Solicitation Number:

PROPOSAL COVER PAGE

1. SUBMIT TO:
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2. For consideration by:
☐ Biology/Life Sci ☐ Chemistry ☐ Computer Science ☐ Electronics ☐ Mechanical ☐ Environmental Sciences ☐ Sensors & Electron Dev
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3. Is this proposal being submitted to another Federal Agency?
☑ No ☐ Yes If Yes, list the agency:

4. Is applicant delinquent on any Federal Debt?
☐ Yes (Attach explanation) ☒ No

5. Proposal Valid Until (min of 6 mos):

6. Entity Identification Number (EIN) or Taxpayer Identification Number (TIN)
62-0648618

7. Data Universal Numbering System (DUNS No.):
055688857

8. Commercial and Government Entity (CAGE) Code: 0LSB5

9. Name of organization to which award should be made:
The University of Memphis

10. Administrative Address of Organization (if different):
315 Administration Building, Memphis, TN 38152-3370

11. Branch/Campus/Other Component (where work is performed, if different):

12. Submitting Organization's Contract/Grant Administration Office:
Office of Research Support (901) 678-2533

13. Submitting Organization's Audit Office:
Internal Audit (901) 678-2125

14. Submitting Organization: (Check all that apply)
☐ For Profit: ☐ Large ☐ Small ☐ Disadvantaged ☐ 8a ☐ Women-Owned ☐ Foreign ☐ Individual
☒ Educational: ☐ HBCU ☐ Minority Institution ☐ Hispanic ☐ Indian Tribal ☐ State ☐ Private ☐ Foreign ☐ FDP
☐ Hospital: ☒ Public ☐ Private ☐ Nonprofit ☐ For Profit
☐ Nonprofit
☐ Not-For-Profit
☐ Other (Specify)

15. Check appropriate box(es) if this proposal includes any of the items listed below:
☐ Human Subjects ☐ Biosafety Level (BL) 1-4 Facility
☐ Vertebrate Animals ☐ Genetically Engineered Organisms
☐ National Environment Policy Act ☐ Limited Rights Data
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☐ Historical Places ☐ Govt Purpose Rights Data
☐ GFE ☐ GFD ☐ Proprietary Data
☐ GFI ☐ GFP ☐ Ozone Depleting Substances

16. Proposed Amount:
$1,508,155

17. Proposed Duration (1-60 mos):
56 months

18. Proposed Start Date:
05/01/2012

19. Type of Award Proposed:
☐ Single Investigator
☐ Young Investigator Program
☐ Short Term Innovation Rsch
☐ Research Instrumentation
☐ Conference/Symposia
☒ Other (Specify):
Research

20. Title of Proposed Project:
Generalized Intelligent Framework for Tutors (GIFT)

21. Principal Investigator (PI)/Project Director (PD) Department and Postal Address:
Dr. Xiangen Hu, Department of Psychology, 400 Innovation Dr., Memphis, TN 38152

22. Year PI's degree conferred
1993

23. Scientific discipline of PI's degree
Psychology

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27 a. Authorized Representative Signing for Applicant Organization:

27 b. Title: Catrina Sullivan, Sr. Coord., Sponsored Program

27 c. By signing and submitting this proposal, the Offeror is providing the certifications contained in this BAA.

27 d. Signature Catrina Sullivan Date: 03/20/12

PROPOSAL

TABLE OF CONTENTS

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STATEMENT OF DISCLOSURE PREFERENCE

The University of Memphis (Organization) in submitting proposal titled Generalized Intelligent Framework for Tutors (GIFT) in Learning in Intelligent Tutoring Environments (LITE) Wo with Xiangen Hu, Ph.D. (Name)

as Principal Investigator/Project Director requires the following procedure be used during its evaluation:

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( ) Restrict the evaluation of the above proposal to Government reviewers only.

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Cover Page	☒ Yes ☐ No	Statement of Work	☒ Yes ☐ No
Project Abstract	☒ Yes ☐ No	Biographical Sketch	☒ Yes ☐ No
Technical Proposal	☒ Yes ☐ No	Cost Proposal/Budget	☒ Yes ☐ No
Current & Pending Support	☒ Yes ☐ No	Bibliography	☒ Yes ☐ No

03/16/2012
Date

Catrina P. Sullivan
Signature of person authorized to sign for organization

03/16/2012
Date

Signature of Principal Investigator/Project Director

ARO Form 52A
(Rev. March 2008)

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PROJECT ABSTRACT

The ARL Team [The Human Research and Engineering Directorate (HRED) of the Army Research Laboratory (ARL)] and **the UM (Memphis) team** [the Advanced Distributed Learning Center for Intelligent Tutoring Systems Research & Development (ADL CITSRD) in the Institute for Intelligent Systems (IIS) at the University of Memphis] propose an eight-month pilot contract plus four years of options to meet ARL needs. The project has two major components. First, the research component consists of a series of three expert workshops, one per year beginning this fiscal year, that assess optimal directions for ARL LITE Lab's open-source Generalized Intelligent Framework for Tutors (GIFT). Second, the development component involves the creation and evaluation of several versions of prototypes that integrate existing ITSs such as AutoTutor in GIFT.

These two components are further divided into four specific tasks.

1. Conduct research on ITSs focusing on three aspects of ITS components: (1) Trainee Modeling Techniques, (2) Instructional Strategy Selection Techniques, and (3) Authoring Tools and Expert Modeling Techniques. The research tasks include but are not limited to: (1) creating literature reviews for the most current research and development, (2) contributing to the living documents for the ARL GIFT ontology, and (3) disseminating research outcomes to the ITS R&D community.
2. Organize expert workshops focusing on the three aspects of ITSs. The workshops will be part of the overall research effort, with the addition of building an expert community for both the ARL team and the Memphis team for future R&D on ITSs.
3. Create a fully functional prototype selectively emphasizing each of the ITS components. The prototypes will serve as supporting activities for the overall research goal, with emphasis on development efforts to provide ITS R&D communities with prototypes. Such prototypes will exemplify the best practice of integrating the ARL team's GIFT framework and existing proven ITS systems such as the Memphis team's AutoTutor framework.
4. Evaluate the prototypes adapting best practice in evaluating advanced learning systems. The evaluation of the prototypes will be in four different aspects of learning technology: Theoretical, Technological, Pedagogical, and Usability. The outcome of the evaluation will help to produce a high quality prototype and at the same time offer best practice in the evaluation of Advanced Learning Environments such as ITSs.

The ultimate goal of this multiyear collaborative effort between **the ARL Team** and **the Memphis team** is to build a science-based suite of documents, guidelines, prototypes, and architectures that exhibit advanced learning technologies embodying the features of GIFT and conversational agents. These deliverables will be informed by the community of researchers who have relevant expertise to bring these advanced technologies to fruition. The hope is that the next generation of personnel in the DoD will be fortified with the optimal learning environments for a broad landscape of subject matters, personnel, and practical challenges in the military.

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Generalized Intelligent Framework for Tutors (GIFT)

Collaborative Research Effort between ARL and UM

Robert Sottilare & Heather Holden

Army Research Laboratory (ARL)
Human Research and Engineering Directorate (HRED)

Xiangen Hu & Art Graesser

Advanced Distributed Learning (ADL) Center for
Intelligent Tutoring Systems (ITS) Research & Development [UM]

March 2012

1. Introduction

The Human Research and Engineering Directorate (HRED) of the Army Research Laboratory (ARL) will plan, manage, and conduct a comprehensive multidisciplinary program of scientific research directed toward defining human performance in perceptual, cognitive, and psychomotor domains. HRED research provides the scientific foundations for militarily relevant databases on human performance and associations among enhancers, distracters, and stressors, which affect that performance. Those data and associations are then embedded in modeling and simulation tools, which in turn serve to guide optimal design of human-system interaction in battlefield environments. HRED also conducts research associated with advanced distributed simulation environments, immersive learning, intelligent technologies for training, synthetic environments, and training application domains. This research and development proposal addresses advanced immersive simulation technology for use in training, mission rehearsal, analysis, and education.

The Institute for Intelligent Systems (IIS, http://iis.memphis.edu/) at the University of Memphis (UM) is an interdisciplinary research center composed of researchers and students from the fields of computer science, mathematics, cognitive psychology, communication sciences, physics, neuroscience, education, linguistics, philosophy, anthropology, engineering, and business. Intelligent systems differ from conventional technologies in that they are fast, dynamic, flexible, and adaptive. Researchers in the IIS have developed technologies in the cutting-edge areas of the learning sciences, cognitive science, artificial intelligence, discourse processing, and complex dynamic systems. The IIS has received more than $30 million in external funding over the last decade and has partnered with numerous universities and corporations. Within IIS is the Advanced Distributed Learning Center for Intelligent Tutoring Systems Research and Development (ADL-C-ITS-R&D), which has the primary mission of understanding how complex computer learning environments can improve learning. Activities range from basic research on the cognitive science of comprehension, learning, memory, and problem solving to software development for intelligent tutoring systems and automated analyses of language, semantics, discourse, and emotions.

The IIS is a catalyst for research and technologies designed to address current and future workforce training challenges facing military, government, academia, and civilian entities. It is widely acknowledged that conventional page-turning software and multimedia handle shallow learning quite well, but do not rise to the level of motivating learners and helping them acquire deep knowledge, skills, and learning strategies required for 21st century jobs. Today's training challenges require natural dialogue systems and intelligent tutoring frameworks to meet workforce needs. The team of researchers from ADL-C-ITS-R&D has a record of success with other federal funders, including the National Science Foundation, Institute of Education Sciences, and Department of Defense, and is well positioned to work with the HRED to identify best practice strategies and develop and test new prototypes. We propose a nine-month pilot contract plus four years of options to meet ARL needs. The project has two major components. First, the research component consists of a series of three expert workshops, one per year beginning this fiscal year, that assess optimal directions for ARL LITE Lab's open-source Generalized Intelligent Framework for Tutors (GIFT). Second, the development component involves the creation and evaluation of several versions of prototypes that integrate existing ITSs such as AutoTutor in GIFT.

The goal of this multiyear collaborative effort between HRED in ARL (**the ARL Team**) and ADL-C-ITS-R&D at the University of Memphis (**the Memphis team**) is to build a science-based suite of documents, guidelines, prototypes, and architectures that exhibit advanced

learning technologies embodying the features of GIFT and conversational agents. These deliverables will be informed by the community of researchers who have relevant expertise to bring these advanced technologies to fruition. The hope is that the next generation of personnel in the DoD will be fortified with the optimal learning environments for a broad landscape of subject matters, personnel, and practical challenges in the military.

2. Technical Background

2.1. Intelligent Tutoring Systems

Intelligent tutoring systems (ITSs) have proven very effective in improving training outcomes. These systems typically contain four components: a *domain model*, an *expert model*, a *learner model*, and a *teaching strategy* (Shute & Psotka, 1994; Curilem, Barbosa et al., 2007; Durlach & Ray, 2011). The goal is to advance the learner to the expert's level using the optimal teaching strategies. The tutor uses "intelligence" (usually some form of artificial intelligence, AI) to provide feedback to the student and to direct the student experience based on the domain model, the expert model, and its assessment of the learner. Meta-analyses show effect sizes on the order of one sigma (Dodds & Fletcher, 2004; VanLehn, 2011), which is approximately a full letter grade in traditional grading schemes. The long sought-after goal is a two-sigma effect size (Bloom, 1984; Corbett, 2001).

Recent advances in natural language processing (NLP), semantic analysis, machine learning, and cognitive modeling have spawned ITSs with the potential to achieve this effect size (Graesser, Conley, & Olney, 2012). Although many of the current computer tutors tend to use heuristics that remain constant as they customize material for individual students (Woolf, 2009), the next generation of tutors will implement more dynamic models that can infer hidden learner characteristics and recognize unanticipated behavior based on learner performance, past experiences, and lessons learned. Aside from these breakthroughs in AI, the next-generation ITSs will include Virtual Worlds (VW) and game-based training environments that are driven by ITS engines (e.g., Thomas & Young, 2010) with multiple learners simultaneously participating.

2.2. Generalized Intelligent Framework for Tutors (GIFT)

As the world turns to more motivating learning environments with VR and conversational agents, it is important to ensure that the learning mechanisms stay on course in terms of optimizing learning in the deep ways that are accepted in the learning sciences, cognitive science, and AI. To ensure a good balance between the motivating "skin" of the learning experience and the deep "muscle and skeleton" of science-based learning, it is important to adopt a general architecture of ITS learning. This is the fundamental goal of GIFT, which is summarized in Figure 1.

The GIFT architecture in Figure 1 introduces the components of sensor, trainee, pedagogical, learning management system (LMS), and domain modules for particular subject matters. These components are approximately aligned with the domain model, expert model, learner model, and teaching strategies that were discussed above, although the correspondences need to be specified with greater precision and clarity in the proposed project. A domain module in GIFT processes feedback requests and scenario changes by adjusting scenario elements or user interface components. It allows for the pass-through of domain independent interventions, and allows the domain to respond to specific hint requests. A domain module can assess feedback either through a priori knowledge of the correct answer, having the ability to calculate

the correct answer, or through comparison of a built-in expert model, depending on how well defined a domain is. The architecture supports a hybrid model approach to feedback selection and requires production rules that dictate activation. Through system use the production rules will be iteratively updated based on the data fed into the student and domain models. Variables of performance, competency, affect, and cognition will all be determinants of implementing a training intervention. The architecture will allow for grouping of feedback/manipulation strategies with a triggering variable and supports empirical evaluations to test their effect on training outcomes.

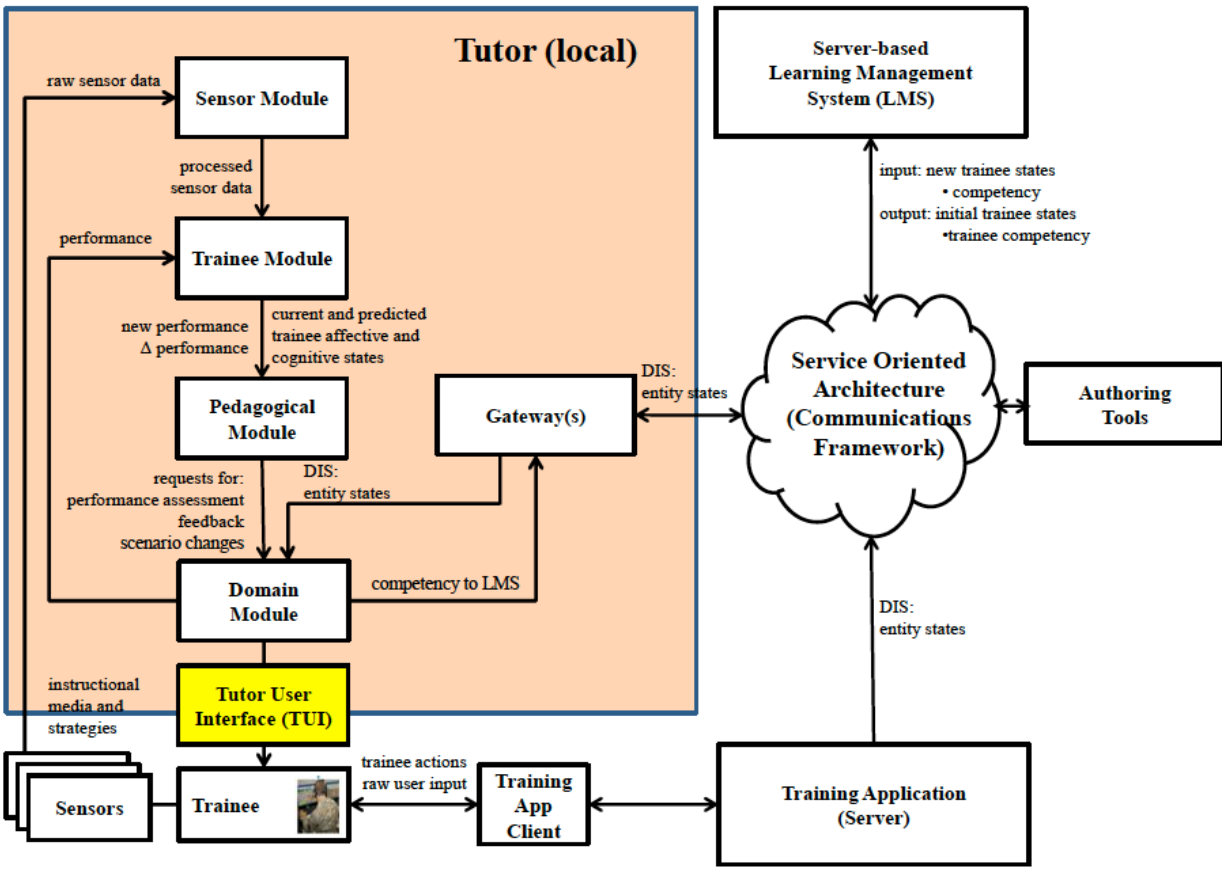

Figure 1. Generalized Intelligent Framework for Tutors (GIFT).

