Iterative Development of the GIFT Wrap Authoring Tool

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INTRODUCTION

The Generalized Intelligent Framework for Tutoring (GIFT) is an empirically-based, service-oriented framework of tools, methods, and standards aimed at overcoming the challenges associated with authoring computer-based tutoring systems (CBTS), managing instruction and assessing the effect of CBTS, components and methodologies ("Generalized Intelligent," n.d.). One of the primary developmental objectives for GIFT is the creation of an integrated, user-friendly authoring experience that can be used across training applications. Humanproof, with teammate Design Interactive, is working to fulfill this objective via continued development of the GIFT Wrap prototype. This prototype, currently in its third generation, allows training developers to configure the real-time, automated delivery of instructional content triggered by assessing state changes within the training application's environment (e.g., entity location) and/or learner (e.g., concept mastery). This ongoing research and development effort is focused on the design and implementation of the user interface (UI) that guides users through the configuration of tutoring events driven by real-time assessments within a training application. Integration with the LandNavHD Unity game, a computer-based land navigation trainer used as a practice environment for dead reckoning procedures, served as the most recent use case for this ongoing effort. The third generation of GIFT Wrap's development focused on building new integrated, user-friendly tools for authoring real-time assessments within the context LandNavHD training environment. This effort also included the continued integration of legacy authoring functionality into the GIFT Wrap design. The following sections briefly describe the previous GIFT Wrap development efforts, provide an overview of the third generation of GIFT Wrap, present usability findings, and discuss concepts for extending GIFT Wrap to live training environments.

BACKGROUND

From a conceptual level, GIFT manages interaction within a training environment through the Learning Effect Model (LEM; Sottilare, Ragusa, Hoffman & Goldberg, 2013). The LEM outlines the inference processes captured in GIFT that leads to the selection of an instructional strategy based on observed performance. In this model, raw data is consumed by GIFT and routed to the domain module for assessment purposes. In this instance, the domain module uses the raw data to compute a performance state on a set of defined concepts, where Condition Classes designate performance as at-, above-, and below-expectation for the associated concept being assessed. This performance state is combined with learner relevant information (i.e., individual differences) to inform the pedagogical model for a strategy selection. The challenge here is establishing the necessary assessments required to capture appropriate performance states that associate with the objectives of the training event. To meet this challenge, user-centered design approaches are being applied to current architectural components with the intent of providing training developers and subject matter experts with intuitive tools to configure these assessments themselves.

Authoring Challenges - Real-time Assessments

In previous versions of GIFT, there were two major challenges for users authoring the real-time assessment component of a course. First, authoring the Domain Knowledge File (DKF) using the DKF Authoring Tool (DAT) proved to be too complex for the average user and much better suited for power users that would be more likely to take full advantage of the DKF's extensive functionality. Second, users were required to

author using both the DAT as well as any content creation tools for the training application (e.g., the Virtual Battlespace mission editor) in order to configure real-time assessments and other elements of adaptive training. Without real-time communication between GIFT and the training application, direct integration was not possible, making the authoring experience disjointed and cumbersome for users (Davis, Riley, & Goldberg, 2017).

Overcoming Authoring Challenges

GIFT Wrap was purposely designed to overcome the challenges associated with authoring real-time assessments by providing users with an integrated, user-friendly authoring tool. The first generation of GIFT Wrap took an initial step towards addressing integration with training applications by providing users with a tool that allowed them to author tutoring content (i.e., a check on learning (COL)) while simultaneously interacting with the training application's content creation tools (i.e., the Augmented Reality Sandtable (ARES) terrain map) (Hoffman, Markuck, & Goldberg, 2016).

The first generation of GIFT Wrap served as proof-of-concept that led to the development of the second generation. The second generation of GIFT Wrap advanced the tool's functionality by (1) providing a redesigned UI for creating, configuring, and managing a DKF that would eventually replace the DAT, and (2) creating a "blended authoring environment" that allowed users to author real-time assessments (e.g., COLs) directly within the context of a training application's content creation tools via an "Overlay UI" with the flexibility to rapidly switch back to the main GIFT Wrap UI and configure the rest of the DKF (Davis, et al., 2017).

