex educational elements which exist in collaborative systems. Specifically, feedback and the method which it is distributed can influence a team. According to Billings, feedback generally improves performance [18]. Additional characteristics of a team including how the team reacts to feedback may determine its success or failure before an assessment task even begins [1]. Team feedback has many dimensions [2]: subject (individual, team), target (public, private), timing (immediate, after), type (proactive, reactive), specificity (generic, specific), tone (positive, negative), and style (collaborative, competitive). These aspects can be effectively tested in an ITS authoring environment by using GIFT.

GIFT is a modular computer-based ITS which has three primary functions which include authoring, instructional management and evaluation of ITSs. GIFT's authoring goals are to decrease effort for creating tutors by providing aid in organizing knowledge, supporting good design principles, and leveraging open source solutions [19]. Instructional manager goals for GIFT are to integrate pedagogical best practices in ITS created from the platform. The effectiveness evaluation construct's purpose is to allow researchers to evaluate whole ITSs or their component tools and methods of ITS technologies [19]. GIFT was developed for use with individual training. The project on which this paper is based has the goal to extend GIFT to team ITSs. A team architecture has been proposed [3]. The Recon Test Bed has been developed to test that architecture.

3 Testbed Development

The Recon Testbed is based on the collaborative team task of reconnaissance, and requires several military skills. In the military, communication is key to mission success, especially for security purposes. There are four types of security operations. They include Screening, Guarding, Covering, and Area Security [20]. The Recon Scenario is derived from Area Security as it involves reconnaissance in support of various assets. Specifically it resembles aspects of patrolling. In patrolling, Observation posts are used to provide security to a platoon [7]. Within the task, users perform the five fundamentals of all security related missions. These include: orient the main body, perform continuous reconnaissance, provide early and accurate warnings, provide reaction time and maneuver space, and maintain enemy contact [7]. How well users execute these fundamentals during the task will partially determine the feedback that is received.

Feedback in teams has many dimensions (see Section 2). It is the goal of the testbed to enable experimenters to vary these dimensions as needed to test the effectiveness of team feedback. In addition, the testbed must allow the experimenter to manipulate the task load (workload) of the participant. This can be done by changing the rate at which events occur.

The recon task itself, built in VBS2, is meant to serve as the testbed for these dimensions. In conducting the task, users are exposed to various military scenarios such as observation, fields of fire, and communication within a fire team element. The team members (two minimum) are assigned sectors to watch. For instance, if there are four teammates on the top of a building, each may be assigned one quarter of the 360-degree field of view. Each is tasked with scanning (observing) their sector by constantly panning to see the extent of activity (target detection) in their sector. Each trainee must identity (target identification) any opposing force member that is spotted. If the threat is moving into a teammate's sector, the learner then must transfer responsibility by communicating the position to that teammate. The teammate must then acknowledge the change of responsibility back to the first teammate, thus accepting responsibility.

In the example of four team members, the initial condition of scanning is based on the 90-degree sector given to each team member. The team member must scan this sector continuously for the purpose of mimicking the actual field task and to effectively participate in the other conditions of the recon scenario. The team is given feedback according to how effectively they cover their entire area. This is relative to fields of fire and reconnaissance strategies outlined in the Army Field Manual for Infantry Platoons and Squads [7].

Figure 1 illustrates two teammates (BLUFOR) each monitoring a 90-degree sector. Participants are responsible for tracking all targets (OPFOR) and ignoring any distractors (civilians). When a target approaches the sector border in the center, the participant must alert the team member who has responsibility for that sector. Workload can manipulated by changing the number of enemies/civilians, the speed by which they move, the similarity of their appearance, and the rate by which they appear/disappear.

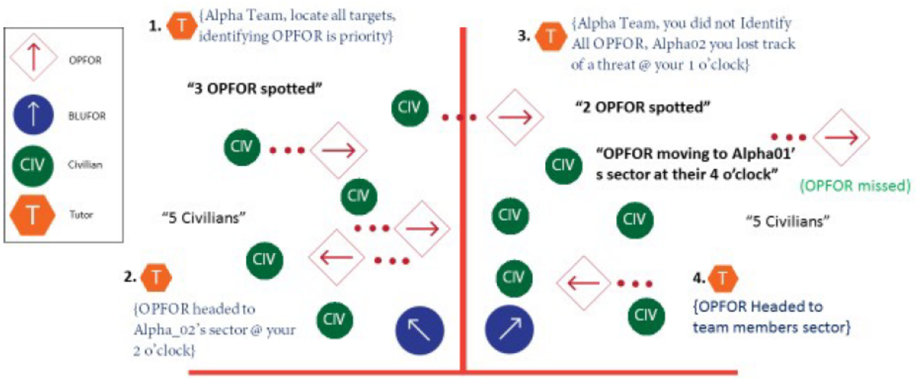

Fig. 1. Example of a recon task in which two team members scan a 180-degree field.