The primary outputs of pedagogical strategy decisions are whether to make an intervention, and the next instructional content that must be presented. While the instructional content decisions are processed out of view of the user, interventions have a sizable effect. Interventions take one of two forms, either that of a domain-specific feedback (such as “aim higher”) or domain-independent feedback such as an emotional or metacognitive prompt. Decisions to change instructional content also come in different forms. Content decisions can modify task demands, modify task complexity, or change the types of content presented. A well-designed domain-specific component must address these parameters and components.

For pedagogy and feedback to be successful, the architecture requires a domain module that supports the types of feedback requested. While the vast majority of the components of an ITS may be made domain independent, there must always be a specific component of the architecture to deal with the problems that the instructor desires to teach. The fundamental problems of domain-dependent components are how to assess student actions, how to respond to instructional changes, how to respond to requests for immediate feedback, and an interface that supports learning (Sottilare, Holden, Goldberg, & Brawner, under review). The architecture designed must have built-in support for these types of instructional activities.

2.3. AutoTutor Framework

AutoTutor is the first system the University of Memphis developed to implement expectation and misconception–tailored (EMT) conversational dialogue mechanisms (Graesser et al., 2005; Graesser, Jeon, & Dufty, 2008; Graesser, Lu et al., 2004; Graesser, Olney, et al., 2005; VanLehn et al., 2007). The initial systems targeted computer literacy and physics, because there was a shortage of instructors in these areas. AutoTutor's physics dialogues are organized around conceptual physics problems that require reasoning and explanations in the answers. These questions require the learner to construct approximately three to seven sentences in an ideal answer and to exhibit reasoning in natural language. It takes a conversation to answer each question, typically 30 to 100 conversational turns between AutoTutor and the student.

Table 1 illustrates AutoTutor in a conversation that was extracted from an actual tutoring session. This session was with a relatively verbose, knowledgeable college student, so the conversation is comparatively short. Lower ability students would take many more conversational turns to construct a good answer. When students are asked these challenging questions, their initial answers are typically only one or two sentences in length. However, one to two sentences provide insufficient information to adequately answer the question, so tutorial dialogue is needed to flesh out a complete answer. AutoTutor engages the student in a dialogue that draws out more of what the student knows and assists the student to construct an improved answer.

AutoTutor can manage a reasonably smooth and pedagogically effective conversation by implementing three dialogue mechanisms in its dialogue manager: (1) EMT dialogue, (2) a five-step dialogue frame, and (3) a systematic template to guide each conversational turn.

Table 1. Example dialogue with AutoTutor.

Tutor	Now let's move on. A lightweight car and a massive truck have a head-on collision. On which vehicle is the impact force greater? Which vehicle undergoes the greater change in its motion? Explain why.
Student	The lightweight vehicle experiences the greater impact and the greater change in motion because the mass of the lighter vehicle is less, therefore having less inertia to resist the change in motion. The momentum of the truck is greater than that of the car.
Tutor	Right! What does Newton's third law of motion say about the forces that bodies exert on each other?
Student	The forces must be equal in magnitude and opposite in reaction.
Tutor	Yes, correct! Can you add to that?
Student	The forces must be equal and opposite reactions acting on opposite bodies.

Tutor	Ya! We've almost covered it, but there's one part I think is still missing. I am sure you can get this. During an interaction, each body exerts an equal but opposite force on the other ____?
Student	Body
Tutor	Yes, right! on the other body. So when two balls, one plastic and the other iron, hit each other, does the heavier or neither ball exert the greater impact force on the other?
Student	Neither
Tutor	Yes, correct! Neither, the forces are equal in magnitude. Let's take a moment for general physics questions. Ask me one and I'll do my best to answer it.
Student	No
Tutor	Alright. To recap what we have just discussed, please give me your complete answer to the original question, as presented at the top of the screen.
Student	Although the lighter car experiences a greater change in motion, both vehicles exert an equal impact force, but opposite in direction. The larger object has a larger mass, and therefore a larger inertial resistance than that of the car.
Tutor	That is right! Putting everything together, um, According to Newton's third law of motion, if one body exerts a force on the other body then the other body must exert an equal and opposite force on the first body. Therefore, the car and the truck both experience the same impact force. By Newton's second law, the car will experience the greater change in its motion because its mass is much smaller. This question is finished so let's go on to the next question.

2.3.1. Expectation and misconception–tailored (EMT) dialogue

As discussed, EMT dialogue tries to get the student to articulate a set of sentence-like expectations and corrects anticipated misconceptions. AutoTutor guides the student in articulating the expectations through a number of dialogue moves: pumps (what else?), hints, and prompts for the student to fill in missing words. Hints and prompts are carefully selected by AutoTutor to produce content in the answers that fill in missing content words, phrases, and propositions. For example, a hint to get the student to articulate expectation E1 might be "What about the forces exerted by the vehicles on each other?" This hint would ideally elicit the answer "The magnitudes of the forces are equal." A prompt to get the student to say "equal" would be "What are the magnitudes of the forces of the two vehicles on each other?" As the learner expresses information over many turns, the list of expectations is eventually covered and the main question is scored as answered. Complete coverage of the answer requires AutoTutor to have a pool of hints and prompts available to extract all of the content words, phrases, and propositions in each expectation. AutoTutor adaptively selects those hints and prompts that fill missing constituents and thereby achieves pattern completion.

AutoTutor is dynamically adaptive to the learner in ways other than coaching them to articulate expectations. AutoTutor corrects the learners' misconceptions and errors. AutoTutor gives brief feedback on the quality of student contributions: positive (very good, yeah), neutral (uh huh, okay), or negative (not quite, not really). AutoTutor answers some categories of learners' questions by retrieving answers from glossaries or paragraphs in textbooks via intelligent information retrieval. AutoTutor asks counter-clarification questions (e.g., I don't understand your question, so could you ask it in another way?) when it does not understand the students' questions.

2.3.2. Five-step dialogue frame

The five-step dialogue frame is prevalent in human tutoring (Graesser & Person, 1994; VanLehn et al., 2007) and is implemented in AutoTutor. The five steps are as follows:

(1) Tutor asks main question.
(2) Student gives initial answer.
(3) Tutor gives brief feedback on the quality of the student's answer in (2).
(4) Tutor and student collaboratively interact via EMT dialogue.
(5) Tutor verifies that the student understands.

Students often answer that they understand in Step (5), though most do not. A good tutor would press the student further by asking more questions to verify the student's understanding, but even good tutors rarely do this.

2.3.3. Managing one conversational turn

Each turn of AutoTutor in Steps (3)–(4) has three template slots (i.e., units, constituents). The first slot of most turns is brief feedback (positive, neutral, or negative) on the quality of the student's last turn. The second slot advances the coverage of the ideal answer with prompts for specific words, hints, assertions with correct information, corrections of misconceptions, or answers to student questions. The third slot is a cue to the student for the floor to shift from AutoTutor as the speaker to the student. For example, AutoTutor ends each turn with a question or a gesture to cue the learner to do the talking. Discourse markers (and, also, okay, well) connect the utterances of these three slots of information within a turn.

The three levels of AutoTutor go a long way toward simulating a human tutor. AutoTutor can keep the dialogue on track, because it is always comparing what the student says to anticipated input (i.e., the expectations and misconceptions in the curriculum script). Pattern-matching operations and pattern-completion mechanisms drive the comparison. These matching and completion operations are based on latent semantic analysis (LSA; Landauer et al., 2007) and symbolic interpretation algorithms (Rus, McCarthy, McNamara, & Graesser, in press). AutoTutor cannot interpret student contributions that have no matches to content in the curriculum script, comparison text, glossaries, or other existing sources. Therefore, AutoTutor cannot explore the topic changes and tangents of trainees. However, students do not take the initiative very frequently in human tutoring sessions (Graesser & McNamara, 2010; Graesser, Person, & Magliano, 1995), so AutoTutor is a reasonable facsimile of human tutoring.

2.4. A Formal Framework of Intelligent Tutoring Systems

We believe that having a formal (mathematical) framework for ITSs will help capture the similarity between GIFT and other ITS frameworks such as AutoTutor. A mathematical description of ITSs will make it easier for prototype production and for a conceptual analysis of the differences among different ITS frameworks. The formal model presented in the proposal is sufficiently general and allows analysts to track the measures of computational mechanisms for broader scientific exploration. This is a starting point for both GIFT prototype creation and expert workshops. A mathematical foundation that accommodates multiple architectures and algorithms is obviously necessary for the communication, software integration, and technical engineering solutions.

The formal model in this section is described in the context of AutoTutor. However, the model can be applied to other ITSs that involve a fine-grained interaction between the student

and computer tutor—with or without natural language processing. AutoTutor's interaction with trainees in a tutoring session follows five steps: (1) the tutor provides a seed question that requires reasoning, (2) the student supplies a response that gets interpreted by the tutor from the standpoint of expected good answers versus misconceptions, (3) the tutor evaluates the quality of the student's response, (4) the tutor selects the next dialogue move or main question, and (5) the tutor delivers the move or item to the trainee. Thus, the system's next moves are very sensitive to the student's abilities and the dialogue history. Implementations of ITSs differ in the details of the last three steps, namely, evaluating the response, selecting the next item, and deciding how to deliver the item. Based on these observations, we outline the basic assumption of the model, and then give the details of the model setup. In the description, we refer to some facts about AutoTutor, although more details of AutoTutor are presented in the next section.

2.4.1. Basic assumptions

The tutor's expert knowledge is organized around a curriculum script that is a structured organization of didactic content (mini-lectures), difficult problems or questions, good answers to the problems/questions (called expectations), hints and prompt questions to get the students to articulate the expectations, misconceptions and corrections, and other content (assertions, summaries, etc.). Each constituent in this structure has a set of words called a "bag of words" of items (called nodes) that may or may not be organized according to a structure. For the moment, it is assumed there is not detailed structure within each node, but that the overall structure of nodes is organized according to a framework constrained by the authoring tool of the ITS.

When AutoTutor is in full swing, the main questions, feedback, hints, prompts, assertions, summaries, etc. are presented to students in the form of a sequence of dialogue moves within a conversational turn. For example, in one conversational turn there may be a sequence of three dialogue moves: short feedback to the student, then an assertion, and then a hint. The exact content generated for any one dialogue move in a conversation is selected from the nodes in the curriculum script, based on the student characteristics and the dialogue history. There is a family of hints and prompts in the curriculum script associated with each expectation. For example, the expectation *Temporary memory in computers is called RAM* would have many prompt questions to get the student to articulate the content, such as *Temporary memory in computers is called what? RAM is a temporary what?* The prompts are not generated randomly or capriciously. Instead, they serve many purposes (e.g., filling in missing content, diagnosis, or establishing a common ground). The right content is generated for the right student at the right time during the conversation by intelligent selection of nodes from the curriculum script.

A tutoring session is a dialogue with mixed initiatives that are formally specified by "IF<state>THEN<action>" production rules. Tutor-initiated dialogs are guided by systematically constrained rules that perform the following four steps:

1. The tutor selects the first item.
2. The student responds to the selected item. The student's response may be limited by the format, but not necessarily the content. The format can be multiple-choice with a fixed set of alternatives or open-ended with natural language answers.
3. The tutor is capable of assigning a vector of numerical values to each item-response pair. The assignment can either be fixed or be a dynamically computed function of the history of the interaction between the tutor and student.
4. The tutor's selection of the next item follows a probability distribution that is a function of the history of the interaction between the tutor and student and that

optimizes an algorithm that reflects the particular theory the researchers are investigating. The tutor decides how the selected item will be delivered and delivers the content.

For student-initiated dialogs, which are rare, at any point during the tutoring session, students may propose a topic (e.g., by asking a question), after which

1. The tutor evaluates the proposal.
2. The tutor selects one or more appropriate items.
3. The tutor decides how each selected item is to be delivered and delivers the content.

2.4.2. Model setup

In the above simplification of tutor-student interaction, the knowledge of the tutor is represented by production rules in addition to the declarative knowledge in the curriculum script. The student model is indirectly represented by the evaluation of item-response pairs. In tutoring situations, student input is not limited to closed-class responses but can be expressed in the form of natural language in a conversational style. Such evaluation in AutoTutor is achieved as a semantic representation vector that is based on either LSA or features of more symbolic algorithms. Whenever student-initiated actions occur (which is not frequent in normal human tutoring), the tutor's delivery of specific knowledge is not based on the tutor's preplanned lessons, but is instead triggered by what students want to learn or their interaction history with the tutor. The quality of these student-initiated activities is also evaluated and incorporated in the student model.

The mathematical model that goes with the above description can be explicitly formulated as the following components.

Knowledge representation. A set of items

$$X = \{x_1,\ldots,x_n\} \tag{2.1}$$

with an algebraic structure modeled as a subset of **X** x **X**. An item may be a collection of structured elements. The algebraic structure of items reflects particular assumptions about the knowledge structure of the tutor.

Evaluation method. The evaluation method uses a function that assigns a vector of numerical values to any combination of (x_i, r_i), where r_i is a generic notation for response of item x_i, simply denoted as $f(x_i, r_i)$. Such a function is determined by the response r_i and the structured element of x_i. When x_i = null, the student's response is in fact an initiation of a dialog. The evaluation model is generically denoted as

$$\left(x_{i_1}, f\left(x_{i_1}, r_{i_1}\right)\right). \tag{2.2}$$

Selection mechanism. A selection mechanism is a conditional probability for any x as the n^{th} iteration between the tutor and student.

$$p\left(x_{i_n}\right) = \Pr\left\{x_{i_n} \mid \left(x_{i_1}, f\left(x_{i_1}, r_{i_1}\right)\right), \ldots, \left(x_{i_{n-1}}, f\left(x_{i_{n-1}}, r_{i_{n-1}}\right)\right)\right\}. \tag{2.3}$$

The conditional probability is also a function of the algebraic structure among the items. The tutor-initiated dialogs are the case where

$$\left(x_{i_{n-1}}, f\left(x_{i_{n-1}}, r_{i_{n-1}}\right)\right)$$

is not null. Student-initiated dialogs are the cases where the above item *is null*.

Tutoring strategy. A delivery model specifies how any selected item x_{in} is presented. Several factors go into this model: the structure of the elements contained in the item, the

frequency of how often item x_{in} has been selected, and how x_{in} was presented in previous turns—for example, which elements were delivered prior to the current turn.

The two levels of models, namely **Selection Model (*Selection mechanism*)** and **Delivery Model (*Tutoring strategy*)**, correspond very well to the two levels of adaptivity in ITSs. We only define these two models in a general fashion here. Such a definition is general enough to describe most ITSs using the above framework. Similar to the Selection Model, the Delivery Model is also probabilistic in nature. The only difference between these two models is the level of grain size. The smallest element of the Selection Model is an item, whereas the smallest element of the Delivery Model is an element.

The four components correspond well with the common models of ITSs. For example, **Knowledge Representation** is the organization of the knowledge items in the curriculum script and corresponds to the *domain model*. The **Selection Mechanism** matches the *expert model*, whereas the **Evaluation Method** assesses what students know and creates *a learner model*. The **Tutoring Strategy** matches the *teaching strategy*.

2.4.3. Example application of the formal framework of ITS: Analysis of AutoTutor

The mathematical specification of the four components permits us to identify a mapping with the components of AutoTutor's framework.

Knowledge representation. In the AutoTutor framework, this is the collection of topics, subtopics, problems, main questions, answer content, and families of alternative dialogue moves in the curriculum script of the subject matter (e.g., physics, computer literacy, biology, mathematics). The relations among the content nodes are organized in a fashion that does justice to the domain knowledge. The knowledge representation has been extensively studied in well-defined domains such as mathematics, programming, and to some extent physics and biology. Knowledge representations can be in different forms, such as concept maps (as implemented in Guru Tutor, a project led by Andrew Olney) or learning progressions (implemented in DeepTutor, a project led by Vasile Rus).

Evaluation method. In all variations of AutoTutor, students interact with the tutor in the form of natural language. Students' contributions are evaluated by a semantic engine such as latent semantic analysis (Hu et al., 2007; Landauer et al., 2007). So $f(x_i,r_i)$ in (1.2) is in the form of semantic comparison (cosine match between two 300-dimension real-valued vectors). The semantic comparison produces a value that measures the level of understanding of the student; therefore, it is used as the student's model for the knowledge (specifically to the topic). That is, the student's model of a domain is reflected in the cosine values associated with the nodes in the domain knowledge, answers to particular questions, or solutions to particular problems.

Selection mechanism. AutoTutor selects the next topic for students to learn based on how much the students understand relevant topics. It is similar to other systems such as ALEKS (www.aleks.com). The most intuitive understanding of the selection mechanism is to select topics based on a prerequisite structure. An alternative is to select topics on topics that slightly extend what the student has mastered, at the zone of proximal development. At a smaller grain size, the selection mechanism chooses which expectation to concentrate on next and which dialogue move to select from a set of alternatives. The selection mechanisms of an ITS are related to knowledge representation in addition to following generic algorithms. Once again, selection mechanisms are implemented in Guru Tutor (based on a concept map of biology) and DeepTutor (based on learning progressions of physics) in addition to AutoTutor.

