

UTILIZING INTELLIGENT TUTORING SYSTEMS AND THE GENERALIZED INTELLIGENT FRAMEWORK FOR TUTORING (GIFT) FOR RESEARCH

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ABSTRACT

This paper discusses using Intelligent Tutoring Systems (ITSs) and the Generalized Intelligent Framework for Tutoring (GIFT) to conduct research. The paper describes the functionalities and authoring tools in GIFT that can be utilized by an experimenter who wishes to create an experiment using GIFT. Lessons learned and suggestions are included. Further, there are examples and discussion of previous research that has used GIFT, and suggestions about improvements that could be made to use GIFT for research.

Keywords: intelligent tutoring systems, adaptive tutoring, research design, analysis

1. INTRODUCTION

Intelligent Tutoring Systems (ITSs) are adaptive computer based systems that can respond to an individual student with personalized materials based on performance, individual differences, and more. ITSs are generally designed by an instructional designer and/or course instructor who intends to use it as a supplement or primary means of providing information to students (Sottolare, Graesser, Hu, & Holden, 2013). While the utilization of adaptive tutoring has been shown to be as effective as a human tutor (VanLehn, 2011), it also has been shown to be a time-consuming and costly process (Sottolare, Brawner, Goldberg, & Holden, 2012). As a result, it is often difficult for an instructor or subject matter expert (SME) to sit down and construct their course without the help of individuals who have expertise with ITSs and computer programming. In fact, most ITSs are tightly coupled with the material that they are teaching, and are not necessarily editable or reusable in different domains. Domain-independent frameworks such as the Generalized Intelligent Framework for Tutoring (GIFT) aim to reduce the skill level and time required to author ITSs, and provide reusability (Sottolare, Brawner, Goldberg, & Holden, 2012). Specifically, one of the goals of GIFT is to provide an ability to conduct ITS research. While there have been a number of studies using ITSs in the classroom, and comparing ITS performance to non-ITS performance,

there have not been as many studies about which characteristics or aspects an ITS should track and adapt on (Holden & Sinatra, 2014; Sinatra, Ososky, Sottolare, & Moss, 2017). One of the reasons for this is the lack of flexibility in the authoring of ITSs, and the lack of ability to easily manipulate the components of the ITS's learner, pedagogical, and domain models and modules. GIFT provides the ability to interchange and manipulate the elements of all of these modules, which allows for experiments to be conducted to determine what the most ideal elements of each module are for different educational domains.

Additionally, GIFT has been designed to be used to conduct research, export data, and assist in formatting the data for future analysis. The experiments that are run with GIFT do not necessarily have to be adaptive in nature, as multiple linear courses can be created as different experimental conditions in an experiment and data later exported and compared to each other (Sinatra, 2014; Sinatra, 2016). The current paper describes approaches that have been used for research in GIFT, provides suggestions on research that can be done using GIFT's authoring tools and setup, and provides future recommendations for features in GIFT that can assist in the research process.

2. CASE STUDY EXAMPLE OF A STUDY THAT HAVE BEEN CONDUCTED WITH GIFT, AND OTHER TYPES OF STUDIES

The following section describes a case study example of an experiment that was conducted with GIFT. Additionally, a general overview of other experiments and domains that have used GIFT for research are described.

2.1. Logic Grid Puzzle Tutorial Experiment

The Logic Grid Puzzle Tutorial experiment was one of the first set of studies that was conducted using the early versions of GIFT (GIFT version 2.5, and GIFT version 4.0). The Logic Grid Puzzle Tutorial study was a traditional psychology research experiment that was conducted using GIFT. The ultimate goals of the experiment were to examine the impact of different self-

reference personalized instructional strategies on adaptive tutoring (Sinatra, Sottolare, & Sims, 2014; Sinatra, 2015). However, based on the features of GIFT at the time of the experiment, the adaptive manipulations occurred externally in PowerPoint using Visual Basic for Applications (VBA). The adaptive components to the course included feedback about the specific actions that the participant made during the PowerPoint based tutorial. However, the feedback did not change based on previous performance or on user characteristics.