The dimensions of feedback can be varied in the task by changing the content or delivery of the ITS feedback. Table 1 describes how feedback dimensions can be manipulated in the Recon Testbed to test the effectiveness of team feedback.

Table 1. Dimensions of Feedback

Dimension	Levels	How realized in Recon Testbed
Subject	*Individual, Team*	Tutor provides feedback about an **individual** team member or **entire** team
Target	*Public, Private*	Tutor provides feedback to either a single person (**private**) or team (**public**)
Timing	*immediate, after, omitted*	Feedback occurs based on patterns or task effectiveness **during** the task, or **after** overall the grade or rating is given. Feedback is **omitted** when an error is committed, but is not sufficiently important to interrupt training to provide immediate feedback or to be included in the After Action Review.
Type	*Proactive, reactive*	**Proactive**: feedback before a learner makes error, **Reactive**: Feedback after a learner makes an error
Specificity	*Generic, specific*	**Generic:** "*Good Job Soldier*" **Specific**: "*You missed an OPFOR located at 7 o'clock*"
Tone	*Positive, negative*	**Positive:** "*...you might want to try…*" **Negative**: "*...your poor performance is hurting the team*"
Style	*Collaborative, Competitive*	**Collaborative**: "Slow down scanning to help team…" **Competitive**: "Your performance is worse than Joe."

4 Initial Implementation and Future Work

The first implementation will study two dimensions of feedback: Access (public vs. private) to feedback, and target (group vs. individual) feedback. For example, the feedback is given to a single person in the private condition while the entire team is given feedback in the public setting. Individual and Group feedback refers to whom the feedback is about (one person's actions or the team's efforts). Table 1 describes the tasks of each learner when monitoring their sector. The team tutor will be the basis of experiments to test the effectiveness of different types of team ITS feedback.

Table 2. Tasks performed in the initial Recon Testbed by each learner.

Task	Description
Scanning	The Learner rotates their viewpoint within the 180 degree sector. Learner must cover the entire 180 continuously throughout the task
Identify	The learner presses a key whenever they spot a new OPFOR avatar. This must be done quickly with 10 seconds of the OPFOR becoming visible
Transfer (informing)	When an OPFOR avatar is close to moving into a teammate's assigned sector, the learner must inform the team member.
Transfer (confirming)	Learner must confirm transfer of responsibility for the OPFOR moving into their sector from the teammate who initiated the transfer process.

Beyond the initial study, we plan to expand the Recon Testbed significantly. Currently, the testbed allows for the manipulation of feedback dimensions that enables researchers to systematically test the effectiveness of different types of feedback on training. The testbed is scalable and flexible, allowing for different sizes of teams, and varying levels of task load, which can be altered in the future. By including these features, the testbed will provide a platform to study several aspects of military-relevant team training.

References

1. D. Bonner, S. Gilbert, M.C. Dorneich, S. Burke, J. Walton, C. Ray, & E. Winer, (2015, February). Taxonomy of Teams, Team Tasks, and Tutors. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium*.
2. J. Walton, M.C. Dorneich, S. Gilbert, D. Bonner, E. Winer, & C. Ray (2015, February). Modality and Timing of Team Feedback: Implications for GIFT. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium*.
3. E. Winer, J. Holub, T. Richardson, M. Hoffman, S. Gilbert, & M. Dorneich (2015). "Characteristics of a Multi-User Tutoring Architecture software architecture," In. R. Sottilare (Ed) *2nd Annual GIFT User Symposium*. Pittsburgh, PA, June 12-13. *Army Research Laboratory*, Orlando, Florida, 2015. ISBN: 978-0-9893923-4-1
4. J. Stevens, P. Kincaid, & R. Sottilare (2015). Visual modality research in virtual and mixed reality simulation. *The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology*.
5. M. E. Dempsey, (2011). The US Army learning concept for 2015 (TRADOC Pam 525-8-2). Washington, DC: Department of the Army HQ, US Training and Doctrine Command.
6. A. C. Graesser, M. W. Conley, & A. Olney, (2012). Intelligent tutoring systems.