***Tutoring strategy*.** ITS implementations differ from each other by employing different tutoring strategies. In the AutoTutor framework, tutoring follows *expectation and misconception tailored dialogue* (EMT; Graesser, D'Mello et al., 2012; Graesser, Olney et al., 2005; Graesser, Person, & Magliano, 1995) rather than highly sophisticated tutoring strategies (e.g., modeling scaffolding-fading, building on prerequisites, and Socratic techniques that get students to self-discover deficits). The production rules computationally implement these tutoring strategies.

3. Project Description

The Memphis team plans to collaborate with the ARL team for the next five years to assist the ARL team in building prototypes based on GIFT. This includes providing technical guidance for the ARL team in developing computer prototypes that implement AutoTutor components and similar ITSs with or without natural language. This collaborative effort between the ARL team and the Memphis team includes four types of projects:

- **Research about ITSs.** The Memphis team and the ARL team will work together to conduct research on ITSs, focusing on the following three aspects of ITSs: **(1) Trainee Modeling Techniques, (2) Instructional Strategy Selection Techniques, and (3) Authoring Tools and Expert Modeling Techniques.** The ARL team will provide an initial ontology for each of the three research thrusts. The Memphis team will modify the ontology throughout this effort based on what they find in the literature and the workshops. Thus, the literature reviews and ontologies will be living documents. The collaborative research will provide a theoretical guide for each of the expert workshops.
- **Organization of expert workshops that focus on three aspects of ITSs. *Trainee Modeling Techniques, Instructional Strategy Selection Techniques, and Authoring Tools and Expert Modeling Techniques.***
- **Creation of fully functional prototypes that integrate the ARL team's GIFT framework and the Memphis team's AutoTutor framework.** We propose to have a total of four versions of prototypes. Each of the first three prototypes will correspond to the three workshops. The final prototype will integrate input from all three workshops and incorporate features of the first three prototypes.
- **Systematic evaluation of the prototypes.** The Memphis team will systematically evaluate the prototypes. The evaluations will include theoretical/formal analysis, technological analysis, instructional/content analysis, and usability analysis.

The Memphis team and the ARL team will spend total of five years, divided into five phases, to accomplish the above four research projects.

3.1. Phase 1: Theoretical and Technological Preparation and First Expert Workshop (Trainee Modeling Techniques)

Phase 1 of the proposed collaborative effort includes two projects, which will end on December 31, 2012.

Project 1.1: Theoretical and Technological Preparation. The Memphis team plans to work with the ARL Team to understand the technical details of GIFT. This initial research effort includes the following: (1) a literature review of intelligent tutoring systems (ITSs), (2)

refinement of the formal model of ITS (Section 2.4), and (3) conceptual analysis of the GIFT and AutoTutor frameworks. Specifically, this project will include:

a. Face-to-face meetings with the ARL team. The ARL team will be invited to the University of Memphis campus to work with Memphis researchers to systematically introduce GIFT.
b. The Memphis team working to understand existing GIFT implementations and prototypes.
c. The Memphis team working with the ARL team to examine the existing open-source GIFT framework.
d. The Memphis team providing implementation details of the most updated variations of AutoTutor.
e. Specific general requirements for GIFT prototypes (e.g., open-source requirements, etc.).
f. Production of a design document for the first version of the GIFT prototype.
g. Discussion of key issues and topics that will be covered in the first workshop.

Project 1.2: First Expert Workshop on Trainee Modeling Techniques. The first workshop will focus on *trainee modeling techniques*. The purpose of the workshop is to collect expert views on theoretical and technological issues centered on trainee modeling. Specifically, it includes:

a. Logistics that facilitate the success of this and other expert workshops, as outlined in Section 4.
b. The outcomes of this and other workshops, as outlined in Section 4.
c. A workshop focused on trainee modeling. The initial set of topics will be from Sottilare, Goldberg, and Durlach (2011). More details will be discussed during the first ARL and Memphis team meeting.
d. Further exploration of the details of the evaluation method. We expect to have a detailed mathematical modeling specification for equation (2.2).

This workshop will also serve as the second meeting between the ARL team and the Memphis team to approve plans (prototype design document, for example) from the initial meeting.

3.2. Phase 2: First Prototype and Second Expert Workshop (Instructional Strategy Selection Techniques)

Phase 2 of the proposed collaborative effort includes two projects: the first GIFT prototype and the expert workshop on *instructional strategy selection techniques*. This phase will start January 1, 2013 and end December 31, 2013.

Project 2.1: First GIFT Prototype. We plan to produce the first GIFT prototype.

a. Technical/logistical details for this and other prototypes are specified in Section 4.
b. The content domain, evaluation population, and expected outcome (for evaluation of success) will be from **Project 1.1.**
c. The first GIFT prototype will be to migrate a selected AutoTutor implementation within the GIFT framework, with the following requirements:
    a. It will be fully functional, satisfying GIFT prototype requirements (as a result of Project 1.1).

b. It will incorporate expert suggestions from the first workshop on trainee modeling techniques (from Project 1.2).

d. Delivery contents will be in three different domains.
e. The Memphis team will assist the ARL team in developing a beta-prototype for the second expert workshop on *instructional strategy selection techniques*. The Memphis team will also identify issues and topics to be focused on during the second workshop.

Project 2.2: Expert Workshop on Instructional Strategy Selection Techniques. The main focus of the workshop is to collect expert views on theoretical and technological issues centered on instructional strategy selection techniques. Specifically, it will include:

a. Logistics that guarantee the success of this and other expert workshops, as outlined in Section 4.
b. The outcomes of this and other workshops, as outlined in the next section.
c. A workshop focused on selected adult learning principles (http://psyc.memphis.edu/learning/whatweknow/index.shtml).
d. Examination of the beta-implementation of tutoring modeling from the first GIFT prototype (Project 1.2).

This workshop will also serve as the third meeting between the ARL team and the Memphis team to evaluate outcomes of the first prototype (Project 1.2) and adjust plans for the second version of the GIFT prototype (due to new theory and new server/delivery technologies).

3.3. Phase 3: Evaluation of the First GIFT Prototype, Creation of the Second GIFT Prototype, and Third Expert Workshop (Authoring Tools and Expert Modeling Techniques)

Phase 3 of the proposed collaborative effort includes three projects: evaluation of the first GIFT prototype, production of the second GIFT prototype, and hosting an expert workshop on authoring tools and expert modeling techniques. This phase will start January 1, 2014 and end December 31, 2014.

Project 3.1: Evaluation of the First GIFT Prototype. The third-party independent evaluation team, CREP (http://www.memphis.edu/crep/), will evaluate the produced prototype (Project 2.1).

a. Details of the proposed evaluation of prototype are outlined in Section 4.4.
b. We will report their findings at the third workshop.

Project 3.2: Second GIFT Prototype. We plan to produce a second GIFT prototype built on the first GIFT prototype (Project 2.1).

a. Technical/logistical details for this and other prototypes are specified in Section 4.
b. Content domain, evaluation population, and expected outcomes (for evaluation of success) will be from **Project 1.1** and potential modifications from the second workshop **(Project 2.2)**.
c. The second GIFT prototype will have the following requirements:
    a. It will be fully functional, satisfying GIFT prototype requirements (as a result of Project 1.1).

b. It will be an improved version, incorporating new server and delivery technology.
c. It will incorporate expert suggestions from the second workshop on instructional strategy selection techniques (from Project 2.2).

d. Delivery contents will be in three different domains.
e. We will provide a beta-prototype for the third expert workshop on authoring tools and expert modeling techniques and provide the issues and topics that will be focused on during the third workshop.

Project 3.3: Expert Workshop on Authoring Tools and Expert Modeling Techniques. The main focus of the workshop will be to collect expert views on theoretical and technological issues centered on the workshop theme of authoring tools and expert modeling techniques. Specifically

a. Logistics that guarantee the success of this and other expert workshops are outlined in Section 4.
b. The outcome of this and other workshops are outlined in Section 4.
c. We will explore the detailed mathematical models (**Knowledge Representation**) as a function of domains. For example:
    a. What would be the general algebraic structure of the domain knowledge?
    b. What are the relations between the topics?
d. We will incorporate existing methods of knowledge organizations such as "learning spaces" that are part of ALEKS mathematics tutoring.
e. We will explore how to incorporate domain knowledge structure that already exists, such as concept maps and learning progressions.

This workshop will also serve as the fourth meeting between the ARL team and the Memphis team to evaluate the outcome of the second GIFT prototype (Project 2.2) and adjust plans for the third version of the GIFT prototype (due to new theories and new server/delivery technologies).

3.4. Phase 4: Evaluation of the Second GIFT Prototype, Create Third GIFT Prototype. Phase 4 of the proposed collaborative effort includes two projects: evaluating the second GIFT prototype and assisting the ARL team in developing the third GIFT prototype. This phase will start January 1, 2015 and end December 31, 2015.

Project 4.1: Evaluation of the Second GIFT Prototype. The third-party independent evaluation team, CREP, will evaluate the produced prototype (Project 3.2).

a. Details of the evaluation of the prototype are outlined in Section 4.4.
b. We will report CREP's findings to facilitate the creation of the final GIFT prototype.

Project 4.2: Third GIFT Prototype. The Memphis team will assist the ARL team to develop a third GIFT prototype that is an extension of the second GIFT prototype (Project 3.3).

a. Technical/logistical details for this and other prototypes are specified in Section 4.
b. The content domain, evaluation population, and expected outcome (for evaluation of success) will be from **Project 1.1** and potential modifications from the third workshop **(Project 3.3)**.

c. The third GIFT prototype will extend the second GIFT prototype (Project 3.2) with the following requirements:
    a. It will be fully functional, satisfying GIFT prototype requirements (as result of Project 1.1) and additional requirements from the previous workshops (Projects 1.2, 2.2, 3.3).
    b. It will be an improved version, incorporating new server and delivery technology.
    c. It will incorporate expert suggestions from the third workshop on authoring tools and expert modeling techniques (from Project 3.3).
d. Delivery contents will be in three different domains.

3.5. Phase 5: Evaluation of the Third GIFT Prototype and Creation of the Final GIFT Prototype. Phase 5 of the proposed collaborative effort includes two projects: evaluation of the third GIFT prototype and creation of the final GIFT prototype. This phase will start January 1, 2016 and end December 31, 2016.

Project 5.1: Evaluation of the Third GIFT Prototype. The third-party independent evaluation team, CREP, will conduct evaluation of the produced prototype (Project 3.2).

a. Details of the evaluation of prototype are outlined in Section 4.4.

Project 5.2: Final GIFT Prototype. We plan to produce the final GIFT prototype built on the previous three GIFT prototypes (Projects, 2.1, 3.2, 4.2).

a. Technical/logistical details for this and other prototypes are specified in Section 4.
b. The content domain, evaluation population, and expected outcome (for evaluation of success) will be from **Project 1.1** and potential modifications from the third workshop **(Project 3.3)**.
c. The final GIFT prototype will be built upon all previous versions of GIFT prototypes (Projects 2,1, 3.2, 4.2) with the following requirements:
    a. It will be fully functional, satisfying GIFT prototype requirements (as a result of Project 1.1) and additional requirements from the previous workshops (Projects 1.2, 2.2, 3.3) plus recommendations from the third-party evaluation team (CREP).
    b. It will be an improved version (incorporating new server and delivery technology) based on the most updated server/delivery technologies up to 2015.
d. Delivery content will be in one of the three different domains.

4. Logistics and Objectives for the Proposed Projects

4.1. Research on Intelligent Tutoring Systems

The Memphis team and the ARL team will work together to conduct research on ITSs, focusing on three aspects, namely: (1) Trainee Modeling Techniques, (2) Instructional Strategy Selection Techniques, and (3) Authoring Tools and Expert Modeling Techniques. The ARL team will provide an initial ontology for each of the three research thrusts. The Memphis team will modify the ontology throughout this effort based on what they find in the literature and the workshops. Thus, the literature reviews and ontologies will be living documents. The collaborative research

will provide a theoretical guide for each of the expert workshops. Specifically, the objective of the research is to

1. Provide literature reviews for each of the three research thrusts that correspond to the three expert workshops.
2. Provide feedback on GIFT technical documentation.
3. Disseminate research outcomes to the ITS research and development community in the form of academic articles, conference proceedings, and a book series containing a book for each of the three research areas. Publications (academic articles and conference proceedings) derived from this effort will be jointly written between ARL (lead authors) and Memphis (coauthors).
4. Summarize the experimentation and validation component of the project.

4.2. Expert Workshops

Our first objective for the proposed contract will be to plan and host *expert workshops that assess optimal directions for ARL LITE Lab's open-source Generalized Intelligent Framework for Tutors (GIFT).* Drs. Xiangen Hu, Art Graesser, and seven other members of the Memphis team will collaborate with ARL researchers to organize a sequence of three expert workshops.

4.2.1. Overview of the expert workshops

Year 1: Trainee modeling techniques

One expert workshop on *trainee modeling techniques* will focus on cognitive theories of learning, computer implementation, and practical issues of student modeling (i.e., tracking the knowledge, skills, and strategies of students during the course of their learning).

Year 2: Instructional strategy selection techniques

One expert workshop on *instructional strategy selection techniques* will focus on the selection of pedagogical strategies, discourse scaffolding techniques, and tutoring tactics that help students learn.

Year 3: Authoring tools and expert modeling techniques

One expert workshop on *authoring tools and expert modeling techniques* will focus on the extraction of knowledge, skills, and strategies from experts with the hope of capturing this knowledge in digitized databases that can be used by the new generation.

4.2.2. Ensure success of the expert workshops

We plan to take the following four steps to attract experts in the field of learning technology to participate in the workshops at the University of Memphis and thus ensure their success.

Step 1: Selection of times

We will have the workshop during the first two weeks in September. To avoid conflict, we will (1) consider participation of key personnel from the ARL, and (2) avoid major academic/ technical events (such as conferences, trade shows, etc.).

Step 2: Selection of experts

We will select knowledgeable experts based on academic credentials (e.g., recent publications and research grants) and sector representation (e.g., academic, industry, military, and government). We will use three methods to select the participants:

a. Recommendations from ARL, experts in the IIS, and connections with experts at other institutions. The initial seeds of highly influential experts (from each sector) will be selected and asked to participate.
b. Open invitation via existing channels such as the ADL network, professional associations, and relevant conferences.
c. Recommendations of the ARL LITE lab. We will select those who have successfully accomplished relevant R&D work with GIFT.

Step 3: Incentive for participation

Participation of the workshops is invitation only, and efforts will be taken to maximize motivation to attend and participate. Specifically,

a. The workshops will have **high prestige**: The workshops will be co-organized by the ARL (military), ADL (government), and University of Memphis (academia), so they will be high-level workshops.
b. The content of the workshops will be **focused**: The workshops will focus on three major components of GIFT.
c. Participants of the workshops will be **appropriately compensated**: Domestic participants will be allotted $2600 for travel, hotel, and speakers' fees. International participants will be allotted $3600 for travel, hotel, and speakers' fees.
d. Intellectual contributions of the participants will be **published**: We will work with publishers and journal editors to optimize dissemination of articles in high-profile outlets.
e. We expect that participants of the workshops will **continue working with the ARL LITE lab** and the ADL-C-ITS-R&D after the workshops and that this group of experts may support future efforts of the ARL in implementing ITSs in Army training. This may result in long-term collaborations with the ARL and the ADL-C-ITS-R&D.

Step 4: Local support (Memphis)

The Memphis team will allocate appropriate resources (facilities, project management, and administrative) to ensure the success of the workshops.

4.2.3. Expected outcomes for the expert workshops

The workshops will be conducted in the falls of 2012, 2013, and 2014 at the Institute of Intelligent Systems (IIS) located in the FedEx Institute of Technology (FIT) on the campus of the University of Memphis. The last two workshops (2013 and 2014) will likely be held in conjunction with major international conferences such as the International Society for Artificial Intelligence in Education and Education Data Mining.

The expected outcomes of the workshops are as follows:

1. Edited books and web portals for each workshop with contributions from the participants.

2. A set of three documents used for prototype production and publicly available to the research and development community.
3. A report that includes recommendations for the next generation of intelligent learning/training environments.
4. Feedback on the mathematical model/framework.
5. A community that will work with the ARL and ADL Center for ITS R&D, serving as long-term advisory body for future research and development effort.

4.3. Prototype Learning Environment

The Memphis team will assist the ARL team in developing *a prototype learning environment that integrates existing ITSs, such as AutoTutor, in GIFT*. The prototype will integrate capabilities that equal or enhance AutoTutor and AutoTutor Lite into GIFT. The existing systems with computer agents in the IIS at the University of Memphis are well documented and will serve as exemplars for the targeted learning environments. The prototype will include browser-based content presentation, automatic processing and transfer of presentation-based courseware content into GIFT, 21st century human-interaction capabilities (such as agents and virtual humans), and contemporary machine learning techniques that also incorporate data mining methodologies. The prototype will incorporate important insights from the workshops. The final delivery of the prototype will be 2015 (one year after the third workshop), with annual functional deliverables (one month prior to each workshop).