GIFT was utilized to create an experimental flow that had three different conditions (self-reference, popular culture, and generic/baseline). The course included informational material, surveys/questionnaires, a tutorial that featured a manipulation during learning a skill (Logic Grid Puzzle performance), followed by assessments in the form of multiple choice questions, logic clue based questions, free recall, and performance of completing puzzles. The Q-sensor, which measures electrodermal activity (stress) was utilized and data was recorded using GIFT. The manipulation was in regard to the type of names that were present during the tutorial: names of the participants and people they knew, names of popular culture characters, and names that were generic. The study aimed to examine the impact of including names that are familiar or unfamiliar during the learning phase of a tutor to examine if they would assist in learning performance. See Figure 1 for a screen shot example of the popular culture name condition in which the names of characters were included in the learning materials, and Figure 2 for the generic names. Note that all of the content was identical except for the names that were present in both the puzzle grid, and the clues. The self-reference condition is not pictured, however, it asked participants to enter their own name, and names of friends, and they were incorporated into the puzzle. Individual difference characteristics such as Need for Cognition were collected, however, they were not adapted upon. One of the goals of the study was to examine the utility of the self-reference effect and different individual differences when teaching individuals a skill. Ultimately the results of this study, and other similar studies can be incorporated into GIFT in terms of types of adaptations that may occur based on relevant individual difference characteristics. For instance, if those with low need for cognition have better performance when popular culture names are used, that is a potential approach to adaptive content that can be given to a learner interacting with the system that has those characteristics.

One of the advantages of using GIFT for this study was the ease of data collection. The study was primarily linear with three different conditions. Participants were assigned to a condition when they arrived in person, and they were put in the corresponding version of the GIFT course. Everything about the courses except for the adaptive PowerPoint was identical. The software

opened and closed surveys, PowerPoints, and materials as appropriate, which reduced the need for multiple research assistants. This experimental flow also ensured consistency, and allowed for having multiple participants engage with the study simultaneously on different computers.

Either/Or Clue:

Clue 4) Harry's baked good was either the one with green sprinkles or the cupcake.

This is an Either/Or Clue.

This type of clue may be useful to review after working through the other clues.

Since we already know that the cupcake does not have green sprinkles, that means that Harry ordered the cupcake.

Enter an O on the grid to represent this relationship.

Remember to also add three Xs for the information you have now ruled out.

		Baked Good			Sprinkles Color		
		Brownie	Cookie	Cupcake	Green	Purple	Yellow
Name	Harry		X		X	X	O
	Ron				O	X	X
	Hermione					O	X
Sprinkles Color	Green		X				
	Purple						
	Yellow						

Figure 1. Example of the Popular Culture name adaptation in the Logic Grid Puzzle Tutorial Experiment.

Either/Or Clue:

Clue 4) Colby's baked good was either the one with green sprinkles or the cupcake.

This is an Either/Or Clue.

This type of clue may be useful to review after working through the other clues.

Since we already know that the cupcake does not have green sprinkles, that means that Colby ordered the cupcake.

Enter an O on the grid to represent this relationship.

Remember to also add three Xs for the information you have now ruled out.

		Baked Good			Sprinkles Color		
		Brownie	Cookie	Cupcake	Green	Purple	Yellow
Name	Colby		X		X	X	O
	Russell				O	X	X
	Denise					O	X
Sprinkles Color	Green		X				
	Purple						
	Yellow						

Figure 2. Example of the Generic Condition name adaptation in the Logic Grid Puzzle Tutorial Experiment. Notice that the names within the puzzle are different from those in Figure 1.

