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

Anne M. Sinatra[1]
U.S. Army Research Laboratory[1]

INTRODUCTION

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.

There are 7 research vectors within the GIFT Adaptive Training project: Learner Modeling, Team Modeling, Domain Modeling, Instructional Management, Authoring, Training Effectiveness and Architecture. In recent years, the Team Modeling vector has branched out from the original Learner Modeling vector. While to date there have been a limited number of projects under the team vector, these projects are beginning to expand, as team tutoring is a goal of GIFT. Further, many of the current and past individual focused research projects could potentially be targets to be adapted or scaled up for team use.

The current paper will (1) discuss the goals of GIFT in regard to team tutoring, (2) discuss the theoretical foundation behind GIFT's team tutoring implementation, (3) discuss the progress made using GIFT for simultaneous two and three player team tutors, and (4) present the future directions and developmental steps being taken toward team tutoring in GIFT. Both the technological and authoring challenges presented by shifting from individual tutoring to team tutoring will be discussed, as well as possible approaches that can be used to help meet these challenges.

GIFT AND TEAM TUTORING

By default, GIFT is set up as a means of providing adaptive tutoring to a single individual who is on his or her own computer. Ultimately, GIFT is intended to be able to handle multiple concurrent users who are being trained on the same material in the same computer-based environment (learners can be either distributed or in the same classroom). Further, GIFT is intended to be able to track the performance of individual team members as well as the team as a whole, and provide adaptive feedback as appropriate. There are two main challenges to being able to conduct team tutoring: (1) technological and (2) authoring. The authoring challenge can be further broken down into the authoring tools required to support team tutoring, and the research/guidelines that should be followed for providing feedback to a team. In regard to the technological aspect, establishing that GIFT messages can be sent as needed between multiple players, a training application, and the GIFT software is the first challenge. In regard to authoring, one of the main challenges is having GIFT's adaptive authoring capabilities set up such that feedback and adaptation rules can be set separately at the individual level based on the specific required tasks, and the team level for overall tasks. Since GIFT is a flexible domain-independent framework, team tutor authoring tools and methods need to be designed to allow for maximum flexibility and combinations of ways to assess the team. The approaches used for authoring team tutors should be able to support teams that have different numbers of members and structures. Therefore, the first authoring challenge is supporting the authoring requirements for team tutoring, and allowing for the flexibility of different domains as well as team configurations. In designing the authoring tools the techniques and approaches for team research and

learning should be taken into consideration. There are different strategies that may work better with different types of teams, and GIFT should be able to be configured to support varying types of team taskwork and feedback (e.g., team feedback throughout the training experience vs. after action review team feedback). In GIFT's current structure there is a Domain Knowledge File (DKF) that drives adaptive feedback in a training application (such as Virtual Battlespace 3). The DKF structure needs to be adapted such that rules can be constructed for both teams and individuals in a straightforward, easy to author manner. While some work has begun in this direction, there is no specific authoring tool or authoring plan in place to assist in differentiating between team member roles, and combined team feedback at the current time. In current time, one of the workarounds is using the authoring tools to construct multiple individual DKFs and an overall team DKF which are then all utilized for the interactions. Further, leveraging the adaptive courseflow course object in GIFT with the context of team tutoring has not yet occurred. In the current configuration of GIFT, the adaptive courseflow is run by the eMap and structured by elements of component display theory: rules, examples, recall, and practice (Wang, Goldberg, Tarr, Cintron, & Jiang, 2013). Depending on the performance of the individual learner and characteristics of the individual, different remediation may be provided by the adaptive courseflow. In the current version of the eMap, the rules and examples phases of instruction are largely based on non-interactive static content, supporting the display of file types such as PowerPoints, html, and PDFs. The recall phase is largely multiple choice based, and the practice phase involves interacting with an external training application to demonstrate that the task can be performed by the learner. While remediation on static information that is presented is likely to remain an individual task, the incorporation of team assessment in regard to recall and practice of material could be useful. For example, the recall phase could be updated to allow for multiple team members to work together to answer multiple choice questions, and only submit their responses once everyone has approved them. The practice phase could be updated to support easy authoring of team DKFs for team tutoring and interactions in a training environment.