With the assistance of the Memphis team, the ARL team plans on developing a prototype that will integrate capabilities similar to or beyond those now in AutoTutor and AutoTutor Lite into GIFT. To ensure the quality of the prototype, it is important to align production of the prototype with activities in the workshops. Specifically, it is important to **support** the workshop by having demo components of the prototype ready prior to the workshops and making them available to the participants. It is also important to **benefit** from the workshops by incorporating experts' suggestions into the prototype after each workshop. In addition, efforts will be made to encourage participating individuals and organizations to evaluate the prototype or components of the prototype.

4.3.1. Factors for the success of GIFT and AutoTutor integration

The ARL team will bear primary responsibility for the production of the prototypes, with necessary support from the Memphis team. Because the prototype will be an integration of the AutoTutor Framework with the GIFT framework, the Memphis team will be responsible for 37% of the prototyping effort (see Section 4). The Memphis team will pay special attention to the following four factors to ensure success of the GIFT–AutoTutor integration.

1. **Selection of programming/compiling platform:** While we will consider suggestions from the knowledgeable experts who participate in the workshop, we will also consider (1) the software being open-sourced and (2) acceptability by users/developers in the military, government, and academia (researchers). We are not limited by the current implementations of AutoTutor or AutoTutor Lite, so we will be open to adapting better technology.
2. **Selection of programming team for the prototype:** The Memphis team currently has 10 computer scientists (MS or PhD computer science graduates). We will allocate roles to members of the group after considering available resources, the strength of each

researcher's record, and changes in dynamic problem solving. We are open to working with expert teams from other organizations to ensure the highest quality prototype.

3. **Selection of test domain to be used as evaluation:** We will use the prototype to deliver learning in an appropriate domain so the prototype can be objectively evaluated. The selection of the domain/content will be based on the following considerations: (1) existing learning content that has already been delivered with GIFT, (2) existing learning content that already has instances of AutoTutor or AutoTutor Lite, and (3) domain/ content that has existing effective ITS implementations (such as mathematics). A fourth domain for the prototype would be a game-based scenario that can support an individual or small group in the task of land navigation. The Memphis team will select one of the above to implement in AutoTutor Lite and then integrate it with the GIFT framework.
4. **Selection of target population for evaluation of the prototype:** There are four possible populations: (1) test populations that are accessible via connections of the ARL, (2) test populations that are potentially accessible via our partnership with NPRST (http://www.nprst.navy.mil/), and (3) University of Memphis students. We plan to use the University of Memphis student population for the initial pilot study and select one of the above three for the formal evaluation study.

4.3.2. Technical requirements of the prototypes

There will be a total of four iterations of the GIFT-AutoTutor integration environment.

- Each version will be built on the previous versions.
- Each version will incorporate experts' views from the workshops in the previous year.
- Each version will be 100% functional, delivering content in up to three different domains.
- Each version will be independently evaluated by a third-party evaluation team (CREP) and the Memphis team.
- The prototypes will incorporate the most advanced/available server/delivery technologies.
- The prototypes will be open-source and freely available to the U.S. Army and the University of Memphis.
- A full set of design documents and source code will be available to ARL and the University of Memphis.
- Intellectual property ownership from the prototype is up to the agreement between the University of Memphis and the ARL.

4.4. Evaluation of the Prototypes

The Memphis team and the ARL team will collaboratively evaluate the prototypes based on the following four aspects:

1. **Theoretical/formal**: This evaluation effort will be to evaluate the prototype against the formal mathematical model of ITSs (Section 2.4). As an example (Section 2.4.3), we have evaluated AutoTutor against each of the four components. Section 2.4.3 is very brief. We expect the theoretical analysis/evaluation for the prototypes to be at a similar level as Hu & Olney (2004).

2. **Technological**: The evaluation will focus on issues such as
    a. **Standardization** (such as SCORM conformity): This is applicable for each of the three components: trainee modeling, instructional strategy, and authoring & expert modeling. We will be evaluating the five utilities of SCORM.
    b. Technology standards (such as delivery platform): We will evaluate the prototype and determine if the product is using the most recent acceptable technology of the Army (or target customers).
    c. Efficiency of the systems (such as server footprint and client response latency): We will run a simulation (of virtual students) and make sure the algorithms are optimized to remove redundant computation.
3. **Pedagogical/learning science**: This will be closely associated with the domains. Given that we will have three types of testing content (well-defined, ill-defined, and group learning such as land exploration), we will explore access to students' learning gains. The required resources might be limited for a full-scale efficacy study. We will at least run a pilot study with the existing test population that is available to the Memphis team. Specifically, since the target population will be primarily adults, we will create and evaluate the prototypes based on the 25 adult learning principles (available at http://psyc.memphis.edu/learning/whatweknow/index.shtml).
4. **Usability**: We will evaluate user experiences including but not limited to postsession surveys, after-action reviews, and focus groups. We may also consider usability evaluations of the prototypes that include collecting users' data with eye-tracking devices.

To ensure unbiased evaluation, the evaluation effort will be a collaborative effort among the Memphis team, the ARL team, and independent third-party experts. Many of the development projects the Memphis team has produced have been independently evaluated by a third party to avoid biased evaluation. We plan to follow the same principles for the proposed prototypes. We may use the same group, CREP (http://www.memphis.edu/crep/), for this purpose, to the extent that their evaluation methodology is relevant to the proposed research. Each version of the prototype will be independently evaluated with different foci:

- The evaluation focus of the first prototype will be trainee-modeling techniques, consistent with the focus of the prototype (Project 2.1) and expert workshop (Project 1.2).
- The evaluation focus of the second prototype will be instructional strategy selection techniques, consistent with the focus of the prototype (Project 3.2) and expert workshop (Project 2.3).
- The evaluation focus of the third prototype will be authoring tools and expert modeling techniques consistent with the focus of the prototype (Project 4.2) and expert workshop (Project 3.3).

The focus of the evaluation for the final GIFT prototype will be a complete evaluation that will focus on all aspects of the learning technology. Because there are different foci of the prototypes and the relations between the prototypes, the evaluation outcome will be analyzed consistently. In particular, the evaluation of the final GIFT prototype should be comparable with each of the earlier GIFT prototypes.

5. Proposed Task & Responsibility Plan

The ARL/Memphis collaborative effort can be divided into five general categories (outlined in the Appendix): (1) theoretical and technical preparations, (2) expert workshops, (3) AutoTutor GIFT prototypes, (4) evaluations of the prototypes, and (5) final reports. The proposed percentage efforts for the Memphis team and the ARL team are outlined in the task and responsibility matrix in the Appendix. For example, the Memphis team will be responsible for 85% of the expert workshops and 36.67% of the AutoTutor GIFT prototype. The overall weighting of AutoTutor GIFT prototypes is twice as much as other tasks. In addition, the Appendix tables show the allocation of personnel in the Memphis team for each of the subtasks. The task and responsibility matrix shows that the Memphis team will be 59.51% responsible for the entire collaborative effort.

6. Proposed Milestones

Tables and charts of proposed milestones can be viewed in pages K-2–K-10 in the Appendix.

BIOGRAPHICAL SKETCH

NAME: Xiangen Hu **POSITION TITLE: Professor**

RESEARCH AND PROFESSIONAL EXPERIENCE:

Professional Preparation

Huazhong University of Science and Technology, PRC	Applied Mathematics	B.S. 1982
Huazhong University of Science and Technology, PRC	Applied Mathematics	M.S. 1985
University of California, Irvine	Social Sciences	M.A. 1991
University of California, Irvine	Psychology	Ph.D. 1993

Appointments

2009–	Professor of Psychology, The University of Memphis, TN
2004–	Director, ADL Workforce Co-lab, Memphis, TN
2000–2009	Associate Professor of Psychology, The University of Memphis, TN
1993–2000	Assistant Professor of Psychology, The University of Memphis, TN
1986–1987	Lecturer of Mathematics, Huazhong University of Science & Technology, PRC
1985–1986	Assistant Professor of Mathematics, Huazhong University of Science & Technology, PRC

Publications

Of particular relevance

Hu, X., Craig, S. D., Bargagliotti, A. E., Graesser, A. C., Okwumabua, T., Anderson, C., Cheney, K. R., & Sterbinsky, A. (2012). The effects of a traditional and technology-based after-school setting on 6th grade students' mathematics skills. *Journal of Computers in Mathematics and Science Teaching, 31*(1), 17–38.

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Hu, X., & Graesser, A. C. (2004). Human Use Regulatory Affairs Advisor (HURAA): Learning about research ethics with intelligent learning modules. *Behavior Research Methods, Instruments, & Computers, 36*(2), 241–249.

Other publications

Hu, X., Xu, Y., Hall, C., Walker, K., & Okwumabua, T. (in press). A potential technological solution in reducing achievement gap between white and black students. In D. Albert, C. Doble, D. Eppstein, J. Falmagne, & X. Hu (Eds.), *Knowledge spaces: Applications to education*.

Hu, X., Cai, Z., Wiemer-Hastings, P., Graesser, A., & McNamara, D. (2007). Strengths, limitations, and extensions of LSA. In T. Landauer, D. McNamara, S. Dennis, &

W. Kintsch (Eds.), *Handbook of latent semantic analysis* (pp. 401–426). Mahwah, NJ: Erlbaum.

Graesser, A. C., Hu, X., & McNamara, D. S. (2005). Computerized learning environments that incorporate research in discourse psychology, cognitive science, and computational linguistics. In A. F. Healy (Ed.), *Experimental cognitive psychology and its applications: Festschrift in honor of Lyle Bourne, Walter Kintsch, and Thomas Landauer* (pp. 183–194). Washington, DC: American Psychological Association.

Collaborators & Other Affiliations

Collaborators and co-editors

Albert, Dietrich (University of Graz); Bargagliotti, Anna (Loyola Marymount University); Batchelder, William (University of California, Irvine); Cai, Zhiqiang (University of Memphis); Craig, Scotty (University of Memphis); Eppstein, David (University of California, Irvine); Falmagne, Jean-Claude (University of California, Irvine); Fowler, Daniel (Advanced Distributed Learning); Franceschetti, Don (University of Memphis); Garzon, Max (University of Memphis); Gholson, Barry (University of Memphis); Graesser, Art (University of Memphis); Hall, Charles (University of Memphis); Karabatsos, George (University of Illinois-Chicago); Louwerse, Max (University of Memphis); McNamara, Danielle S. (Arizona State University); Okwumabua, Theresa (University of Memphis); Olney, Andrew (University of Memphis); Penumatsa, Phanni (University of Memphis); Person, Natalie (Rhodes College); Riefer, David (California State University, San Bernardino); Smith, Jared (University of California, Irvine); Sullins, Jeremiah (University of Memphis); Ventura, Matthew (ETS); Walker, Kristin (Memphis City Schools); Wiemer-Hastings, Peter (DePaul University); Wilson, William (Shelby County Schools); Wisher, Robert (U.S. Army Research Institute); Xu, Yonghong (University of Memphis)

Graduate advisors

Batchelder, William (University of California, Irvine); Falmagne, Jean-Claude (University of California, Irvine); Indow, Tarow (University of California, Irvine); Luce, Duncan R. (University of California, Irvine)

Thesis advisor and Postgraduate-scholar sponsor for [total advised = 5]:

- Bayen, Ute (Postdoc, Heinrich-Heine Universität Düsseldorf, Germany)
- Chen, Mary (M.S., Capital Group Companies)
- Kellogg, Jeffry (M.S., Marian University)
- Mo, Lun (Ph.D., Memphis City Schools)
- Luellen, Jason (Ph.D., Behavioral Pathway Systems)
- Walker, Kristin (Ph.D., Memphis City Schools)

BIOGRAPHICAL SKETCH

NAME: Arthur C. Graesser POSITION TITLE: Professor

RESEARCH AND PROFESSIONAL EXPERIENCE:

Professional Preparation

Florida State University	Psychology	B.A. 1972
University of California, San Diego	Psychology	Ph.D. 1977 (Chair: George Mandler)

Appointments

2011–	Senior Research Fellow, University of Oxford, U.K.
1985–present	Full Professor, Psychology & Institute for Intelligent Systems, University of Memphis
1985–2010	Co-Director, Institute for Intelligent Systems, University of Memphis
1976–1985	Assistant thru Full Professor, Psychology, California State University, Fullerton

Publications

Of Particular Relevance (recent publications)

D'Mello, S. K., Graesser, A. C., & King, B. (2010). Toward spoken human-computer tutorial dialogues. *Human Computer Interaction, 25*, 289–323.

D'Mello, S., & Graesser, A. C. (2010). Multimodal semi-automated affect detection from conversational cues, gross body language, and facial features. *User Modeling and User-adapted Interaction, 20*, 147–187.

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Hancock, J. T., Beaver, D. I., Chung, C. K., Frazee, J., Pennebaker, J. W., Graesser, A., & Cai, Z. (2010). Social language processing: A framework for analyzing the communication of terrorists and authoritarian regimes. *Behavioral Sciences of Terrorism and Political Aggression, 2,* 108–132.

Other Publications (chronologically ordered)

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review*, *101*, 371–395.

Graesser, A. C., Gernsbacher, M. A., & Goldman, S. (Eds.). (2003). *Handbook of discourse processes*. Mahwah, NJ: Erlbaum.

Wiley, J., Goldman, S. R., Graesser, A. C., Sanchez, C. A., Ash, I. K., & Hemmerich, J. A. (2009). Source evaluation, comprehension, and learning in Internet science inquiry tasks. *American Educational Research Journal, 46,* 1060–1106.

Graesser, A. C., McNamara, D. S., & Kulikowich, J. (2011). Coh-Metrix: Providing multilevel analyses of text characteristics. *Educational Researcher, 40,* 223–234.

Graesser, A. C., & Forsyth, C. (in press). Discourse comprehension. In D. Reisberg (Ed.), *Oxford handbook of cognitive psychology*. Oxford, U.K.: Oxford University Press.

Colleagues Who Have Collaborated During the Last Five Years (not my doctoral students and postdocs)

Roger Azevedo (McGill U), Ryan Baker (WPI), David Beaver (U Texas), Zhiqiang Cai (U Memphis), Cindy Chung (U Texas), Scotty Craig (U Memphis), Don Franceschetti (U Memphis), Barry Gholson (U Memphis), Susan Goldman (U Illinois-Chicago), Doug Hacker (U Utah), Jeff Hancock (Cornell), Xiangen Hu (U Memphis), Pam Jordan (U Pittsburgh), Tom Landauer (KAT), David Lin (U Memphis), Danielle McNamara (Arizona State U), James Pennebaker (U Texas), Roz Picard (MIT), Mercedes Rodrigo (U Philippines), Carolyn Rose (Carnegie Mellon), K. Song (North Korea), Lynn Streeter (KAT), Kurt VanLehn (Arizona State U), Jennifer Wiley (U Illinois-Chicago), Robert Wisher (DoD)

Graduate Advisors: George Mandler, Don Norman, David Rumelhart

Postdoc Advisor for: David Dufty (Taverner, Australia), Jonathan Golding (U Kentucky), Peter Hastings (DePaul U), Christian Hempelmann (Georgia Southern U), Jim Hoeffner (U Michigan), Max Louwerse (U Memphis), Phil McCarthy (U Memphis), Kris Moreno (Microsoft), Tenaha O'Reilly (ETS), Victor Ottati (Loyola U), Yasuhiro Ozuru (U Alaska), Roger Taylor (SUNY Oswego), Rolf Zwaan (Erasmus U, Netherlands)

Doctoral Thesis Advisor for: Bill Baggett (FedEx Research), Eugene Bertus, Cheryl Bowers (Lambuth U), Sidney D'Mello (Notre Dame U), Levy Eymard (FedEx Research), Chris Forsythe (Sandia Labs), Darold Hemphill (SAIC), Tanner Jackson (Arizona State U), Moongee Jeon (Konkuk U, South Korea), Kathy Lang (SAIC), Debra Long (U California-Davis), Shulan Lu (Texas A&M), Joe Magliano (Northern Illinois U), Keith Millis (Northern Illinois U), Heather Mitchell (Lebanon Valley College), Brent Olde (Navy Research Labs), Andrew Olney (U Memphis), Natalie Person (Rhodes College), Shane Swamer, Matthew Ventura (ETS), Shannon Whitten (U Central Florida), Katja Wiemer (Northern Illinois U)

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Graesser, A. C., Chipman, P., Haynes, B., & Olney, A. (2005). AutoTutor: An intelligent tutoring system with mixed-initiative dialogue. *IEEE Transactions on Education, 48*(4), 612–618.