2.2. Other Studies that were conducted with GIFT

Other studies that have used GIFT include examining the location of feedback that comes from either inside or external to the environment (Goldberg & Cannon-Bowers, 2013). External programs such as VMedic (TC3 Sim) and VBS2 have been used to conduct affect research, as well as team based research (Paquette et al., 2016; Bonner et al., 2016). Specifically, a two person team tutor to evaluate surveillance performance was conducted using GIFT and VBS2 (Bonner et al., 2016). This study has demonstrated the ability to conduct team research using GIFT, as the two computers communicated with each other, and both team and individual feedback was provided. Additional work in

the line of research is in progress that increases the number of team participants to three, and includes different roles/responsibilities for team members. GIFT has been used to conduct research in a psychomotor domain through using it for marksmanship training (Goldberg & Amburn, 2014). Additionally, GIFT has been used to assess the impact of using interactive (virtual reality sand table) vs. static means and displays to provide information to individuals (Boyce et al., 2016). Therefore, GIFT has been shown to be versatile in the types of domains that have been used for experiments. Further, it has been able to be incorporated in different virtual environments, as well as use sensors as an input for the system to adapt on. Many non-traditional educational domain and simulation based experiments can be conducted using GIFT.

GIFT has a gateway module that connects it with external training applications. The gateway module can be used to transmit data between GIFT and programs/sensors so that adaptations can occur. If an external program or sensor is of interest to a researcher, but not yet integrated with GIFT the developer's guide can be used to provide information about how to create new interop plugin to connect to GIFT. In this case there is the need for computer programming, however, if an already integrated program or sensor is used there is no need to engage in programming.

3. FEATURES OF GIFT THAT CAN BE UTILIZED TO CREATE RESEARCH EXPERIMENTS

GIFT has many tools that can be used to create experiments, and has a way of providing participants an opportunity to engage with an experiment online. When conducting a study there are a number of different course components or objects that a researcher may want to use. Among these are surveys/questionnaires, providing information to the participant, presenting slideshows, engaging in a dialogue with the participant, and engaging with an external computer-based environment. Additionally, it is important for the experimenter to be able to establish a controlled way in which to conduct research either in a laboratory or through an online approach.

The GIFT authoring tool has been carefully designed to not only provide the opportunity to create fully online ITSs, but also to be leveraged to conduct research. Among the researcher relevant items of the authoring tools are the ability to include actionable and non-actionable surveys that can be used to collect participant data, as well as conduct real-time assessments that can influence the flow of the GIFT course. Additionally, html, PDFs, as well as premade PowerPoint shows or Slide Shows can be incorporated into a GIFT course. Either a linear courseflow can be utilized for a traditional experiment, or an adaptive courseflow can be

used to conduct research that involves testing different approaches to remediation in an ITS.

Once an experimenter has created their GIFT course that they would like to use for an experiment, they can create an experimental copy of it that will have an online link. The online link can be provided to participants who can then enter a participant number in a survey (or participate anonymously), and complete their interaction on their own computer. The data from the interaction will be recorded to GIFT's logs, and the researcher will have an opportunity to download and extract data from the logs after participation is complete. There are features in GIFT that also allow for the organization of data such that all data from an individual participant is exported onto one line so that it can easily be converted to excel or SPSS format for analysis.

3.1. Authoring Tools in GIFT

3.1.1. Development of the Authoring Tools over time

There have been many iterations of authoring tools in GIFT. While functionality is a high priority in regard to the development of GIFT, usability is also an extremely important element. In early versions of GIFT there were separate tools that were engaged with to create the courseflow (Course Authoring Tool), the learner configuration files, the surveys (Survey Authoring System), and more. The early tools emphasized functionality, and looked very similar to an .xml editor. The next step in the development of the authoring tools was to move toward a more straightforward and visual course authoring tool in order to design courseflow. Over time, the authoring tools not only became more visual and easier to populate (e.g., using drag and drop), but they also became more integrated with each other. In the current version of GIFT, the GIFT Authoring Tool includes the ability to not only create the courseflow, but to identify concepts, learner configuration, pedagogical configurations, adaptive courseflows, and create surveys. One of the main focuses in these developments is to make the process straightforward for a course author who is new to GIFT, as well as provide ease of use. See Figure 3 for an example of the early course authoring tools, and Figure 4 for the updated design. The same course (Logic Puzzle Tutorial) is being shown in both of the figures.