Team Meta-Analysis and Behavioral Markers

Initial theoretical work to provide the foundation of the team implementation in GIFT was done through a cooperative project with UCF's Institute for Simulation and Training. The project involved a large meta-analysis of team research relevant to team tutoring and the specific goals of GIFT. The initial procedure and results of the meta-analysis were presented at GIFTSym3 (Burke, Feitosa, & Salas, 2015). This project included searching the team literature from the years of 2003 – 2013 for relevant team articles and their outcomes. The meta-analysis identified behavioral, attitudinal, and cognitive contributions in the areas of Team Performance, Team Learning, Team Satisfaction, and Team Viability (Sottilare, Burke, Salas, Sinatra, Johnston, & Gilbert, in review). Additionally, behavioral markers, or indicators of team performance were developed and identified. Markers that were associated with the theoretically identified contributors of trust, collective efficacy, cohesion, communication, and conflict/conflict management were established (Sottilare, Burke, Salas, Sinatra, Johnston, & Gilbert, in review). These markers can be used to assess the team, and help to guide remediation and feedback that they receive. This research serves as the theoretical basis for the team implementation in GIFT. The next steps forward include operationalizing the behavioral markers such that they can be used in a computer-based tutoring environment without the need of a human coder. This project tackles some of the initial team theoretical and authoring challenges of GIFT as it paves the way for identifying the types of markers and measures that should be available to an author who is creating a team tutor.

Initial Team Implementations and Research

The first working team implementations of GIFT have been part of a collaborative effort with Iowa State University. There has been one conducted experiment, and one planned experiment that demonstrates the different functionalities of team research in an intelligent tutoring system environment. The first project is

a surveillance task in Virtual Battlespace 2 (VBS2) in which two players work collaboratively to identify and transfer threats that they see in an area that they are monitoring. The first part of this project was to tackle the initial technological challenge of how to get the system to simultaneously monitor two individuals and provide feedback during training. The second piece was designing a team research study that would add to the body of literature about team training in an intelligent tutoring system environment and how to provide team feedback. This task and lessons learned from its implementation have been documented in a number of publications (Gilbert, Winer, Holub, Richardson, Dorneich, & Hoffman, 2015; Bonner, Walton, Dorneich, Gilbert, Winer & Sottilare, 2015; Bonner, et al., 2016).

The output of the studies also has led to considerations about how to grade, assess, and deal with computer-generated team based data (Gilbert et al., in press). A challenge of computer-based team tutoring is being able to have the system assess the team member's performance in real time, and react immediately. The initial study constructed Team DKFs and demonstrated how team data can flow in GIFT. The second study has built upon the original to allow for three team members to engage in the environment simultaneously. In the surveillance task implementation there are individual team member DKFs, and an overall team DKF. This resulted in three DKFs in the original two person task, and will ultimately result in more DKFs as the number of team members increase. For instance, if there is a leader and two additional team members there may be a DKF for the overall team, and each team member, but also potentially for subteams. Future work will continue to expand upon team tutoring in GIFT with increasingly more complex teams.

Workshops

In addition to initial theoretical research, workshops have and will be conducted in the future with experts in the areas of team tutoring, team performance, collaborative learning, and team research. The initial workshop titled "Building Intelligent Tutoring Systems for Teams: What Matters" was held at the conclusion of the meta-analysis project in March 2016 in Orlando, FL. Experts discussed the current state of teamwork as it relates to intelligent tutoring systems. The attendees brainstormed about the current and future state of team tutoring, and provided thoughts on steps forward.