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Graesser, A. C., D'Mello, S. K., Hu. X., Cai, Z., Olney, A., & Morgan, B. (2012). AutoTutor. In P. McCarthy & C. Boonthum-Denecke (Eds.), *Applied natural language processing: Identification, investigation, and resolution* (pp. 169–187). Hershey, PA: IGI Global.

Graesser, A. C., Hu, X., & McNamara, D. (2005). Computerized learning environments that incorporate research in discourse psychology, cognitive science, and computational linguistics. In A. Healy (Ed.), *Experimental cognitive psychology and its applications: Festschrift in Honor of Lyle Bourne, Walter Kintsch, and Thomas Landauer* (pp. 183–194). Washington, DC: American Psychological Association.

Graesser, A. C., Jeon, M., & Dufty, D. (2008). Agent technologies designed to facilitate interactive knowledge construction. *Discourse Processes, 45*, 298–322.

Graesser, A. C., Lu, S., Jackson, G. T., Mitchell, H., Ventura, M., Olney, A., & Louwerse, M. M. (2004). AutoTutor: A tutor with dialogue in natural language. *Behavioral Research Methods, Instruments, and Computers, 36*, 180–193.

Graesser, A. C., Lu, S., Olde, B. A., Cooper-Pye, E., & Whitten, S. (2005). Question asking and eye tracking during cognitive disequilibrium: Comprehending illustrated texts on devices when the devices break down. *Memory and Cognition, 33*, 1235–1247.

Graesser, A. C., & McNamara, D. S. (2010). Self-regulated learning in learning environments with pedagogical agents that interact in natural language. *Educational Psychologist, 45*, 234–244.

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Graesser, A. C., Olney, A. M., Haynes, B. C., & Chipman, P. (2005). AutoTutor: A cognitive system that simulates a tutor that facilitates learning through mixed-initiative dialogue. In C. Forsythe, M. L. Bernard, & T. E. Goldsmith (Eds.), *Cognitive systems: Human cognitive models in systems design*. Mahwah, NJ: Lawrence Erlbaum.

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VanLehn, K., Graesser, A. C., Jackson, G. T., Jordan, P., Olney, A., & Rose, C. P. (2007). When are tutorial dialogues more effective than reading? *Cognitive Science, 31*, 3–62.

Woolf, B. (2009). *Building intelligent interactive tutors*. Burlington, MA: Morgan Kaufmann.

CURRENT AND PENDING SUPPORT

The following information should be provided for each investigator and other senior personnel. Failure to provide the information may delay consideration of the proposal.

Investigator: Xiangen Hu

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Applications of Intelligent Tutoring Systems (ITS) in Improving the Skill Levels of Students with Deficiencies in Mathematics

Source of Support: Institute of Education Sciences
Award Amount (or Annual Rate:) $ 2,322,310 Period Covered: 7/1/09–6/30/13
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: 1 Summer: 1

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Virtual Civilian Aeromedical Evacuation Sustainment Training (V-CAEST)

Source of Support: DOD-TATRC
Award Amount (or Annual Rate:) $ 1,397,856 Period Covered: 9/1/11–8/31/13
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: 2 Summer: 1

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Shareable Knowledge Objects (SKO) as Enhanced, Portable ITS Modules

Source of Support: ONR
Award Amount (or Annual Rate:) $ 1,477,402 Period Covered: 7/12-6/14
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: 2.25 Summer: 1

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Generalized Intelligent Framework for Tutors (GIFT)

Source of Support: ARL
Award Amount (or Annual Rate:) $ 218,610 Period Covered: 5/12-12/12
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: .45 Summer: 0.24

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Generalized Intelligent Framework for Tutors (GIFT)

Source of Support: ARL
Award Amount (or Annual Rate:) $ 1,292,365 Period Covered: 1/13-12/16 [option years]
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: 1 Summer: .24

* If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

CURRENT AND PENDING SUPPORT

The following information should be provided for each investigator and other senior personnel. Failure to provide the information may delay consideration of the proposal.

Investigator: Arthur C. Graesser

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Guru: A computer tutor that models expert human tutors

Source of Support: Institute of Education Sciences
Award Amount (or Annual Rate:) $ 1,858,176 Period Covered: 7/1/08–6/30/12
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: 1 Summer:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Inducing, tracking, and regulating confusion and cognitive disequilibrium during complex learning

Source of Support: NSF
Award Amount (or Annual Rate:) $ 420,000 Period Covered: 5/09-4/12
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: Summer: .5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: NSCC/LA: Modeling discourse and social dynamics in authoritarian regimes

Source of Support: NSF
Award Amount (or Annual Rate:) $ 581,999 Period Covered: 1/09-12/12
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: Summer: .5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Applications of intelligent tutoring systems (ITS) to improve the skill levels of students with deficiencies in mathematics

Source of Support: IES
Award Amount (or Annual Rate:) $ 2,322,310 Period Covered: 7/09-6/13
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: 1 Summer:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: DeepTutor: An intelligent tutoring system based on deep language and discourse processing and advanced tutoring strategies

Source of Support: IES
Award Amount (or Annual Rate:) $ 1,650,272 Period Covered: 7/10-6/13
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: .5 Summer: .5

* If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

CURRENT AND PENDING SUPPORT

The following information should be provided for each investigator and other senior personnel. Failure to provide the information may delay consideration of the proposal.

Investigator: Arthur C. Graesser, page 2

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Shareable Knowledge Objects (SKO) as Enhanced, Portable ITS Modules

Source of Support: ONR
Award Amount (or Annual Rate:) $ 218,610 Period Covered: 7/12-6/14
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: 1.44 Summer: .5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: AutoMentor: Virtual mentoring and assessment in computer games for STEM learning

Source of Support: NSF (subcontract from U. Wisconsin)
Award Amount (or Annual Rate:) $ 742,248 Period Covered: 9/09-8/14
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: Summer: .5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Beyond Boredom: Modeling and Promoting Engagement during Complex Learning

Source of Support: NSF
Award Amount (or Annual Rate:) $ 1,263,875 Period Covered: 7/11-6/14
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: Summer: .5

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Generalized Intelligent Framework for Tutors (GIFT)

Source of Support: ARL
Award Amount (or Annual Rate:) $ 218,610 Period Covered: 5/12-12/12
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: Summer: .06

Support: ☐ Current ☒ Pending ☐ Submission Plannedin Near Future ☐ *Transfer of Support

Project/Proposal Title: Generalized Intelligent Framework for Tutors (GIFT)

Source of Support: ARL
Award Amount (or Annual Rate:) $ 1,292,365 Period Covered: 1/13-12/16 [option years]
Location of Research: University of Memphis
Person-Months Committed to the Project: Cal: Acad: .54 Summer: .5

* If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

USE ADDITIONAL SHEETS AS NECESSARY

FACILITIES, EQUIPMENT, AND OTHER RESOURCES

Advanced Distributed Learning Center for Intelligent Tutoring Systems Research and Development (ADL-CITSRD)

The ADL-CITSRD (http://www.memphis.edu/mitsc/) facilitates the research required to address the training challenges faced by the military, government, academia, and the workforce both now and in the future. The best way to meet these challenges is through the applied use to of learning technologies (e.g., natural dialogue systems, intelligent tutoring systems). To this end, ADL-CITSRD researchers have extensive experience in research, development, and evaluation of advanced learning environments. Further, ADL-CITSRD seeks to establish an inclusive and dynamic research environment by welcoming outside researchers and policy makers with similar goals to help us accomplish our mission. Our primary research and development focus are complex learning environments. Our activities range from basic research (cognitive psychology of learning and memory) to software development (Intelligent Tutoring Systems).

Institute for Intelligent Systems (IIS)

The faculty, staff, and students working on this project are members of the Institute for Intelligent Systems (IIS, fedex.memphis.edu/iis/), which is housed in the FedEx Institute of Technology (FIT) building on the campus of the University of Memphis. The IIS is fundamentally an interdisciplinary enterprise, with courses, seminars, and research projects that include 36 faculty, 7 postdoctoral fellows, and approximately 100 students from different departments. The most active departments and colleges are psychology, computer science, education, English, and engineering. The IIS has a full-time administrative secretary, a grants finance manager, a computer programmer, and an experimental psychologist to assist with the projects in the IIS.

FedEx Institute of Technology

The FedEx Institute of Technology is a state-of-the-art building designed to include projects that teach the newest technologies, using the most advanced learning techniques. The IIS occupies approximately 30% of the 88,000 square foot building and has a large collaborative space with 32 workstations, 4 partitioned offices, a large meeting room, and some seating areas for impromptu meetings (3500 sq ft). This space has 20 high-end workstations, 12 high-end laptops, 4 multimedia networked projectors, and 8 servers. There also are 8 additional rooms or offices for seminars, research meetings, IIS faculty, the full-time staff, an eye tracking laboratory, and an emotions computing lab. All of this space is directly assigned to the researchers on this project.

The FedEx building itself has a unique DS3 with copper and fiber feed along with a separate Fiber and Laser Link for redundancy. Every floor of the building has 10GB connection with 100MB to each desktop that can be expanded to 350MB. In addition to the hard-line Ethernet, the FedEx Institute has 802.11b wireless local area network that can support 802.11g. The FedEx Institute has its own server room with 400KVA generator and EPC UPS backup system. This backup system also offers redundancy for the network infrastructure.

In addition to this space in the FedEx building, there are offices and laboratories for each of the faculty members in the buildings of their home departments. When considering all of the

faculty members on this grant, there is approximately 2500 sq. ft. of office and laboratory space (in addition to the FedEx facility).

The University of Memphis
The University of Memphis is the State of Tennessee Connector site for the Internet2 research network and the Internet2 connector for the state of Tennessee. The University operates a state-of-the-art data network with over 17,000 nodes which provides connectivity to the main and regional campuses and facilities, the Internet, and experimental high-performance national research networks (e.g., I2). The University is currently working with Oak Ridge National Laboratory (ORNL) to develop a statewide 10 Gbps optical network for research that will extend the ORNL network across Tennessee.

High Performance Computing Facility
The University of Memphis High Performance Computing Facility, available to all faculty and staff, is dedicated to supporting computationally intensive research. The facility consists of a Beowulf (Linux) cluster of 133 nodes with 8-16 processors and 32-128GB of RAM each. There is also a GPU cluster of 8 nodes with 8 processors, 16GB RAM, and 480 GPU processors each, for a total of 3840 GPU processors. The clustered sub-system is rated at about 11.8 TFlops and the GPU cluster has a theoretical peak performance of 16 TFlops. The entire system has a theoretical peak performance of almost 28 TFlops.

Psychology Department
The Psychology Building has a computer lab with 15 Dell computers dedicated to running participants in experiments in cognition and learning. There is a full-time computer technician in the psychology department who is available when computer equipment needs to be assembled and when equipment breaks down. There is a subject pool in the psychology department for running participants in experiments. Students participate for extra course credit and for satisfying a research participation requirement (with a paper option for those who prefer not to participate).

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PROPOSAL BUDGET

YEAR- 1

OFFEROR The University of Memphis

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR (PI/PD) Xiangen Hu, Ph.D.

A. SENIOR PERSONNEL, PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in parentheses)	Man Hrs/Mo	Rates	-Mos CAL	-Mos ACAD	-Mos SMR	Funds Requested by Offeror
1. Xiangen Hu, Professor				0.45	0.24	6,118.00
2. Art Graesser, Professor				0.18		3,894.00
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION)						
7. (2) TOTAL SENIOR PERSONNEL (1-6)						10,012.00
B. OTHER PERSONNEL (SHOW NUMBERS IN PARENTHESES)						
1. ( ) POST DOCTORAL ASSOCIATES						
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)						
3. ( ) GRADUATE STUDENTS						
4. ( ) UNDERGRADUATE STUDENTS						
5. ( ) SECRETARIAL - CLERICAL (If charged directly)						
6. (1) OTHER Project Assistant 6 calendar months						14,500.00
7. TOTAL SALARIES AND WAGES (A + B)						24,512.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						8,261.00
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						32,773.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.00. ATTACH ADDITIONAL EXPLANATION PAGES, IF NECESSARY.)						
A Mac Pro configured on store.apple.com is priced at $4999 and includes the following specifications: two 2.66GHz 6-Core Intel Xeon "Westmere" (12 cores), 6GB (6X1GB), 1TB 7200-rpm Serial ATA 3Gb/s hard drive, ATI Radeon HD 5770 1GB, One 18x SuperDrive, Apple Magic Mouse, and Apple Keyboard with Numeric Keypad (English) & User's Guide.						
TOTAL PERMANENT EQUIPMENT						5,000.00
E. TRAVEL (LIST ON BUDGET EXPLANATION PAGE)						
1. DOMESTIC (INCLUDE CANADA, MEXICO, AND U.S. POSSESSIONS)						5,000.00
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $						
2. TRAVEL						
3. SUBSISTENCE						
4. OTHER						
(30) TOTAL PARTICIPANT COSTS						96,900.00
G. OTHER DIRECT COSTS (ITEMIZE ON BUDGET EXPLANATION PAGE)						
1. MATERIALS AND SUPPLIES						
2. PUBLICATIONS COSTS/DOCUMENTATION/DISSEMINATION						
3. CONSULTANT SERVICES						45,000.00
4. COMPUTER (ADPE) SERVICES						
5. SUBAWARDS						
6. OTHER						
7. TOTAL OTHER DIRECT COSTS						151,900.00
H. TOTAL DIRECT COSTS (A THROUGH G)						184,673.00

I. INDIRECT COSTS		Rate	Base	Total	
	Overhead	0.41	82,773	33,937	
	G&A				
	Fringe				
TOTAL INDIRECT COSTS	FCCM				33,937.00

J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	218,610.00
K. FEE (%) BASE $	
L. COST SHARING	
M. AMOUNT OF THIS REQUEST	218,610.00

PI/PD NAME (TYPED) & SIGNATURE	DATE
OFFEROR'S AUTHORIZED REP. NAME (TYPED) & SIGNATURE	DATE

PROPOSAL BUDGET

YEAR- Option 1

OFFEROR The University of Memphis

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR (PI/PD) Xiangen Hu, Ph.D.

A. SENIOR PERSONNEL, PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in parentheses)	Man Hrs/Mo	Rates	-Mos CAL	-Mos ACAD	-Mos SMR	Funds Requested by Offeror
1. Xiangen Hu, Professor			1.0	0.25		10,905.00
2. Art Graesser, Professor			0.5	0.5		22,713.00
3. Andrew Olney, Assistant Professor			0.5	0.5		8,797.00
4. Vasile Rus, Associate Professor			0.5	0.5		10,331.00
5. Trey Martindale, Associate Professor			0.36	0.5		5,238.00
6. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION)			0.5	0.25		5,802.00
7. (6) TOTAL SENIOR PERSONNEL (1-6)						63,786.00
B. OTHER PERSONNEL (SHOW NUMBERS IN PARENTHESES)						
1. ( ) POST DOCTORAL ASSOCIATES						
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)						
3. ( ) GRADUATE STUDENTS						
4. ( ) UNDERGRADUATE STUDENTS						
5. ( ) SECRETARIAL - CLERICAL (If charged directly)						
6. (1) OTHER Project Assistant 6 calendar months						14,500.00
7. TOTAL SALARIES AND WAGES (A + B)						78,286.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						26,382.00
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						104,668.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.00. ATTACH ADDITIONAL EXPLANATION PAGES, IF NECESSARY.)						
TOTAL PERMANENT EQUIPMENT						
E. TRAVEL (LIST ON BUDGET EXPLANATION PAGE)						
1. DOMESTIC (INCLUDE CANADA, MEXICO, AND U.S. POSSESSIONS)						5,000.00
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $						
2. TRAVEL						
3. SUBSISTENCE						
4. OTHER						
(30) TOTAL PARTICIPANT COSTS						96,900.00
G. OTHER DIRECT COSTS (ITEMIZE ON BUDGET EXPLANATION PAGE)						
1. MATERIALS AND SUPPLIES						
2. PUBLICATIONS COSTS/DOCUMENTATION/DISSEMINATION						1,500.00
3. CONSULTANT SERVICES						66,000.00
4. COMPUTER (ADPE) SERVICES						
5. SUBAWARDS						
6. OTHER						20,000.00
7. TOTAL OTHER DIRECT COSTS						189,400.00
H. TOTAL DIRECT COSTS (A THROUGH G)						294,068.00
I. INDIRECT COSTS		Rate	Base	Total		
	Overhead	.41	197,168	80,839		
	G&A					
	Fringe					
TOTAL INDIRECT COSTS	FCCM					80,839.00
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						374,907.00
K. FEE (%) BASE $						
L. COST SHARING						
M. AMOUNT OF THIS REQUEST						374,907.00

PI/PD NAME (TYPED) & SIGNATURE	DATE
OFFEROR'S AUTHORIZED REP. NAME (TYPED) & SIGNATURE	DATE

PROPOSAL BUDGET

YEAR- Option 2

OFFEROR The University of Memphis

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR (PI/PD) Xiangen Hu, Ph.D.