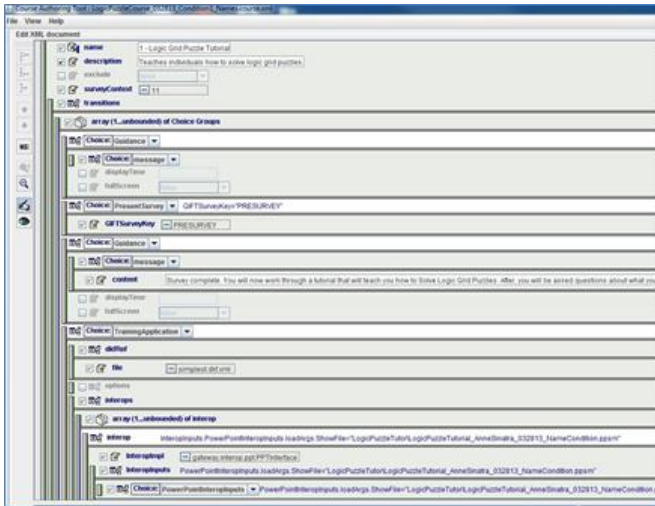


Figure 3. An example of an early version of the course authoring tool. Notice that while it is linear, it is not visual, and may look overwhelming to a new user.

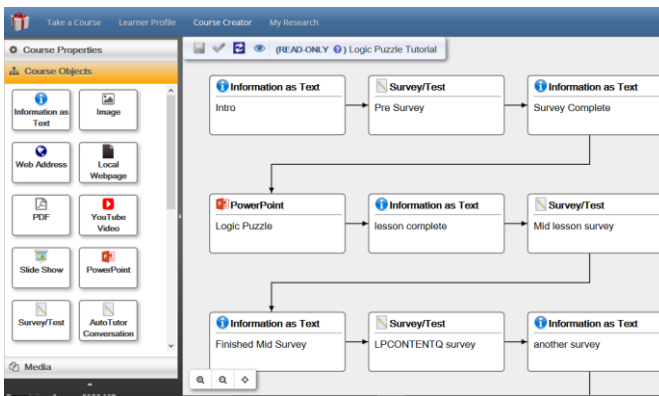


Figure 4. The current interface for GIFT Course Authoring. Note the visual interface as well as drag and drop functionality. The same course is loaded in this authoring tool as in Figure 3.

The changes and adjustments that have been made to the authoring tools have made it so that it is easier for an instructor or course author to engage with GIFT. One of the main goals for GIFT's design, is that a person does not have to have a background in computer programming to author in GIFT, which has become a reality. In the current state of the authoring tools a researcher in any domain (e.g., psychology, math, language), should be able to interact with the interface to create an experiment or course. Further, graduate students, or other students who wish to conduct their own traditional research experiments can utilize the tools without any external help needed in regard to programming.

3.1.2. An approach to getting started with the Authoring Tools

One recommendation for a user who is new to GIFT who wishes to author a course is to load one of the existing courses into the authoring tool and look at how it is constructed. Many of the course examples, including the Logic Grid Puzzle course which is available standard in GIFT, will demonstrate unique elements or flow to the courses that can help a new author gain an understanding of how GIFT works. Since GIFT is domain independent, if an author wanted to start by making a copy of an existing course and changing/replacing the content that is in it to be consistent with their desired topic, they could do so. It is also helpful to both engage with the original course by running it, then viewing the editor to see what both the original course looked like, and how it is different after changes have been made.

3.1.3. Functionality and distinction of the course objects in the Authoring Tools

As can be seen in Figure 4, the available course objects in the authoring tool include "Information as Text", "Image", "Web Address", "Local Webpage", "PDF", "YouTube Video", "Slide Show", "PowerPoint", "Survey/Test", as well as more, that are available through scrolling down the page. "Conversation Trees", "Question Bank", and "Adaptive Courseflow" objects are among the notable additional objects that can be included.