THIRD GENERATION GIFT WRAP

Incorporating DAT Functionality

The second generation of GIFT Wrap was designed to be flexible enough to incorporate all existing DAT functionality into a new, more user-friendly UI that could support both novice GIFT users as well as more experienced GIFT training authors (Davis, et al., 2017). The third generation of GIFT Wrap contains several new features (see Figure 1) that previously only existed in the DAT including, but not limited to, the following:

- Users may now create child Concepts nested up to three layers deep allowing training developers the flexibility to assess Concepts at different levels of granularity.
- User may now create multiple strategies for state transitions and/or assessment levels for a given Condition Class.
- Users may now add time delays for Task triggers to better control the pace and timing of tutoring events.

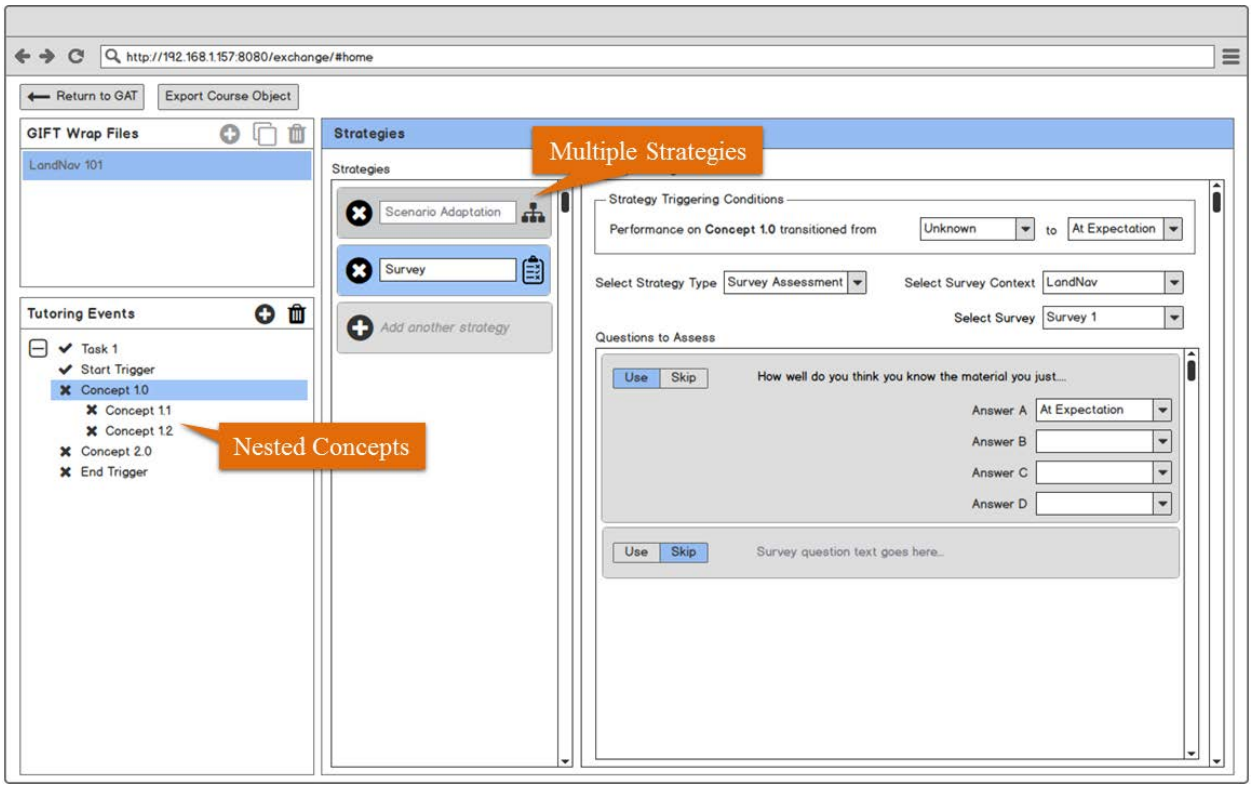

Figure 1. GIFT Wrap New Features

Extending the Blended Authoring Experience

Beyond incorporating additional DAT functionality into the new GIFT Wrap design, the blended authoring experience was extended outside the ARES training application to include the LandNavHD Unity game. In order to accomplish this, GIFT Wrap was integrated with the GIFT Unity plugin to establish communication between GIFT Wrap and the LandNavHD. Also, two new event handlers were created in the LandNavHD Unity project that send messages to GIFT providing information used for real-time assessment. Once GIFT Wrap and the LandNavHD were fully integrated, new real-time assessments were created specifically for the LandNavHD. Carrying forward the land navigation training use case used with the second generation of GIFT Wrap, the following Condition Classes were created to support the training tasks used in the LandNavHD: Avoid Area, Follow Path, and Locate Navigation Points. Next, the GIFT Wrap Overlay UI was updated to accommodate authoring these new real-time assessments within context of the LandNavHD environment. The current version of the LandNavHD does not include content creation tools that would allow users to create or edit new scenarios. To account for this, a top-down image of the terrain was extracted and a new layer was created in the GIFT Wrap UI to simulate the functionality of authoring within the training application's virtual environment. Each of the new LandNavHD real-time assessments and corresponding Overlay UIs are described below.

Avoid Area

This Condition Class checks whether or not a specific entity avoided an area in the virtual environment. This is used to assess the learner's ability to move by terrain association and/or dead reckoning while avoiding certain obstacles, areas, terrain features, etc. GIFT Wrap allows users to easily draw areas to avoid directly on the LandNavHD terrain (see Figure 2) rather than requiring manual entry of a set of coordinates.

Users may also adjust the positioning of the area, name it, change its color, and set a tolerance (e.g., entity entered area for more than 30 seconds). While this assessment was created for land navigation, it is generalizable to numerous scenarios relating to zones of interest and trainee location within that interacting space.

