GIFT Research Transition: An Outline of Options

How transition in GIFT moves through phases of idea, project, and paper, and to real-world use.

Keith W. Brawner[1]

[1]*Army Research Laboratory*
Keith.W.Brawner@us.army.mil

Abstract. This paper describes the use of the Generalized Intelligent Framework for Tutoring (GIFT) to transition research and findings into use beyond publication. A proposal is submitted to use GIFT as a research platform for community development, with examples of how it provides transition opportunities for individual researchers. Several projects which have already transitioned are discussed, while two projects by the author are specifically shown as examples.

Keywords. Intelligent Tutoring Systems, Research Transition

1 Current Transition Path for Research in the ITS Community

The Generalized Intelligent Framework for Tutoring (GIFT) development is currently performed under contract for the Army Research Laboratory. There any many reasons why the military is interested in training technology in general, and adaptive intelligent training technologies in specific [1]. Fundamentally, the end result of research conducted at ARL is technological advancements which are usable by soldiers, or, succinctly, "Technology Driven. Warfighter Focused".

Technology transition is defined as the process of transferring skills, knowledge, or ability from research (typically performed at university or Government labs) to users who can further develop or exploit these items into products, processes, applications, or services. There are many ways for research projects to transition from research to development, to new product, to lifecycle support. While this innovative diffusion may occur solely through technological 'push' of publishing or the 'pull' user adoption, these typically do not occur without a transition partner [2]. Part of the purpose of ARL is to function as a transition partner: leveraging technology advances made in academic laboratories, developing them into usable products, and transitioning them to developmental support roles.

ITS research has historically transitioned directly to the user, which bypasses the developmental and exploitive portions of a traditional transition. One example of this is a project such as the Cognitive Tutor, which bypassed the "external development" phase through marketing to local school districts. Another example includes the Crystal Island program, which has also transitioned through collaboration with the

local school districts, rather than an industrial base. Further examples include AutoTutor transition of Operation ARIES through the facilitating intermediary of Pearson Education, or GnuTutor through open source software release.

Researchers generally face competing desires for their project. As a research goal, they desire to perform research, create findings, publish results, and solve interesting problems. A researcher may have a related goal, which competes for their time: the desire for their technology to be useful to a population of users. Given finite resources, the individual or organization must compromise one of these goals to facilitate the other. A two-way facilitating transition partner would allow the researcher to see their creation used and obtain meaningful feedback while maintaining research pursuits.

ARL in general, and the GIFT project in specific, have a goal of facilitating this research transition. This goal is not empty talk, as the repackaging and transition of several research projects has already occurred programmatically. In addition to being an ARL researcher, the author is anticipated to obtain a doctorate at the University of Central Florida in August 2013. Research done at ARL and UCF alike are both transitioning to the field through the GIFT, and will be described in this paper. The author will outline how you can use GIFT to transition your research, give examples of projects which have done so, and describe the benefits of this approach.

2 Proposal for a Community Research Platform

GIFT is intended to be both a community platform and growing standard [3, 4]. This fundamentally offers several advantages, a short selection of which is described below:

- Like any open source software approach, a researcher or developer is able to build upon the work of others. This magnifies the ability of an individual developer to contribute.
- Like any community project, a developer is able to quickly see the use of their work. An individual developer/researcher is able to quickly access a population of users of their research, which magnifies their individual impact.
- ITS technology can be leveraged against a broad amount of training content, while keeping the same core functionality. This magnifies the use of the product.
- The ITS technology can improve through various software versions, which improves learning while costing little or nothing for implementation. Content is used in a more useful fashion, making the use of an incrementally updated project attractive.
- A researcher or developer can use standardized tools to create, modify, or adjust individual items for the purpose of experimentation, evaluation, and validation.
- Experimental comparisons can be conducted fairly at multiple locations, with multiple populations. This allows the research conducted within the framework to be fairly compared.
- A researcher can leverage tools which make the interpretation of data easier. A shared set tools has been of aid to other researchers in Educational Data Mining [5].

3 Re-GIFT-ing: models of transition

There are several models of transition which can be used with varying levels of researcher interaction and levels of opportunity. Transition into GIFT may be through a tool, a compatible software or hardware product, a plug-in, a releasable item, or a piece of software integrated into an official baseline. These differing modes of transition are summarized in **Error! Reference source not found.** alongside the required user interaction, an example of a project which has followed this transition path, and the potential impact that it has to the field.

The first project to discuss is the tool created by the Personalized Assistant for Learning (PAL) for data analysis [6]. During the course of a PAL experiment with GIFT, the developers found it helpful to have a tool to parse through GIFT data. After developing this tool, they provided this it back to the community through simply posting it on the http://www.gifttutoring.org forums. An author following this transition path may host a "**GIFT tool**" on their own site, make it available to only their lab, or other method. To the author's knowledge, no one has used or modified this tool outside of their laboratory. However, others have the opportunity to use this tool and improve on it, and its functionality has directed the development of a more thorough tool available within the GIFT Release: the Event Reporting Tool (ERT).