The second workshop is the "Team Modeling and Team Taskwork Expert Workshop", which is set to take place in Ames, IA in June 2017. Experts in team research from different backgrounds and focuses will gather to talk about their experiences with team taskwork research, and their ideas on how it can be incorporated into GIFT. This workshop is part of a series that have been conducted since 2012 and will output a book in the Design Recommendations for Intelligent Tutoring Systems series.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The next step forward in GIFT's team implementation is to expand beyond a two and three person team and into new training environments/tasks. While GIFT has been demonstrated to be capable of handling multiple learners at the same time in a surveillance task, there are more complicated tasks that require hierarchical and varying team roles in order to achieve. Further, future research will focus on operationalizing the behavioral markers that were identified in the initial theoretical research that was conducted. While the identification of these markers was vital, most of them have been primarily established for implementation in an in-person training environment (Sottilare, Burke, Salas, Sinatra, Johnston, & Gilbert, in review). In order to provide opportunities for them to be implemented in real time during computer-based adaptive tutoring, work needs to be put into their operationalization and how they can be authored within GIFT. For instance, if the marker indicated that positive statements between teams members lead to improved performance, then there needs to be a way for positive statements to be determined by the system, and feedback based on the team using positive statements needs to be authored.

While the number of statements made and the meaning could potentially be tackled by semantic analysis, other items like identifying backup behavior (when one teammate is helping another that has fallen behind) may be much more difficult to identify.

Through operationalizing behavioral markers, scaling up the number of individuals who can be involved in a GIFT team tutor, and providing opportunities for more complex teams, GIFT will continue to make strides forward in the area of team tutoring. As these functions continue to develop it will lead to the need for team tutoring authoring tools, and the creation of additional team tutors. The past, current and future efforts will ultimately lead to a straightforward and efficient means of creating team based adaptive tutoring systems using GIFT.

REFERENCES

Bonner, D., Gilbert, S., Dorneich, M. C., Winer, E., Sinatra, A. M., Slavina, A., ... & Holub, J. (2016, September). The Challenges of Building Intelligent Tutoring Systems for Teams. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 60, No. 1, pp. 1981-1985). SAGE Publications.

Bonner, D., Walton, J., Dorneich, M. C., Gilbert, S. B., Winer, E., & Sottilare, R. A. (2015). The Development of a Testbed to Assess an Intelligent Tutoring System for Teams. In *AIED Workshops*.

Burke, C. S., Feitosa, J., & Salas, E. (2015, August). The Unpacking of Team Models in GIFT. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym3)* (p. 49).

Gilbert, S., Sinatra, A. M., MacAllister, A., Kohl, A., Winer, E., Dorneich, M., Slavina, A., Bonner, D., Ouverson, K. (in press). Analyzing Team Training Data: Aspirations for a GIFT Data Analytics Engine. In R. Sottilare (Ed.), *Proceedings of 5th Annual GIFT Users Symposium (GIFTSym5)*: U.S. Army Research Laboratory.

Gilbert, S., Winer, E., Holub, J., Richardson, T., Dorneich, M., & Hoffman, M. (2015, August). Characteristics of a multi-user tutoring architecture. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym3)* (p. 39).

Sottilare, R.S., Burke, S., Salas, E., Sinatra, A., Johnston, J., & Gilbert, S. (in review). Towards a design of process for adaptive instruction of teams: A meta-analysis. In review at Journal of Artificial Intelligence in Education.

Wang-Costello, J., Goldberg, B., Tarr, R.W., Cintron, L.M., & Jiang,H (2013). Creating an advanced pedagogical model to improve intelligent tutoring technologies. In The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC).

ABOUT THE AUTHORS

Dr. Anne Sinatra *is part of the adaptive training research team within ARL's Learning in Intelligent Tutoring Environments (LITE) Lab, she is lead on the Team Modeling vector and works on the Generalized Intelligent Framework for Tutoring (GIFT) project. Her background is in Human Factors and Cognitive Psychology.*