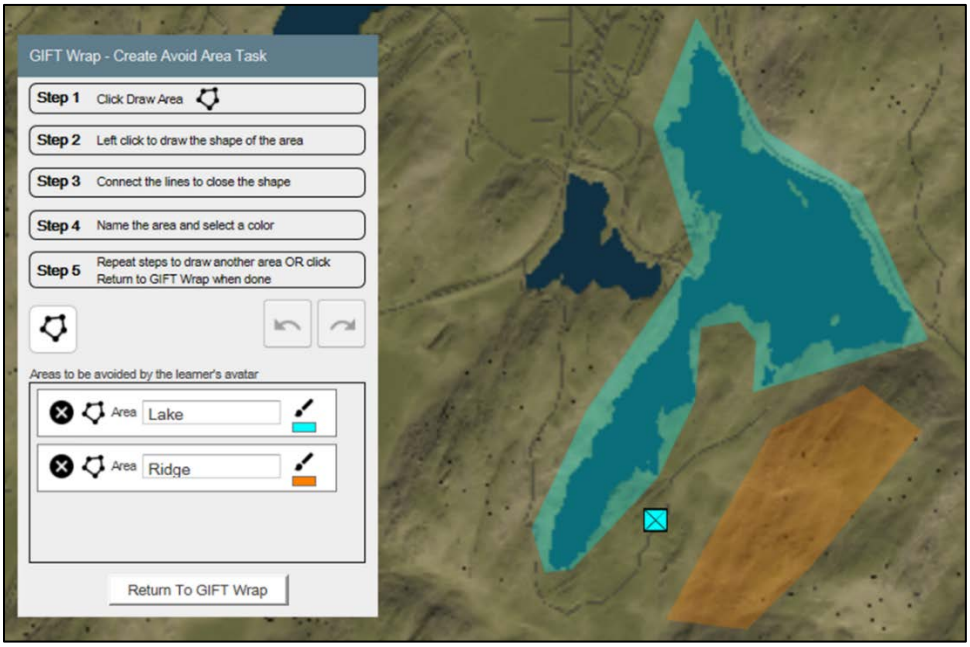

Figure 2. Avoid Area Overlay UI

Follow Path

This Condition Class checks whether an entity traveled along a series of connected straight line paths in the virtual environment within a set of thresholds for deviation. This is used to assess a learner's ability to move by dead reckoning, point-to-point land navigation. GIFT Wrap allows users to easily draw paths/routes to follow directly on the LandNavHD terrain (see Figure 3) rather than requiring manual entry of a set of coordinates. Users may also adjust the positioning of the end points and set a tolerance (e.g., entity may deviate no more than 30 meters from the path).

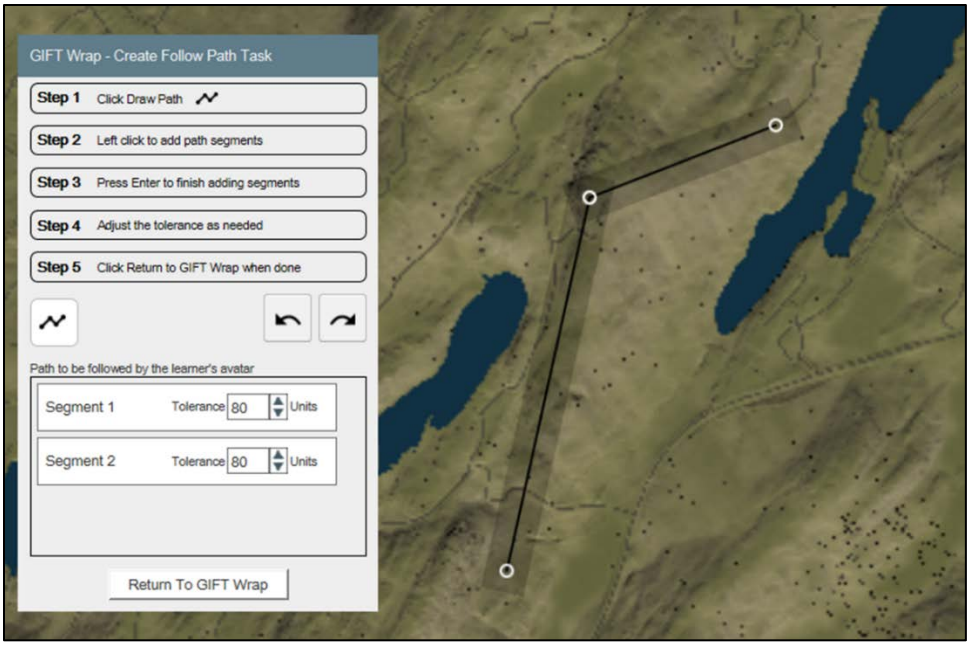

Figure 3. Follow Path Overlay UI

Locate Navigation Points

This Condition Class checks whether or not an entity reached the location of a specific location (coordinate) in the virtual environment within a set threshold. This is used to assess the learner's ability to navigate to specified locations in the virtual environment. GIFT Wrap allows users to easily drop points directly on the LandNavHD terrain (see Figure 4) rather than requiring manual entry of a set of coordinates. Users may also adjust the positioning of the point and set a tolerance (e.g., entity must be within 30 meters of the point).

Figure 4. Locate Navigation Point Overlay UI

VALIDATING THE DESIGN

The third generation of GIFT Wrap represents the most recent attempt to develop user-friendly authoring tools aimed at configuring real-time assessments that occur during training. However, user testing is always needed to validate claims that the most recent design iteration is indeed an improvement over previous versions. Therefore, a small scale usability test was conducted to compare and contrast authoring a DKF using the DAT and the third generation of GIFT Wrap. A total of seven of participants were asked to complete a comparable set of tasks with both interfaces, in a counter-balanced manner, in order to gather user feedback on their perceived ease of use as well as compare system performance. The results (i.e., descriptive statistics) from each survey and performance measure, findings from the user interviews, and test facilitators' observations are reported in the following sections.