A. SENIOR PERSONNEL, PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in parentheses)	Man Hrs/Mo	Rates	-Mos CAL	-Mos ACAD	-Mos SMR	Funds Requested by Offeror
1. Xiangen Hu			1.0	0.5		13,697.00
2. Art Graesser			0.5	0.5		23,394.00
3. Andrew Olney			0.5	0.5		9,061.00
4. Vasile Rus			0.5	0.5		10,640.00
5. Trey Martindale			0.36	0.25		7,823.00
6. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION)			0.5	0.25		8,046.00
7. (6) TOTAL SENIOR PERSONNEL (1-6)						72,661.00
B. OTHER PERSONNEL (SHOW NUMBERS IN PARENTHESES)						
1. ( ) POST DOCTORAL ASSOCIATES						
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)						
3. ( ) GRADUATE STUDENTS						
4. ( ) UNDERGRADUATE STUDENTS						
5. ( ) SECRETARIAL - CLERICAL (If charged directly)						
6. (X) OTHER Project Assistant 6 calendar months						14,935.00
7. TOTAL SALARIES AND WAGES (A + B)						87,596.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						29,520.00
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						117,116.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.00. ATTACH ADDITIONAL EXPLANATION PAGES, IF NECESSARY.)						
TOTAL PERMANENT EQUIPMENT						
E. TRAVEL (LIST ON BUDGET EXPLANATION PAGE)						
1. DOMESTIC (INCLUDE CANADA, MEXICO, AND U.S. POSSESSIONS)						5,000.00
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $						
2. TRAVEL						
3. SUBSISTENCE						
4. OTHER						
(30) TOTAL PARTICIPANT COSTS						96,900.00
G. OTHER DIRECT COSTS (ITEMIZE ON BUDGET EXPLANATION PAGE)						
1. MATERIALS AND SUPPLIES						
2. PUBLICATIONS COSTS/DOCUMENTATION/DISSEMINATION						1,500.00
3. CONSULTANT SERVICES						46,000.00
4. COMPUTER (ADPE) SERVICES						
5. SUBAWARDS						
6. OTHER						20,000.00
7. TOTAL OTHER DIRECT COSTS						169,400.00
H. TOTAL DIRECT COSTS (A THROUGH G)						285,516.00
I. INDIRECT COSTS		Rate	Base	Total		
	Overhead	.41	189,616	77,743		
	G&A					
	Fringe					
TOTAL INDIRECT COSTS	FCCM					77,743.00
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						364,259.00
K. FEE (%) BASE $						
L. COST SHARING						
M. AMOUNT OF THIS REQUEST						364,259.00

PI/PD NAME (TYPED) & SIGNATURE	DATE
OFFEROR'S AUTHORIZED REP. NAME (TYPED) & SIGNATURE	DATE

Submit by Email | Print Form

PROPOSAL BUDGET

YEAR- Option 3

OFFEROR The University of Memphis

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR (PI/PD) Xiangen Hu, Ph.D.

A. SENIOR PERSONNEL, PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in parentheses)	Man Hrs/Mo	Rates	-Mos CAL	-Mos ACAD	-Mos SMR	Funds Requested by Offeror
1. Xiangen Hu			1.5	0.5		14,667.00
2. Art Graesser			0.5	0.5		24,096.00
3. Andrew Olney			0.5	0.5		9,333.00
4. Vasile Rus			0.5	0.5		10,959.00
5. Phil Pavlik			0.5	0.25		8,287.00
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION)						
7. (5) TOTAL SENIOR PERSONNEL (1-6)						67,342.00
B. OTHER PERSONNEL (SHOW NUMBERS IN PARENTHESES)						
1. ( ) POST DOCTORAL ASSOCIATES						
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)						
3. ( ) GRADUATE STUDENTS						
4. ( ) UNDERGRADUATE STUDENTS						
5. ( ) SECRETARIAL - CLERICAL (If charged directly)						
6. (1) OTHER Project Assistant 6 calendar months						15,383.00
7. TOTAL SALARIES AND WAGES (A + B)						82,725.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						27,878.00
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						110,603.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.00. ATTACH ADDITIONAL EXPLANATION PAGES, IF NECESSARY.)						
TOTAL PERMANENT EQUIPMENT						
E. TRAVEL (LIST ON BUDGET EXPLANATION PAGE)						
1. DOMESTIC (INCLUDE CANADA, MEXICO, AND U.S. POSSESSIONS)						5,000.00
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $						
2. TRAVEL						
3. SUBSISTENCE						
4. OTHER						
( ) TOTAL PARTICIPANT COSTS						
G. OTHER DIRECT COSTS (ITEMIZE ON BUDGET EXPLANATION PAGE)						
1. MATERIALS AND SUPPLIES						
2. PUBLICATIONS COSTS/DOCUMENTATION/DISSEMINATION						1,500.00
3. CONSULTANT SERVICES						46,000.00
4. COMPUTER (ADPE) SERVICES						
5. SUBAWARDS						
6. OTHER						20,000.00
7. TOTAL OTHER DIRECT COSTS						72,500.00
H. TOTAL DIRECT COSTS (A THROUGH G)						183,103.00
I. INDIRECT COSTS — Overhead		Rate 0.41	Base 183,103	Total 75,072		
G&A						
Fringe						
TOTAL INDIRECT COSTS — FCCM						75,072.00
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						258,175.00
K. FEE (%) BASE $						
L. COST SHARING						
M. AMOUNT OF THIS REQUEST						258,175.00

PI/PD NAME (TYPED) & SIGNATURE	DATE
OFFEROR'S AUTHORIZED REP. NAME (TYPED) & SIGNATURE	DATE

PROPOSAL BUDGET

YEAR- Option 4

OFFEROR The University of Memphis

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR (PI/PD) Xiangen Hu, Ph.D.

A. SENIOR PERSONNEL, PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in parentheses)	Man Hrs/Mo	Rates	-Mos CAL	-Mos ACAD	-Mos SMR	Funds Requested by Offeror
1. Xiangen Hu				1.5	0.5	15,717.00
2. Art Graesser				0.5	0.5	24,819.00
3. Andrew Olney				0.5	0.5	9,613.00
4. Vasile Rus				0.5	0.5	11,288.00
5. Phil Pavlik				0.5	0.25	8,536.00
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION)						
7. (5) TOTAL SENIOR PERSONNEL (1-6)						69,973.00
B. OTHER PERSONNEL (SHOW NUMBERS IN PARENTHESES)						
1. ( ) POST DOCTORAL ASSOCIATES						
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)						
3. ( ) GRADUATE STUDENTS						
4. ( ) UNDERGRADUATE STUDENTS						
5. ( ) SECRETARIAL - CLERICAL (If charged directly)						
6. (1) OTHER Project Assistant 6 calendar months						15,844.00
7. TOTAL SALARIES AND WAGES (A + B)						85,817.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						28,920.00
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						114,737.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.00. ATTACH ADDITIONAL EXPLANATION PAGES, IF NECESSARY.)						
TOTAL PERMANENT EQUIPMENT						
E. TRAVEL (LIST ON BUDGET EXPLANATION PAGE)						
1. DOMESTIC (INCLUDE CANADA, MEXICO, AND U.S. POSSESSIONS)						5,000.00
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $						
2. TRAVEL						
3. SUBSISTENCE						
4. OTHER						
( ) TOTAL PARTICIPANT COSTS						
G. OTHER DIRECT COSTS (ITEMIZE ON BUDGET EXPLANATION PAGE)						
1. MATERIALS AND SUPPLIES						
2. PUBLICATIONS COSTS/DOCUMENTATION/DISSEMINATION						1,500.00
3. CONSULTANT SERVICES						66,000.00
4. COMPUTER (ADPE) SERVICES						
5. SUBAWARDS						
6. OTHER						20,000.00
7. TOTAL OTHER DIRECT COSTS						92,500.00
H. TOTAL DIRECT COSTS (A THROUGH G)						207,237.00

I. INDIRECT COSTS		Rate	Base	Total
	Overhead	.41	207,237	84,967
	G&A			
	Fringe			
TOTAL INDIRECT COSTS	FCCM			84,967.00

J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	292,204.00
K. FEE (%) BASE $	
L. COST SHARING	
M. AMOUNT OF THIS REQUEST	292,204.00

PI/PD NAME (TYPED) & SIGNATURE	DATE
OFFEROR'S AUTHORIZED REP. NAME (TYPED) & SIGNATURE	DATE

PROPOSAL BUDGET

YEAR- Summary

OFFEROR The University of Memphis

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR (PI/PD) Xiangen Hu, Ph.D.

A. SENIOR PERSONNEL, PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A 7 show number in parentheses)	Man Hrs/Mo	Rates	-Mos CAL	-Mos ACAD	-Mos SMR	Funds Requested by Offeror
1. Xiangen Hu						61,104.00
2. Art Graesser						98,916.00
3. Andrew Olney						36,804.00
4. Vasile Rus						43,218.00
5. Trey Martindale						13,061.00
6. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION)						30,671.00
7. (6) TOTAL SENIOR PERSONNEL (1-6)						283,774.00
B. OTHER PERSONNEL (SHOW NUMBERS IN PARENTHESES)						
1. ( ) POST DOCTORAL ASSOCIATES						
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)						
3. ( ) GRADUATE STUDENTS						
4. ( ) UNDERGRADUATE STUDENTS						
5. ( ) SECRETARIAL - CLERICAL (If charged directly)						
6. ( ) OTHER						75,162.00
7. TOTAL SALARIES AND WAGES (A + B)						358,936.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						120,961.00
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						479,897.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.00. ATTACH ADDITIONAL EXPLANATION PAGES, IF NECESSARY.)						
TOTAL PERMANENT EQUIPMENT						5,000.00
E. TRAVEL (LIST ON BUDGET EXPLANATION PAGE)						
1. DOMESTIC (INCLUDE CANADA, MEXICO, AND U.S. POSSESSIONS)						25,000.00
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $						
2. TRAVEL						
3. SUBSISTENCE						
4. OTHER						
(30) TOTAL PARTICIPANT COSTS						290,700.00
G. OTHER DIRECT COSTS (ITEMIZE ON BUDGET EXPLANATION PAGE)						
1. MATERIALS AND SUPPLIES						
2. PUBLICATIONS COSTS/DOCUMENTATION/DISSEMINATION						6,000.00
3. CONSULTANT SERVICES						269,000.00
4. COMPUTER (ADPE) SERVICES						
5. SUBAWARDS						
6. OTHER						80,000.00
7. TOTAL OTHER DIRECT COSTS						675,700.00
H. TOTAL DIRECT COSTS (A THROUGH G)						1,155,597.00
I. INDIRECT COSTS		Rate	Base	Total		
	Overhead	.41	859,897	352,558		
	G&A					
	Fringe					
TOTAL INDIRECT COSTS	FCCM					352,558.00
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						1,508,155.00
K. FEE (%) BASE $						
L. COST SHARING						
M. AMOUNT OF THIS REQUEST						1,508,155.00

PI/PD NAME (TYPED) & SIGNATURE
Xiangen Hu

DATE 03/20/2012

OFFEROR'S AUTHORIZED REP. NAME (TYPED) & SIGNATURE
Catrina Sullivan Catrina Sullivan

DATE 03/20/2012

Narrative Budget Justification: Year 1 (5/1/12–12/31/15)

Generalized Intelligent Framework for Tutors (GIFT)

PI: Dr. Xiangen Hu, The University of Memphis

Salaries & Wages

Faculty

Salaries and wages are based on current salaries and level of effort on the project. Annual salary increases for all faculty, staff, and students will be assessed at 3% per year.

Dr. Xiangen Hu (PI) is a Professor in the Institute for Intelligent Systems (IIS) and Department of Psychology at the University of Memphis. He requests 5% academic year (AY) time and 8% summer support to oversee all aspects of the research proposed for this contract.

Dr. Art Graesser (Co-PI) is a Professor in the Department of Psychology and the Institute for Intelligent Systems at the University of Memphis and is a Senior Research Fellow in the Department of Education at the University of Oxford. He requests 2% AY time to configure the technical content of the planned workshop and begin preliminary work on the prototype learning environment.

Other Staff

We request 50% calendar year effort for a **Project Assistant (TBN)** who will handle the complex workshop planning logistics, coordinate travel for the workshop attendees, arrange honorarium payments, handle overall technology project task management, and provide day-to-day program support for the research team.

Fringe Benefits

Fringe benefits are calculated at 33.7% for all salaried employees.

Travel

Funds for *domestic travel* are requested for the PI to travel to the Army Research Lab once at an estimated cost of $2000/trip including airfare, hotel, and per diem. Funds are also requested for the PI to present the research findings at one domestic academic conference, at an estimated cost of $3000/trip including conference fees, airfare, hotel, and per diem.

Equipment

Equipment funds are needed to purchase one software development workstation, which will be used specifically for prototype development over the course of the project. A Mac Pro configured on store.apple.com is priced at $4999 and includes the following specifications: two 2.66GHz 6-Core Intel Xeon “Westmere” (12 cores), 6GB (6X1GB), 1TB 7200-rpm Serial ATA 3Gb/s hard drive, ATI Radeon HD 5770 1GB, One 18x SuperDrive, Apple Magic Mouse, and Apple Keyboard with Numeric Keypad (English) & User’s Guide.

Consultants

Funds for *technology assistance* are requested to hire a professional software production team for 750 hours at the University of Memphis. The team is needed to work on the prototype learning environment. The software production team will bill $60/hour for their technical services.

Participant Support

Funds for *domestic participant travel, hotel, and speakers' fees* ($2600/person x 15 people) are requested to offset travel and hotel costs for domestic workshop attendees. This budget line item is excluded from calculation of the indirect cost rate.

Funds for *international participant travel, hotel, and speakers' fees* ($3600/person x 15 people) are requested to offset travel and hotel costs for international workshop attendees. This budget line item is excluded from calculation of the indirect cost rate.

We request $3900 for *facilities and catering fees* ($65/person x 30 people x 2 days) to host an expert workshop on trainee modeling techniques. Because this is a two-day intensive workshop, it will be more efficient to cater breakfast, lunch, and snacks to the meeting site on campus. These meals will be provided in lieu of a per diem. This budget line item is excluded from calculation of the indirect cost rate.

Indirect Costs

Indirect costs are calculated at 41.0% of MTDC. The cognizant federal agency for the agreement is the U.S. Department of Health and Human Services (DHHS). Tuition, equipment, participant support, and workshop costs are excluded from the indirect cost rate.

Narrative Budget Justification: Option Years (1/1/13–12/31/16)

Generalized Intelligent Framework for Tutors (GIFT)

PI: Dr. Xiangen Hu, The University of Memphis

Salaries & Wages

Faculty

Salaries and wages are based on current salaries and level of effort on the project. Annual salary increases for all faculty, staff, and students will be assessed at 3% per year.

Dr. Xiangen Hu (PI) is a Professor in the Institute for Intelligent Systems (IIS) and Department of Psychology at the University of Memphis. He requests 11% academic year (AY) time and 8% summer support in Year 1, 11% AY and 17% summer in Year 2, and 17% AY and 17% summer in Years 3 and 4 to oversee all aspects of the research proposed for this contract.

Dr. Art Graesser (Co-PI) is a Professor in the Department of Psychology and the Institute for Intelligent Systems at the University of Memphis and is a Senior Research Fellow in the Department of Education at the University of Oxford. He requests 6% AY and 17% summer support in all years to configure the technical content of the planned workshop and work on the prototype learning environment.

Dr. Andrew Olney (Co-PI) is an Assistant Professor in the Department of Psychology, Associate Director of the Institute for Intelligent Systems, and PI on the IES-funded Guru ITS grant. He requests 6% AY and 17% summer support to work on the proposed research as an AutoTutor expert.

Dr. Vasile Rus (Senior Researcher) is an Associate Professor in the Department of Computer Science and the Institute for Intelligent Systems at the University of Memphis. Dr. Rus is also PI on the IES-funded DeepTutor grant. He requests 6% AY and 17% summer support to work on the proposed research as an AutoTutor expert.

Dr. Trey Martindale (Senior Researcher) is an Associate Professor and Program Coordinator for Instructional Design and Technology in the College of Education, Health and Human Sciences and the Institute for Intelligent Systems at the University of Memphis. Dr. Martindale requests 4% AY and 8% summer support in Years 1 and 2 to work on the proposed research as an instructional design specialist.

Dr. Phil Pavlik (Senior Researcher) is an Assistant Professor in the Department of Psychology and the Institute for Intelligent Systems at the University of Memphis. Dr. Pavlik requests 6% AY and 8% summer support to work on the proposed research as a learning technology specialist.

Other Staff

We request 50% calendar year effort for a **Project Assistant (TBN)** who will handle the complex workshop planning logistics, coordinate travel for the workshop attendees, arrange honorarium payments, handle overall technology project task management, and provide day-to-day program support for the research team.

Fringe Benefits

Fringe benefits are calculated at 33.7% for all salaried employees.