An experimenter who wishes to primarily engage in online surveys will need to make a decision between using the "Survey/Test" and "Question Bank" objects. As of GIFT 2017-1, these two objects are distinct and have different functionality. If a researcher wishes to use an established questionnaire or survey, then they would select the "Survey/Test" object. They would then make a selection between the type of survey (e.g., non-actionable vs. actionable, etc.). For example, if demographics are simply being collected and looked at after the fact then a non-actionable survey may be appropriate. If a participant characteristic is being assessed, and the researcher wishes to adapt based on that characteristic later in the course, then one of the actionable types of surveys should be selected.

If a researcher wanted to generate a random set of questions from an overall question bank, then they would use the "Question Bank" course object. Using the "Question Bank" the researcher would add all of the questions that they wanted to be available, and they would tag them specifically with course concepts that they have defined within GIFT. For instance, if there were three different concepts that the questions covered this would be defined in course properties prior to authoring the course, and while authoring the question, the pre-defined concept can be selected for the question.

Once the question bank is established, the number of questions from each concept to present and the desired difficulty level is selected.

There are different functions and purposes the “Survey/Test”, and “Question/Bank” tools can be used for. While the actual authoring interfaces are similar, it is important to understand the difference in the functionality between them and how they can be used in an experiment.

Another important distinction to make is between the “PowerPoint” and “Slide Show” objects. If the researcher desires to use VBA and adaptive functionality like in the Logic Grid Puzzle experiment example, then it is necessary for them to use the PowerPoint object. In the case of the PowerPoint object it will connect GIFT with the instance of PowerPoint that is on the participant’s computer and will open and close it as needed. This can potentially result in a few challenges, as it requires the participant to have a license for PowerPoint, and in some cases their PowerPoint version may not be compatible with GIFT. In order for courses with this element to work in the Cloud version of GIFT, the gateway module of GIFT will need to connect to the instance of PowerPoint on the participant’s computer, which requires a brief download process.

If an experimenter wants to present information to the user in a PowerPoint type format, but does not actually require interaction then they can use the “Slide Show” object. The “Slide Show” object will convert a PowerPoint show file (.pps) to images that are displayed with navigational arrows for the participant to use. One of the benefits of this is that it does not require the participant to have the external program installed on their computer, and it also does not require a brief download to connect GIFT and their computer before running the experiment. If the experimenter just wishes to present information to the participant then this may be the preferred method to use. Note, that GIFT requires, PowerPoint show files (.pps), which can be saved using PowerPoint.

Static images, PDFs, and other content can be inserted into the experimental courseflow if one wishes to display them to the participant. A local webpage can be used if the experimenter has constructed an .html file which they wish to display to the participant. In order to determine which might be most advantageous to use, the experimenter can look at previous courses to see how they were utilized, or use the course preview function in the Authoring Tool (it is a symbol that looks like an eye).

If one wishes to conduct adaptive training research, in which different adaptations are made based on learner characteristics and performance then the “Adaptive Courseflow” object can be used. This object is broken down into “Rules”, “Examples”, “Recall”, and “Practice” based on Merrill’s Component Display Theory (Merrill, 1983). The experimenter will enter

instructional content for “Rules” and “Examples” in many possible forms (e.g., Slide Shows, images, web pages), and then they will select the number and types of questions they want to use from the question bank for the “Recall” component. The “Practice” component is optional, and currently requires the use of an external training application (e.g., VBS3). This adaptive courseflow may not be the preferred method for a researcher conducting a traditional linear experiment (e.g., psychology), however, it allows many possibilities for those who wish to conduct adaptive training research and examine the best pedagogical as well as individual differences strategies to use for adaptation.

There are many different features and approaches to displaying information to the participant in GIFT that may be of use to the researcher, but in some cases it may require examining the possible course objects and determining which would be the best approach to use for the goals.