The next project, and method of transition, to discuss is the eMotive EEG library. The eMotive EEG was found helpful in other research conducted by the author [7], and was incorporated into GIFT as a software library interface. The purchase of an eMotive EEG headset gives the developer access to the library. The fact the GIFT supports easy integration of the sensor makes it so that each GIFT user is a potential eMotive customer, which benefits eMotive. Transition of research as a "**GIFT compatible**" product involved little interaction with the developers, but may be unsupported in future releases. While developer involvement is low, the potential impact is similarly low.

Continuing to use sensors as an example, the next project to discuss is the Q-Sensor project, which transitioned in a way which is different from the previous versions. All software required to integrate an Affectiva Q-Sensor is provided freely to the GIFT community, as part of a **"GIFT plugin"**. Changes made to the Q-Sensor are supported in future versions of GIFT and the plugin is released in the current GIFT 3.0 version. To date, this type of transition has resulted in the use of Q-Sensor technology in a minimum of two different experiments, with three pilot trials. This has occurred with little interaction from the Q-Sensor developers.

There are now several complete programmed packages which are released with the GIFT version. One of these is the medical instruction and assessment game "vMedic", which contains several scenarios which have GIFT tutoring. Another example is the Human Affect Recording Tool (HART), developed by Ryan Baker [8], which enables affective coding of behavior. Both of these programs have reached a wider audience through leveraging **"GIFT releasable"** transition, with some work required by the developer. The developer of each of these programs targeted use within GIFT as part of the model of development. Each of these programs is provided back to the community as downloadable software packages on www.gifttutoring.org. In this fashion, the vMedic program has reached a significantly wider audience and the HART app has seen distribution and citation.

Lastly, one can transition source code directly into the GIFT baseline via a **"GIFT integration"**, in anticipation of the next release. The work required to integrate into the GIFT framework is done by the developer, before giving it back to www.gifttutoring.org. While this requires more work, it is able to reach a wider audience, and is automatically carried forward into each future release. This is the only release path which is thoroughly tested and vetted prior to each version. This allows for the broadest application of the developed technology.

Table 2. Examples of various GIFT transitions, projects which used this transition method, and levels of interaction provided

Type of Transition	Example of project	User interaction	Potential Impact
GIFT tool	PAL Tool	None	Low
GIFT compatible	eMotive EEG	None	Low
GIFT plug-in	Q-Sensor	Low	Medium
GIFT releasable	HART, vMedic	Medium	Medium
GIFT integration	GSR filtering, MultiSense	High	High

4 Two Research Transition Stories: GSR Filtering, realtime modeling

In this section, the author will tell two stories research transition where first-hand experience was obtained. The first of these stories involves the transition of a new GSR sensor filtering method, available in GIFT 2.0, while the second focuses on a larger piece of work which has intended availability in GIFT 4.0. The aim of this section is to give an example of how an idea becomes a deliverable.

4.1 GSR Filtering

The first project idea is that a realtime sensor filter may be able to collect meaningful measures of affective/cognitive state in realtime. The idea behind this project is that the author was unaware of relevant feature extraction techniques, or implementations, for several datastreams of interest. A dataset was used which collected both ECG and GSR measures while participants experienced various training events [7]. It was hypothesized that meaningful measures of cognition and affect could be extracted from these sensor datastreams.

It was found that meaningful measures of cognition and affect could be extracted, including statistical measures and signal power measures, borrowing from the field of digital signal processing. It is possible that these techniques could be leveraged into an intelligent tutoring system. These results were then published [9].

Just because a method has been published to be useful does not mean that industrial or academic partners and collaborators will take it upon themselves to read an

academic paper, implement the algorithm, and put it in their system. The more that an individual developer can do to help this process, the quicker transition of the research will be [2]. One way to do this is to merge the work of a researcher with a project which is already transitioning to industry. GIFT represents this possibility.

The idea, project, and paper on GSR filtering has transitioned into GIFT via the "GIFT integration" route. Every researcher which downloads GIFT (which is compatible with a GSR sensor) is able to implement the developed feature extraction, do their own experiment and draw their own conclusions. Furthermore, any ITS constructed from the GIFT framework and tools already has this implementation, and the development of a student model which uses this information progresses a significant step towards reality. The ECG filtering from the same paper is intended to be released GIFT 4.0.

To date, GSR filtering algorithms have now been provided to over 100 researchers and developers. The author hopes that his work will be found valuable. In either case, the developed research has been placed in the hands of numerous users, which is more valuable than publication alone. If the work is not found valuable, the author would hope that the other researchers are able to improve on the technique, and feed the results to other researchers through a similar transition path.

4.2 Realtime modeling

The second project idea is that individualized models of learner affect/cognition may be able to be created in realtime. The idea behind the second project is that generalized models of affect and cognition are difficult to create. Individualized models can be made, but their quality is known to degrade over time [10]. Realtime modeling and adaptive algorithms may present a solution to the problem.