Travel

Funds for *domestic travel* are requested for the PI to travel to the Army Research Lab once each year at an estimated cost of $2000/trip including airfare, hotel, and per diem. Travel funds are also requested for the PI to present research findings at one domestic academic conference each year, at an estimated cost of $3000/trip including conference fees, airfare, hotel, and per diem.

Consultants

We request *consultant fees* to hire Dr. Natalie Person of Rhodes College for two weeks each year.

Funds for *technology assistance* are requested to hire a professional software production team for 1000 hours/year at the University of Memphis. The team is needed to work on the prototype learning environment. The software production team will bill $60/hour for their technical services.

Fees for 10 *expert advisors* ($2000/person) are requested for additional ITS support in Year 4.

Participant Support

Funds for *domestic participant travel, hotel, and speakers' fees* ($2600/person x 15 people) are requested to offset travel and hotel costs for domestic workshop attendees in Years 1 and 2. This budget line item is excluded from calculation of the indirect cost rate.

Funds for *international participant travel, hotel, and speakers' fees* ($3600/person x 15 people) are requested to offset travel and hotel costs for international workshop attendees in Years 1 and 2. This budget line item is excluded from calculation of the indirect cost rate.

We request $3900 for *facilities and catering fees* ($65/person x 30 people x 2 days) to host an expert workshop on trainee modeling techniques in Years 1 and 2. Because this is a two-day intensive workshop, it will be more efficient to cater breakfast, lunch, and snacks to the meeting site on campus. These meals will be provided in lieu of a per diem. This budget line item is excluded from calculation of the indirect cost rate.

Other Direct Costs

In all years, the created prototype learning environments will require evaluation by the Memphis team and third-party entities such as the Center for Research in Educational Policy (CREP).

Publication funds are requested to cover the cost of submitting academic papers to journals.

Indirect Costs

Indirect costs are calculated at 41.0% of MTDC. The cognizant federal agency for the agreement is the U.S. Department of Health and Human Services (DHHS). Tuition, equipment, participant support, and workshop costs are excluded from the indirect cost rate.

APPLICATION FOR FEDERAL ASSISTANCE

SF 424 (R&R)

2. DATE SUBMITTED	Applicant Identifier
3. DATE RECEIVED BY STATE	**State Application Identifier**

1. * TYPE OF SUBMISSION

☐ Pre-application ☑ Application ☐ Changed/Corrected Application

4. Federal Identifier

5. APPLICANT INFORMATION * Organizational DUNS: 055688857

* Legal Name: The University of Memphis

Department: Psychology & Institute for Intelligent Systems Division:

* Street1: 315 Administration Building Street2:

* City: Memphis County: Shelby * State: TN * ZIP Code: 381523370

* Country: USA

Person to be contacted on matters involving this application

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Ms.	Catrina	Pierce	Sullivan	

* Phone Number: (901) 678-2836 Fax Number: 901-678-2199 Email: clpierce@memphis.edu

6. * EMPLOYER IDENTIFICATION *(EIN) or (TIN)*:

62-0648618

7. * TYPE OF APPLICANT:

Please select one of the following

Other (Specify): State Institution of Higher Education

Small Business Organization Type

☐ Women Owned ☐ Socially and Economically Disadvantaged

8. * TYPE OF APPLICATION: ☑ New

☐ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

If Revision, mark appropriate box(es).

☐ A. Increase Award ☐ B. Decrease Award ☐ C. Increase Duration

☐ D. Decrease Duration ☐ E. Other *(specify)*

9. * NAME OF FEDERAL AGENCY:

U.S. Army Research Laboratory

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:

12.431

TITLE: Broad Agency Announcement for Basic and Applied Scientific Research

* Is this application being submitted to other agencies? Yes ☐ No ☑

What other Agencies?

11. * DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:

Generalized Intelligent Framework for Tutors (GIFT) in Learning in Intelligent Tutoring Environments (LITE) Workshops and Prototype

12. * AREAS AFFECTED BY PROJECT *(cities, counties, states, etc.)*

13. PROPOSED PROJECT:

* Start Date * Ending Date

14. CONGRESSIONAL DISTRICTS OF:

a. * Applicant TN-009 b. * Project TN-009

15. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Dr.	Xiangen		Hu	Ph.D.

Position/Title: Professor * Organization Name: The University of Memphis

Department: Psychology & Institute for Intelligent Systems Division:

* Street1: 432 Psychology Building Street2:

* City: Memphis County: Shelby * State: TN * ZIP Code: 381523370

* Country: USA

* Phone Number: 901-678-3608 Fax Number: 901-678-2579 * Email: xhu@memphis.edu

OMB Number: 4040-0001

Expiration Date: 04/30/2008

16. ESTIMATED PROJECT FUNDING

a. * Total Estimated Project Funding	$1,508,155.00
b. * Total Federal & Non-Federal Funds	$1,508,155.00
c. * Estimated Program Income	$0.00

17. * IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES ☐ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE:

b. NO ☑ PROGRAM IS NOT COVERED BY E.O. 12372; OR

☐ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

18. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

☑ *** I agree**

**** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.***

19. Authorized Representative

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Ms.	Catrina	Pierce	Sullivan	

* Position/Title:	Sr. Coordinator, Sponsored Programs	* Organization:	The University of Memphis
Department:	Office of Research Support	Division:	
* Street1:	315 Administration Building	Street2:	
* City:	Memphis	County:	Shelby
* State:	TN	* ZIP Code:	381523370
* Country:	USA		
* Phone Number:	901-678-2836	Fax Number:	901-678-2199
* Email:	clpierce@memphis.edu		

*** Signature of Authorized Representative**
Completed on submission to Grants.gov

*** Date Signed**
Completed on submission to Grants.gov

20. Pre-application

OMB Number: 4040-0001
Expiration Date: 04/30/2008

RESEARCH & RELATED Senior/Key Person Profile

PROFILE - Project Director/Principal Investigator

Prefix	* First Name	Middle Name	* Last Name	Suffix
Dr	Xiangen		Hu	

Position/Title: Professor
Department: Psychology / IIS
Organization Name: University of Memphis
Division:
* Street1: 400 Innovation Drive
Street2:
* City: Memphis
County: Shelby
* State: TN
Province:
* Country: USA
* Zip / Postal Code: 38152

* Phone Number	Fax Number	* E-Mail
901-678-3608	901-678-1336	xhu@memphis.edu

Credential, e.g., agency login:

*** Project Role:** PD/PI
Other Project Role Category:

***Attach Biographical Sketch**
Attach Current & Pending Support

PROFILE - Senior/Key Person _

Prefix	* First Name	Middle Name	* Last Name	Suffix
Dr	Arthur	C	Graesser	

Position/Title: Professor
Department: Psychology / IIS
Organization Name: University of Memphis
Division:
* Street1: 400 Innovation Drive
Street2:
* City: Memphis
County: Shelby
* State: TN
Province:
* Country: USA
* Zip / Postal Code: 38152

* Phone Number	Fax Number	* E-Mail
901-678-4857	901-678-1336	a-graesser@memphis.edu

Credential, e.g., agency login:

*** Project Role:** Co-PI
Other Project Role Category:

***Attach Biographical Sketch**
Attach Current & Pending Support

ADDITIONAL SENIOR/KEY PERSON PROFILE(S)
Additional Biographical Sketch(es) (Senior/Key Person)
Additional Current and Pending Support(s)

OMB Number: 4040-0001
Expiration Date: 04/30/2008

Print Form

RESEARCH & RELATED Other Project Information

1. * Are Human Subjects Involved? ☐ Yes ☒ No

1.a If YES to Human Subjects

Is the IRB review Pending? ☐ Yes ☐ No

IRB Approval Date:

Exemption Number: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Human Subject Assurance Number:

2. * Are Vertebrate Animals Used? ☐ Yes ☒ No

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ☐ Yes ☐ No

IACUC Approval Date:

Animal Welfare Assurance Number

3. * Is proprietary/privileged information included in the application? ☒ Yes ☒ No

4.a. * Does this project have an actual or potential impact on the environment? ☐ Yes ☒ No

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ☐ Yes ☐ No

4.d. If yes, please explain:

5.a. * Does this project involve activities outside the U.S. or partnership with International Collaborators? ☐ Yes ☒ No

5.b. If yes, identify countries:

5.c. Optional Explanation:

6. * Project Summary/Abstract Add Attachment | Delete Attachment | View Attachment

7. * Project Narrative Add Attachment | Delete Attachment | View Attachment

8. Bibliography & References Cited Add Attachment | Delete Attachment | View Attachment

9. Facilities & Other Resources Add Attachment | Delete Attachment | View Attachment

10. Equipment Add Attachment | Delete Attachment | View Attachment

11. Other Attachments Add Attachments | Delete Attachments | View Attachments ☐

OMB Number: 4040-0001

Expiration Date: 04/30/2008

Task & Responsibility Proposal

Tasks	Task Weight	Responsible		Task Distribution				Notes
		UM	ARL	UM			ARL	
		59.51%	40.49%	R	D	A		
Theoretical & Technical Preparation	**1.00**	**78.75%**	**21.25%**					*Happen during the initial phase of the project, but also applicable to other research effort*
Initial Meeting between UM and ARL		50.00%	50.00%			x		ARL research come to UM
Literature Review		80.00%	20.00%	x				UM research focus on this
UM Researchers Analysis of GIFT Framework		90.00%	10.00%	x	x			ARL provide necessary documentation
UM Researchers Analysis of GIFT Prototype		95.00%	5.00%	x	x			ARL provide necessary working code
Workshops	**1.00**	**85.00%**	**15.00%**					*Applicable to all three workshops*
Prepare the workshops		80.00%	20.00%	x	x	x		Prepare literature, software, content examples
Organizing the workshops		95.00%	5.00%			x		Local arrangements, space, time, transportation, etc.
Programing the workshops		80.00%	20.00%	x		x		Contact experts, arrange topics, incentivize experts
Disseminate Workshop Outcome		85.00%	15.00%	x	x			Apply to protoypes, report & publish workshop outcome
AutoTutor GIFT Prototypes	**2.00**	**36.67%**	**63.33%**					*Applicable to All AutoTutor GIFT Prototypes*
Open-Source GIFT framework		30.00%	70.00%		x			ARL provide general, open-source GIFT framework
Open-Source AutoTutor framework		70.00%	30.00%		x			UM provide general, open-source AutoTutor framework
Integration of AutoTutor & GIFT		10.00%	90.00%		x			ARL and UM work together
Evaluation of the AutoTutor GIFT Prototypes	**1.00**	**70.00%**	**30.00%**					*Applicable to Evaluation of all Prototypes*
Formal Analysis of AutoTutor GIFT prototype		90.00%	10.00%	x				UM researchers analysis the prototype with the formal (mathematical model)
Create Evaluation Criteria		70.00%	30.00%	x		x		Creating expected criteria of success for technology, for learning gains, and user experiences
Selection of content domains		50.00%	50.00%	x				ARL and UM work together to select 1-3 content domains
Select target test population		50.00%	50.00%	x		x		ARL and UM work together to identify test population/site
Evaluation of the Prototypes		80.00%	20.00%	x				UM and CREP primarily responsible for this
Provide feedback to benefit workshops		80.00%	20.00%	x				UM researcher will incorporate outcome to the workshop programs
Final Report	**1.00**	**50.00%**	**50.00%**					**Final report**

Note 1: R=Researcher, D=Developer, and A=Administrative Staff.

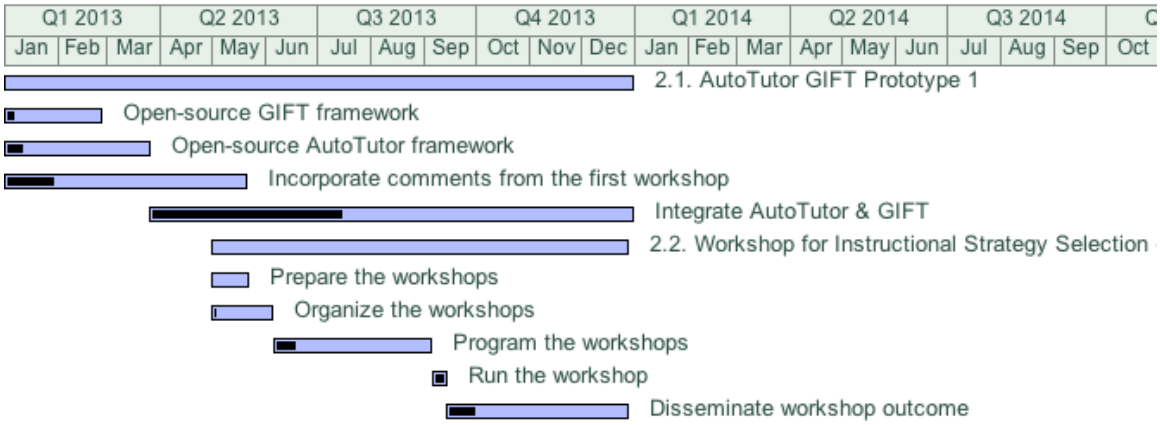
Note 2: Task Distribution for ARL is left Open for appropriate assignments.

Year 1: 5/1/2012 -- 12/31/2012					
Tasks	**Start**	**Duration**	**End**	**Notes**	
	5/1/2012	**(weeks)**	**12/31/2012**		
1.1. Theoretical & Technical Preparation					
Initial Meeting between UM and ARL	5/15/2012	1	5/22/2012	**Note:**	The first meeting between the ARL team and the Memphis team in Memphis
				Deliverable:	Entire project plan approved
Literature Review for Trainee Modeling	5/1/2012	15	8/14/2012	**Note:**	Finish review and get ready for the first expert workshop
				Deliverable:	Literature review for trainee modeling done
UM Researchers Analysis of GIFT Framework	5/1/2012	15	8/14/2012	**Note:**	Have the report ready for the first expert workshop
				Deliverable:	Ontology (from the ARL team) will be reviewed and (possibly) updated
UM Researchers Analysis of GIFT Prototype	5/1/2012	15	8/14/2012	**Note:**	Have the report ready for the first expert workshop
				Deliverable:	GIFT framework will be examined and a document will be written for the analysis
1.2. Workshop for Trainee Modeling					
Prepare the workshops	5/1/2012	3	5/22/2012	**Note:**	Reserve facility, block hotel rooms, prepare invitation letter, create website
				Deliverable:	Contract with the University (FIT) signed. Contract with the hotels signed. Functional website created
Organize the workshops	5/1/2012	5	6/5/2012	**Note:**	Generate expert list, create invitation letter, assign topics, contact individuals
				Deliverable:	Experts commitment letters signed. Travel schedules finalized
Program the workshops	6/6/2012	13	9/5/2012	**Note:**	Assign topics to participants, generate focused discussion questions
				Deliverable:	Create survey forms (evaluation of the workshop, overall & individual). Final program done.
Run the workshop	9/6/2012	1	9/13/2012	**Note:**	Run the workshop at the UM
				Deliverable:	Workshop done with survey forms collected
Disseminate workshop outcome	9/14/2012	15	12/28/2012	**Note:**	Help participants to produce written form of their contributions (may go beyond Dec. 31, 2012)
				Deliverable:	Commitment from participants (contributing to the book) and publisher contract signed
				Deliverable:	Ontology document updated
				Deliverable:	Literature review for trainee modeling updated
				Deliverable:	Formal model of ITS (the evaluation component) updated