4. EXAMPLES OF STUDIES THAT CAN BE CONDUCTED WITH GIFT

As mentioned earlier in the paper, there are a number of different approaches and types of studies that can be designed using GIFT. While traditional ITS studies tend to be in the area of Math and Physics, the majority of work that has been done to date with GIFT has not been in these areas. GIFT is domain-independent and very flexible. GIFT is not limited in regard to the types of questions that can be constructed, the methods of adaptation, or course objects that are used. GIFT has been designed such that different instructors or researchers that have different end goals can utilize it and the tools in order to meet their own goals. In particular this is one of the challenges in regard to the design of GIFT. It has to be powerful, but also needs to be constructed to be general, so that it can be used in different ways. In particular, this is one of the reasons that there are multiple approaches, as mentioned in the previous section, to presenting and collecting information. However, this flexibility is a great strength for the experimenter, as it allows for many different types of experiments to be conducted.

4.1. Linear Experiments

Linear experiments can easily be conducted with GIFT. The Logic Grid Puzzle experiment case study mentioned earlier in the paper was an example of a linear experiment. While the specific adaptive features of GIFT were not utilized, GIFT allowed for experimental control and facilitated data collection. Many times there can be human error when research assistants are required to open and close computer programs and interact with the participant. In the case of GIFT, the computer automatically leads the participant through the experiment. A research assistant can then be

utilized mostly for startup and stopping of the experiment. Further, online experiments can be run that display information to participants, media (e.g., videos, images), and then collect survey responses. Traditional experiments, such as in the discipline of Psychology could use GIFT to streamline their data collection.

4.2. Adaptive Instruction and Intelligent Tutoring System Experiments

The main goal of GIFT is to facilitate the creation of ITSs. Therefore, GIFT can also be utilized to manipulate elements of an ITS to determine what types of adaptations have the best outcomes. In this case, the researcher may create competing types of media that they want to be presented to the participant and determine which is most effective in leading to the desired learning outcomes. In particular, different versions of a tutor can be created that contain different types of adaptations. For example, in the first version of the course, motivation level can be what the adaptation occurs based on. Whereas, in the second version of the course, it could be Need for Cognition. Or a potential third version of the course can examine the impact of adapting based on both Need for Cognition and Motivation. The participant's course outcomes can then be compared to each other. In this case, the research question would be in regard to the type of individual difference characteristics that should be taken into consideration. However, there are many other possibilities, as the learner module of GIFT and pedagogical module of GIFT are highly configurable and can be utilized in conducting ITS research. Therefore, GIFT can be used to conduct studies to determine the relevant components of the learner model, to determine adaptations based on individual differences, and for remediation based experiments. Conducting ITS research like these examples is generally difficult in domain-dependent systems as they are tied tightly to a concept or a way of adapting. With GIFT as long as the research question can be defined, the experimenter can utilize the tools in order to create the ideal configuration and experimental course.

5. RECOMMENDATIONS FOR FUTURE DIRECTIONS THAT COULD ASSIST WITH STUDY DEVELOPMENT

While the authoring tools for creating experiments in GIFT have been extensively worked on, there has not been as much focus on the data extraction tools. Early versions of GIFT used the Event Report Tool, which had boxes that could be checked by the experimenter after the fact to extract data from participant logs in the configuration that they desired. As GIFT moved toward the Cloud the My Research tab was created, and the ability to create an Experiment with GIFT became the ideal approach to data collection. These features are

useful for experimenters, and over time they could be potentially improved as the authoring tool was.

As mentioned earlier in the paper, in current versions of GIFT, once a course is authored the experimenter clicks on the My Research tab and creates a new experiment. The experimenter will be prompted to enter an experiment name and description, then select the course that they want to make into an experiment. This makes a copy of the course as it currently is, and provides a web-link that the experimenter can provide to the participants so that they can engage with the experiment. If a change is made to the original course it will not populate into the experiment, a new experiment will need to be created.

Once the participant goes to the experimental link, they will encounter a "Start" button. After the button is pushed it will launch GIFT, and does not require a login. Therefore, if a participant number is desired to be collected, then there should be information and a question incorporated into a survey in the course to prompt the entry of the number.

Once data collection is completed, the experimenter finds their experiment in the My Research tab, and can build a report. By building a report the experiment is temporarily paused and no new data can be collected until it is started again. An interface pops up that allows the experimenter to select the information that they want to be included in the report, and how the data should be merged (e.g., all in one line). The experimenter can then save the report from all of their participants in a .csv file, which can be imported into Excel or SPSS for data analysis.