Subjective Measures

Subjective Workload

All participants reported experiencing higher workload with the DAT (M = 62.71, SD = 8.34) than with GIFT Wrap (M = 37.86, SD = 9.21) on the NASA-Task Load Index (NASA-TLX) (Hart & Staveland, 1988) (see Figure 5). The subscales that appear to have contributed the most to differences in the overall score were Mental Demand, Performance, and Frustration (see Figure 6). That is, the participants reported higher Mental Demand and Frustration and poorer Performance associated with the DAT than GIFT Wrap.

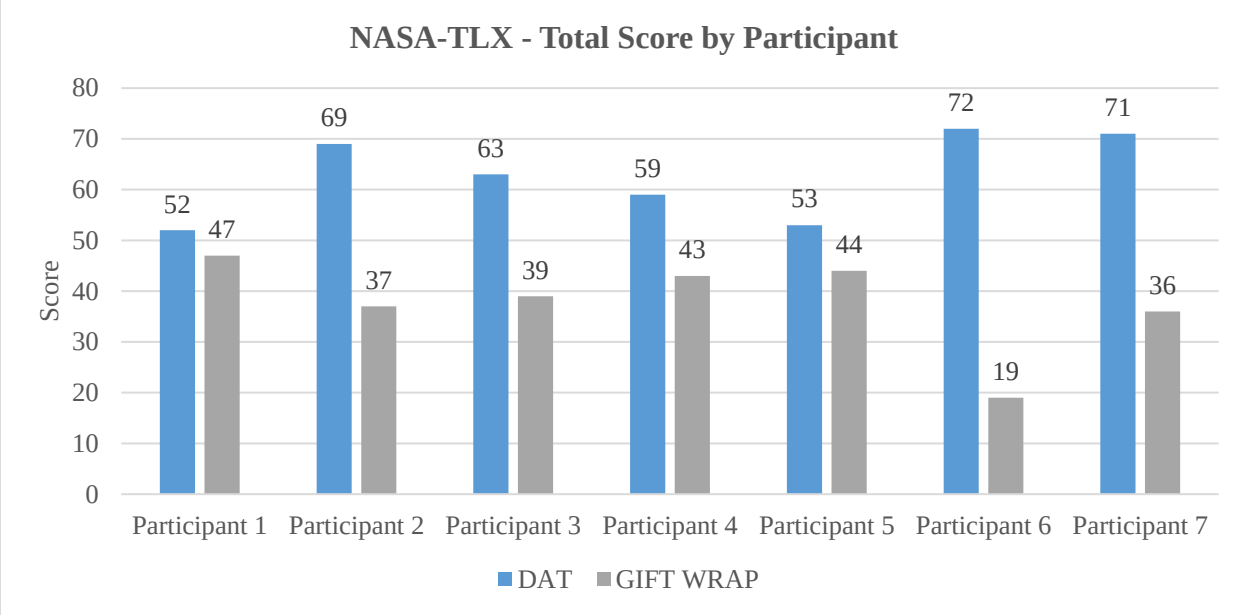