Chart for Year 1

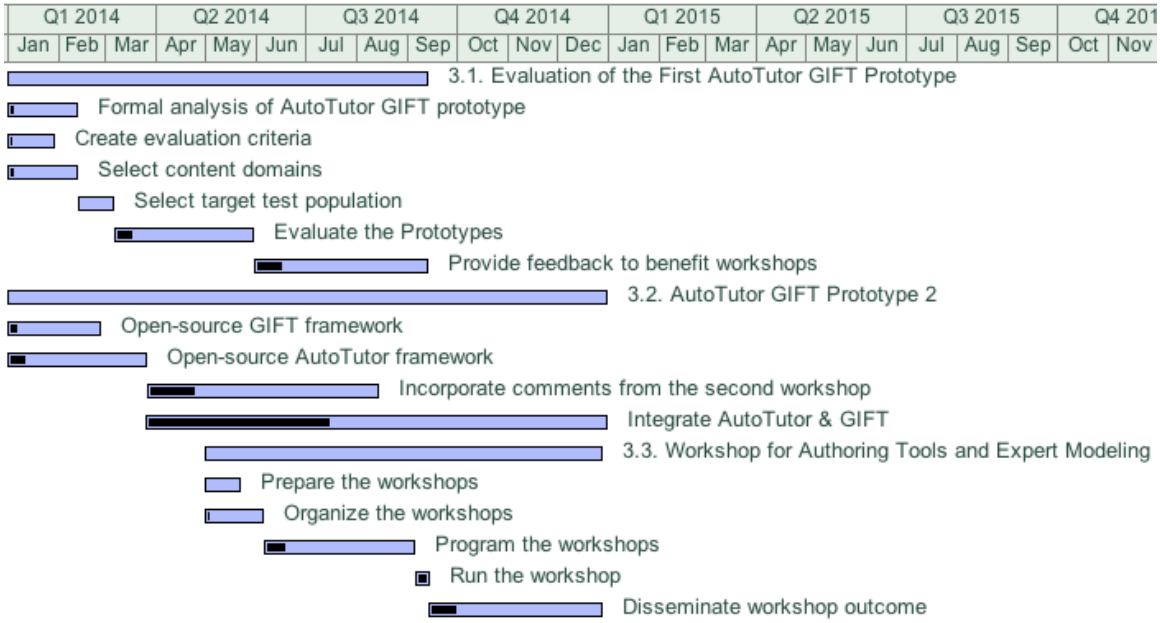
Optional Year 1: 1/1/2013 -- 12/31/2013					
Tasks	**Start**	**Duration**	**End**	**Note**	
	1/1/2013	**(weeks)**	**12/31/2013**		
2.1. AutoTutor GIFT Prototype 1					
Open-source GIFT framework	1/1/2013	8	2/26/2013	**Note:**	The UM Team to fully understand GIFT, especially the Trainee Modeling Component
				Deliverable:	Open-source, working code plus documentations. Focus on Trainee Modeling.
Open-source AutoTutor framework	1/1/2013	12	3/26/2013	**Note:**	The UM Team to fully implement the AutoTutor so it will be integrated with GIFT. Especially the evaluation methods such as semantic analysis that are used to create trainee modeling.
				Deliverable:	Open-source, working code plus documentations. Focus on Trainee Modeling (evaluation such as LSA).
Incorporate comments from the first workshop	1/1/2013	20	5/21/2013	**Note:**	The UM and ARL team work together to incorporate expert views from the first workshop into design of the first prototype
				Deliverable:	Documentation that incorporate suggestions from the first workshop
Integrate AutoTutor & GIFT	3/26/2013	40	12/31/2013	**Note:**	Create the prototype so it will be ready for the second workshop
				Deliverable:	Full functional prototype with focus on trainee modeling techniques
2.2. Workshop for Instructional Strategy Selection (time and location may be different from previous year)					
Prepare the workshops	5/1/2013	3	5/22/2013	**Note:**	Reserve facility, block hotel rooms, prepare invitation letter, create website (may take shorter time because it is similar to the previous year)
				Deliverable	Contract with the University (FIT) signed. Contract with the hotels signed. Functional website created.
Organize the workshops	5/1/2013	5	6/5/2013	**Note:**	Generate expert list, create invitation letter, assign topics, contact individuals (may take shorter time because it is similar to the previous year)
				Deliverable	Experts commitment letters signed. Travel schedules finalized
Program the workshops	6/6/2013	13	9/5/2013	**Note:**	Assign topics to participants, generate focused discussion questions
				Deliverable	Create survey forms (evaluation of the workshop, overall & individual). Final program done.
Run the workshop	9/6/2013	1	9/13/2013	**Note:**	Run the workshop at the UM
				Deliverable	Workshop done with survey forms collected.
Disseminate workshop outcome	9/14/2013	15	12/28/2013	**Note:**	Help participants to produce written form of their contributions (may go beyond Dec. 31, 2013)
				Deliverable	Commitment from participants (contributing to the book) and publisher contract signed
				Deliverable	Ontology document updated
				Deliverable	Literature review for Instructional Strategy Selection updated
				Deliverable	Formal model of ITS (the topic selection component) updated

Chart for Optional Year 1



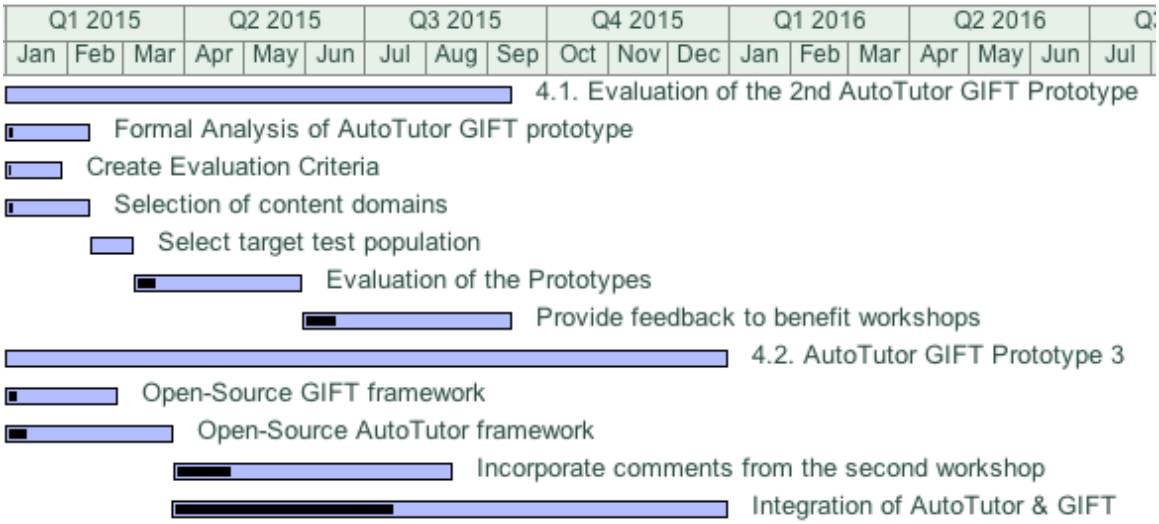
Optional Year 2: 1/1/2014 -- 12/31/2014					
Tasks	**Start** 1/1/2014	**Duration** (weeks)	**End** 12/31/2014	**Note**	
3.1. Evaluation of the First AutoTutor GIFT Prototype					
Formal analysis of AutoTutor GIFT prototype	1/1/2014	6	2/12/2014	**Note:**	Analyze the prototype comparing with the formal models of ITS
				Deliverable	Report due to ARL
Create evaluation criteria	1/1/2014	4	1/29/2014	**Note:**	Create criteria for technology, learning gain, and usability tests
				Deliverable	Written documentation
Select content domains	1/1/2014	6	2/12/2014	**Note:**	Select a domain for the evaluation. Create the ITS in the selected domain
				Deliverable	Fully functional prototype in a given domain
Select target test population	2/13/2014	3	3/6/2014	**Note:**	Decide the type of evaluation (pilot, full), select target population (UM or ARL test population). Involve IRB applications
				Deliverable	IRB filed and approved. Participants recruited.
Evaluate the Prototypes	3/7/2014	12	5/30/2014	**Note:**	Evaluation of the prototype (may take longer depending on content and test sample)
				Deliverable	Smooth running of the participants.
Provide feedback to benefit workshops	5/31/2014	15	9/13/2014	**Note:**	Analyze data and Write report
				Deliverable	Document due to ARL and available of the second workshop.
3.2. AutoTutor GIFT Prototype 2					
Open-source GIFT framework	1/1/2014	8	2/26/2014	**Note:**	the UM Team to fully understand GIFT, especially the Instructional Strategy Selection Component (may take shorter time because it is similar to the previous year)
				Deliverable:	Open-source, working code plus documentations. Focus on Instructional Strategy Selection.
Open-source AutoTutor framework	1/1/2014	12	3/26/2014	**Note:**	the UM Team to fully implement the AutoTutor so it will be integrated with GIFT. Especially the tutoring model such as dialog moves.
				Deliverable:	Open-source, working code plus documentations. Focus on Instructional Strategy Selection (evaluation such as Dialog Advancer Network(DAN)).
Incorporate comments from the second workshop	3/27/2014	20	8/14/2014	**Note:**	the UM and ARL team work together to incorporate expert views from the second workshop into design of the second prototype
				Deliverable:	Documentation that incorporate suggestions from the second workshop.
Integrate AutoTutor & GIFT	3/26/2014	40	12/31/2014	**Note:**	Create the prototype so it will be ready for the third workshop.
				Deliverable:	Full functional prototype with focus on Instructional Strategy Selection.
3.3. Workshop for Authoring Tools and Expert Modeling (time and location may be different from previous year)					
Prepare the workshops	5/1/2014	3	5/22/2014	**Note:**	Reserve facility, block hotel rooms, prepare invitation letter, creating website.
				Deliverable	Contract with the University (FIT) signed, Contract with the hotels signed, Functional website created.
Organize the workshops	5/1/2014	5	6/5/2014	**Note:**	Generate expert list, create invitation letter, assign topics, contact individuals
				Deliverable	Experts commitment letters signed. Travel Schedules finalized
Program the workshops	6/6/2014	13	9/5/2014	**Note:**	Assign topics to participants, generate focused discussion questions
				Deliverable	Create survey forms (evaluation of the workshop, overall & individual). Final program done.
Run the workshop	9/6/2014	1	9/13/2014	**Note:**	Running the workshop at the UM
				Deliverable	Workshop done with survey forms collected.
Disseminate workshop outcome	9/14/2014	15	12/28/2014	**Note:**	Help participants to produce written form of their contributions (may go beyond dec. 31, 2013)
				Deliverable	Commitment from participant (contributing to the book) and publisher contract signed.
				Deliverable	The ontology document updated.
				Deliverable	Literature review for Authoring Tools and Expert Modeling updated.
				Deliverable	Formal Model of ITS (the Knowledge Organization component) updated.

Chart for Optional Year 2



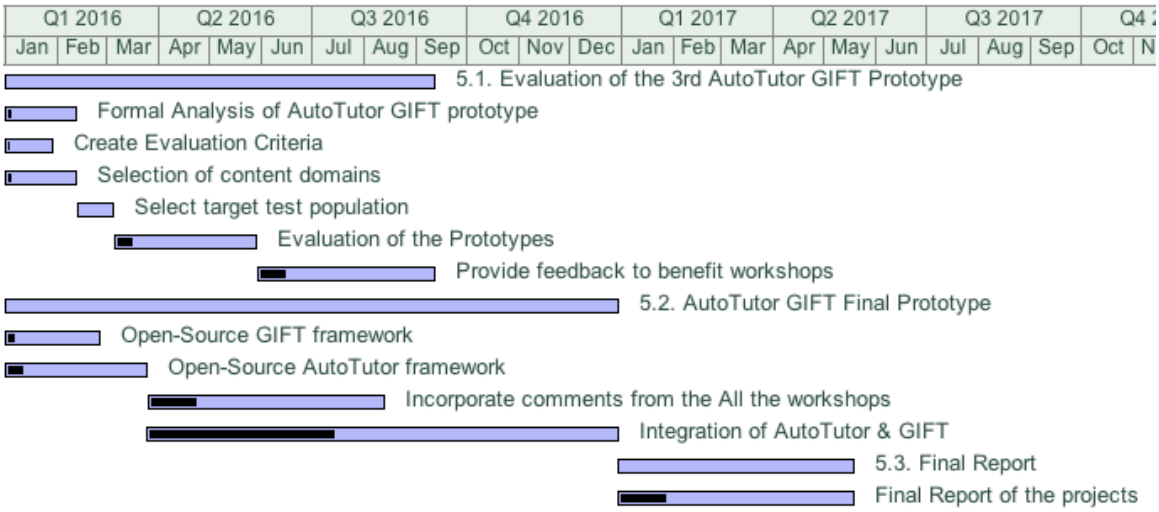
Optional Year 3: 1/1/2015 – 12/31/2015					
Tasks	Start 1/1/2015	Duration (weeks)	End 12/31/2015	Note	
4.1. Evaluation of the 2nd AutoTutor GIFT Prototype					
Formal Analysis of AutoTutor GIFT prototype	1/1/2015	6	2/12/2015	**Note:**	Analysis the prototype comparing with the formal models of ITS
				Deliverable	Report due to ARL
Create Evaluation Criteria	1/1/2015	4	1/29/2015	**Note:**	Create criteria for technology, learning gain, and usability tests (take less time this time, because it is similar to last year)
				Deliverable	Written document
Selection of content domains	1/1/2015	6	2/12/2015	**Note:**	Select a domain for the evaluation, Create the ITS in the selected domain. It may take shorter time. It is likely we will use the same content in the last year.
				Deliverable	Fully functional prototype in a given domain.
Select target test population	2/13/2015	3	3/6/2015	**Note:**	Decide the type of evaluation (pilot, full), select target population (UM or ARL test population). Involve IRB applications. This may be very simple. Because we might use the same as the previous year.
				Deliverable	IRB filed and approved. Participants recruited.
Evaluation of the Prototypes	3/7/2015	12	5/30/2015	**Note:**	Evaluation of the prototype (may take longer, depending content and test sample)
				Deliverable	Smooth running of the participants.
Provide feedback to benefit workshops	5/31/2015	15	9/13/2015	**Note:**	Analyze data and Write report. This may be shorter than last year, because the design and statistics are the same as the last year.
				Deliverable	Document due to ARL and available of the second workshop.
4.2. AutoTutor GIFT Prototype 3					
Open-Source GIFT framework	1/1/2015	8	2/26/2015	**Note:**	the UM Team to fully understand GIFT, especially the Authoring Tools and Expert Modeling Component
				Deliverable:	Open-source, working code plus documentations. Focus on Authoring Tools and Expert Modeling.
Open-Source AutoTutor framework	1/1/2015	12	3/26/2015	**Note:**	the UM Team to fully implement the AutoTutor so it will be integrated with GIFT. Especially the knowledge representation such as knowledge structure of the domain.
				Deliverable:	Open-source, working code plus documentations. Focus on Instructional Strategy Selection (evaluation such as Dialog Advancer Network(DAN)).
Incorporate comments from the second workshop	3/27/2015	20	8/14/2015	**Note:**	the UM and ARL team work together to incorporate expert views from the second workshop into design of the second prototype
				Deliverable:	Documentation that incorporate suggestions from the second workshop.
Integration of AutoTutor & GIFT	3/26/2015	40	12/31/2015	**Note:**	Create the prototype so it will be ready for the third workshop.
				Deliverable:	Full functional prototype with focus on Instructional Strategy Selection.

Chart for Optional Year 3



Optional Year 4: 1/1/2016 -- 12/31/2016					
Tasks	**Start**	**Duration**	**End**	**Notes**	
	1/1/2016	**(weeks)**	**12/30/2016**		
5.1. Evaluation of the 3rd AutoTutor GIFT Prototype					
Formal Analysis of AutoTutor GIFT prototype	1/1/2016	6	2/12/2016	**Note:**	Analysis the prototype comparing with the formal models of ITS
				Deliverable	Report due to ARL
Create Evaluation Criteria	1/1/2016	4	1/29/2016	**Note:**	Create criteria for technology, learning gain, and usability tests (take less time this time, because it is similar to the previous years)
				Deliverable	Written document
Selection of content domains	1/1/2016	6	2/12/2016	**Note:**	Select a domain for the evaluation, Create the ITS in the selected domain. It may take shorter time. It is likely we will use the same content in the previous years.
				Deliverable	Fully functional prototype in a given domain.
Select target test population	2/13/2016	3	3/5/2016	**Note:**	Decide the type of evaluation (pilot, full), select target population (UM or ARL test population). Involve IRB applications. This may be very simple. Because we might use the same as the previous years.
				Deliverable	IRB filed and approved. Participants recruited.
Evaluation of the Prototypes	3/6/2016	12	5/29/2016	**Note:**	Evaluation of the prototype (may take longer, depending content and test sample)
				Deliverable	Smooth running of the participants.
Provide feedback to benefit workshops	5/30/2016	15	9/12/2016	**Note:**	Analyze data and Write report. This may be shorter than last year, because the design and statistics are same as the previous years.
				Deliverable	Document due to ARL and available of the second workshop.
5.2. AutoTutor GIFT Final Prototype					
Open-Source GIFT framework	1/1/2016	8	2/26/2016	**Note:**	the UM Team to fully understand GIFT, This will be in all three components of the GIFT framework.
				Deliverable:	Open-source, working code plus documentations. Include all three components of the AutoTutor Framework.
Open-Source AutoTutor framework	1/1/2016	12	3/25/2016	**Note:**	the UM Team to fully implement the AutoTutor so it will be integrated with GIFT. this include all components of AutoTutor.
				Deliverable:	Open-source, working code plus documentations.
Incorporate comments from the All the workshops	3/26/2016	20	8/13/2016	**Note:**	the UM and ARL team work together to incorporate expert views from all the workshops into design of the second prototype
				Deliverable:	Documentation that incorporate suggestions from the second workshop.
Integration of AutoTutor & GIFT	3/25/2016	40	12/30/2016	**Note:**	Create the prototype so it will be ready for the final documentation
				Deliverable:	Full functional prototype with all three major components.
5.3. Final Report					
Final Report of the projects	12/30/2016	20	5/19/2017	**Note:**	Collecting all the documents, including notes, source code, and documentation of the software.
				Deliverable:	Document due ARL.

Chart for Optional Year 4



*Note that the final report will be extended to 2017. We expect to spend additional time to complete the final report. This effort may be supported as No---Cost Extension.