In the current version, there is no option for the experimenter to select specific logs that they want to extract, they are all extracted at the same time into the same file. This makes it difficult if there is an outlier or a data point that needs to be taken out of the data set because of an error. In the future it would be helpful to give the experimenter more control of the data logs that will be included in the output. However, it is possible to remove the data manually once it is extracted, and reconfigure it in Excel.

Further, it would be beneficial to have a participant number assigned at the beginning of the experiment, such that it is easier for the experimenter to manage and keep track of their data. This could be a potential option that is provided to the experimenter to include in the course, where a number is generated for the participant to continually use throughout the experiment.

Finally, while some of the features of the original desktop version of GIFT's extraction tools have been ported over to the new version, they are not all present. It would be beneficial to continue to add options for data extraction, while also being mindful of researcher needs and usability. The current version of the extraction tools do allow researchers to extract their

data as needed, but small edits to them could potentially improve the functionality.

6. CONCLUSIONS

GIFT is a powerful framework that is flexible and allows for researchers to conduct many different types of studies. In this paper a case study example was provided of a linear psychology experiment that was conducted using GIFT. Further, the authoring tools and different types of experiments that can be created with GIFT were discussed. GIFT is very flexible and can be utilized by experimenters from many backgrounds, with a variety of different research questions and goals. In the current form of GIFT, there are a few considerations to keep in mind, such as the most appropriate way to display information to the users, and collect data. Further, the experimenter should be mindful of the way that the My Research tab features work, and how to extract data. As with the authoring tools, the experimental process and support for data extraction tools will continue to improve based on user experiences and suggestions.

7. 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.
- 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 MD ABERDEEN PROVING GROUND United States.
- Goldberg, B., & Amburn, C. (2015, August). The application of GIFT in a psychomotor domain of instruction: a marksmanship use case. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym3)* (pp. 115-124).
- Goldberg, B., & Cannon-Bowers, J. (2013, July). Experimentation with the generalized intelligent framework for tutoring (GIFT): a testbed use case. In *AIED 2013 Workshops Proceedings Volume* (Vol. 7, pp. 27-36).
- Holden, H. K., Sinatra, A. M., (2013). The Need for Empirical Evaluation of Learner Model Elements. In *Design Recommendations for Intelligent Tutoring Systems, Volume 1: Learner Modeling*, 87.
- Merrill, M. D. (1983). Component display theory. *Instructional-design theories and models: An overview of their current status*, 1, 282-333.
- 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*.
- Sinatra, A. M. (2014). The research psychologist's guide to GIFT. In *Proceedings of the Second Annual GIFT Users Symposium* (p. 86).
- Sinatra, A. M. (2015). Developing an Experiment with GIFT: Then and Now. In *AIED Workshops*.
- Sinatra, A. M. (2016). The Updated Research Psychologist's Guide to GIFT. In *Generalized Intelligent Framework for Tutoring (GIFT) Users Symposium (GIFTSym4)* (p. 135).
- Sinatra, A.M., Ososky, S., Sottolare, R., & Moss, J. (2017). Recommendations for use of Adaptive Tutoring Systems in the Classroom and in Educational Research. Accepted for publication in the *Proceedings of the Human Computer Interaction International 2017 Conference*, Vancouver, Canada, July 2017.
- Sinatra, A. M., Sims, V. K., & Sottolare, R. A. (2014). *The Impact of Need for Cognition and Self-Reference on Tutoring a Deductive Reasoning Skill* (No. ARL-TR-6961). ARMY RESEARCH LAB ABERDEEN PROVING GROUND MD.
- Sottolare, R. A., Brawner, K. W., Goldberg, B. S., & Holden, H. K. (2012). The generalized intelligent framework for tutoring (GIFT).
- Sottolare, R.A., Graesser, A.C., Hu, X., & Holden, H. (2013). Preface. In *Design Recommendations for Intelligent Tutoring Systems, Volume 1: Learner Modeling*, i.
- VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, 46(4), 197-221.

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