Figure 5. NASA-TLX Total Scores by Participant by Tool

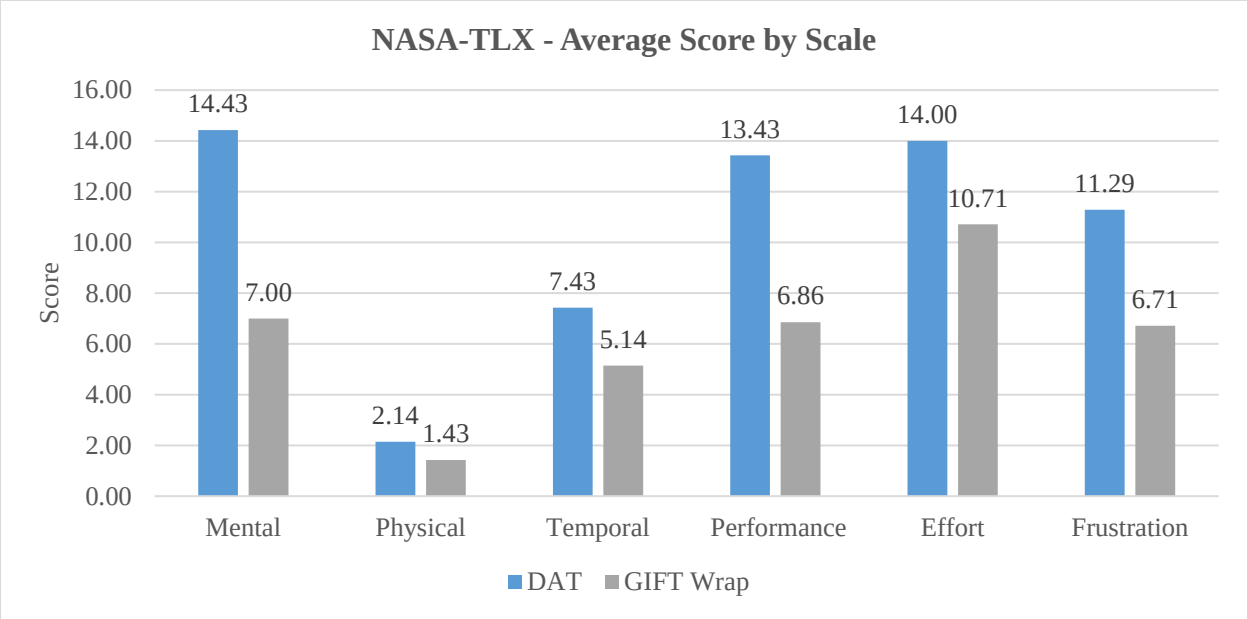

Figure 6. Average Score by Scale

System Usability Scale

All but one participant reported better perceived usability for GIFT Wrap (*M* = 67.86, *SD* = 17.76) than for the DAT (*M* = 36.79, *SD* = 24.01) on the System Usability Scale (SUS) (Brooke, 1996) (see Figure 7). In a review of 500 studies, a score of 68 was found to be the SUS national average (Sauro, 2011). GIFT Wrap received a score roughly equivalent to C while the DAT received a score equivalent to an F.