The realtime modeling project used two datasets [11] and constructed seven total classifiers. The approach used four different types of classification techniques, including neural gasses, resonance theory, clustering, and online linear regression. Each of these techniques was developed with three different schemes for labeling data, including unsupervised, semi-supervised, and fully-supervised.

It was found that semi-supervision had significant contribution to the overall accuracy of the problem. It was also found that realtime affective models could be created with reasonable quality, and that realtime cognitive models are a more difficult problem that requires alternate means in conjunction with the methods presented. These results will be published as a doctoral dissertation later in the year.

Realtime student state assessment is anticipated to be available within GIFT 4.0. Targeting GIFT as a research transition allows industry and academia to benefit from the research, and targets a larger and different audience than publication. Once again, transition of research through GIFT allows larger access, experimentation, citation, and overall exposure.

5 Conclusion/Recommendations

GIFT is a functional Intelligent Tutoring System which has been used as part of several experiments. Research which transitions into GIFT has the potential to be used

by a population of learners, instructional designers, and experimenters. Each of these user groups is anticipated to have their own user interface, which can make use of the research transitioned into GIFT, in whichever fashion is implemented.

In addition, GIFT is intended as a research platform, and Army Research Laboratory has plans for development out to 2017. A research transition into GIFT, in any fashion, should be able to reach a community of users for the next four years, at a minimum. The project has potential longevity beyond 2017, with funding from the Army, DoD, or others. Even if not supported by the Army, it will remain in the public domain, able to be improved by anyone in the community. Using GIFT as an exit vector for research ideas has more potential than simple publication, or of hosting an open source project.

Furthermore, the licensing agreement on GIFT does not hinder the individual researcher from capitalizing on their ideas. Two for-profit companies have targeted GIFT as a technology which can support the ability to commercialize their ideas, while others have been in conversation. Other research organizations have proposed or used GIFT to widen their audience and to focus their expertise.

This paper has discussed how some research technology has *already* transitioned to the field using the GIFT entry vector, and how other portions are intended. The concept which the author presents in this workshop paper and presentation is that it is possible to use GIFT as a platform to transition research results into the field of use, while minimizing the effort required by the researcher.

6 References

1. Army, D.o.t., *The U.S. Army Learning Concept for 2015*, 2011: TRADOC.
2. Fowler, P. and L. Levine, *A conceptual framework for software technology transition*, 1993, DTIC Document.
3. Sottilare, R.A., et al. *A Modular Framework to Support the Authoring and Assessment of Adaptive Computer-Based Tutoring Systems (CBTS)*. in *The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC)*. 2012. NTSA.
4. Sottilare, R.A., et al., *The Generalized Intelligent Framework for Tutoring (GIFT)*. 2012.
5. Koedinger, K.R., et al., *A data repository for the EDM community: The PSLC DataShop.* Handbook of Educational Data Mining, 2010: p. 43-55.
6. Regan, D., E.M. Raybourn, and P. Durlach, *Learning modeling consideration for a personalized assistant for learning (PAL)*, in *Design Recommendations for Adaptive Intelligent Tutoring Systems: Learner Modeling (Volume 1).*2013.
7. Goldberg, B.S., et al., *Predicting Learner Engagement during Well-Defined and Ill-Defined Computer-Based Intercultural Interactions*, in *Proceedings of the 4th International Conference on Affective Computing and Intelligent Interaction (ACII 2011), LNCS*, S.D. Mello, et al., Editors. 2011, Springer-Verlag: Berlin Heidelberg. p. 538-547.
8. Baker, R.S., et al. *Towards Sensor-Free Affect Detection in Cognitive Tutor Algebra*. in *Proceedings of the 5th International Conference on Educational Data Mining*. 2012.

9. Brawner, K. and B. Goldberg. *Real-Time Monitoring of ECG and GSR Signals during Computer-Based Training*. 2012. Springer.
10. AlZoubi, O., R. Calvo, and R. Stevens, *Classification of EEG for Affect Recognition: An Adaptive Approach.* AI 2009: Advances in Artificial Intelligence, 2009: p. 52-61.
11. Carroll, M., et al., *Modeling Trainee Affective and Cognitive State Using Low Cost Sensors*, in *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC)*2011: Orlando, FL.

Authors

Keith W. Brawner is a researcher for the Learning in Intelligent Tutoring Environments (LITE) Lab within the U. S. Army Research Laboratory's Human Research & Engineering Directorate (ARL-HRED). He has 7 years of experience within U.S. Army and Navy acquisition, development, and research agencies. He holds a Masters degree in Computer Engineering with a focus on Intelligent Systems and Machine Learning from the University of Central Florida, and will obtain a doctoral degree in the same field in Summer 2013. The focus of his current research is in machine learning, active learning, realtime processing, datastream mining, adaptive training, affective computing, and semi/fully automated user tools for adaptive training content.