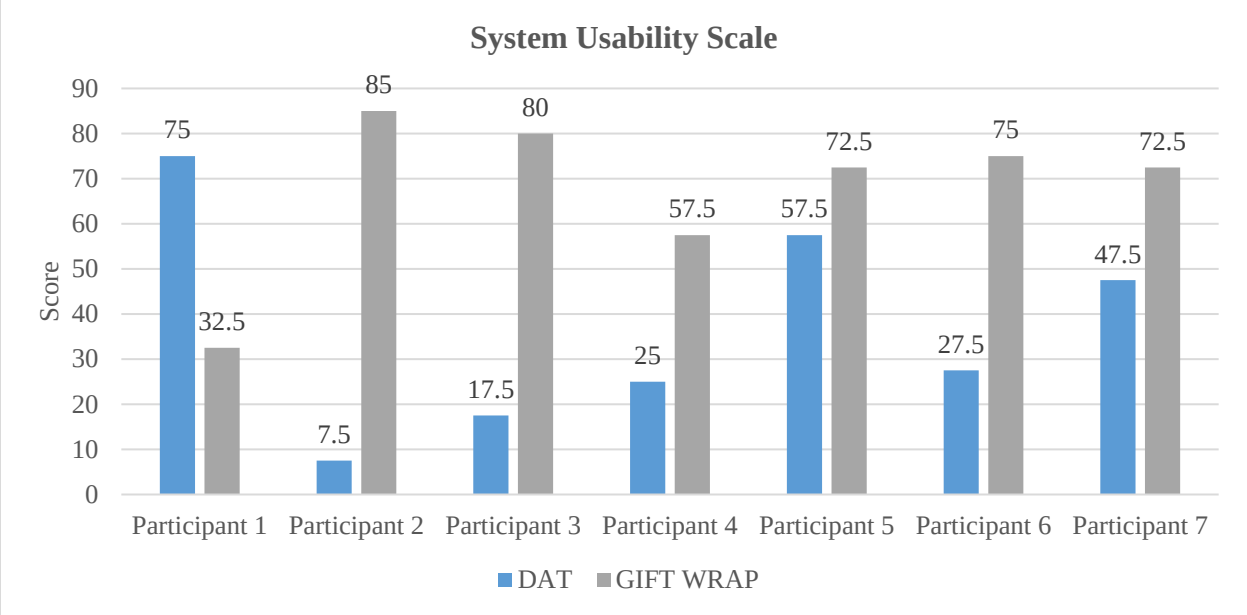

Figure 7. SUS Scores by Participant by Tool

Objective Performance Measures

All participants required more time to complete the test tasks with the DAT (*M* = 1309.00 (21min 49s), *SD* = 353.92) than with GIFT Wrap (*M* = 592.00 (9min 52s), *SD* = 89.74) (see Figure 8). Furthermore, participants required more prompting to complete the test tasks with the DAT (*M* = 16.00, *SD* = 7.02) than with GIFT Wrap (*M* = 5.71, *SD* = 2.75) (see Figure 9).

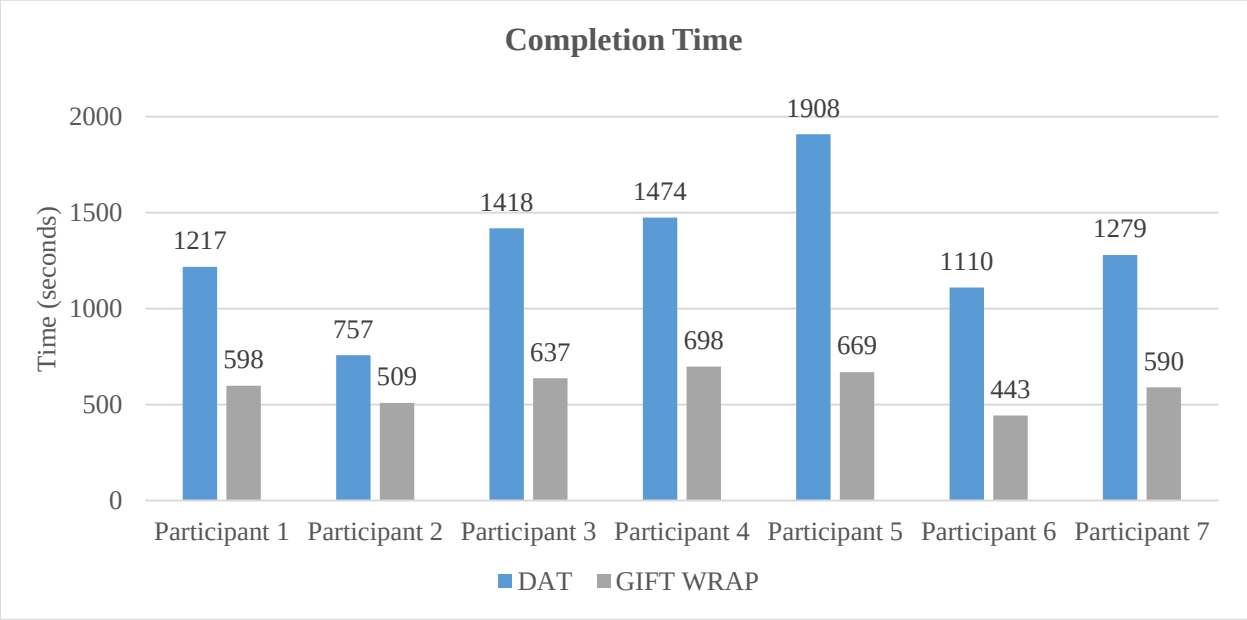

Figure 8. Completion Times by Participant by Tool

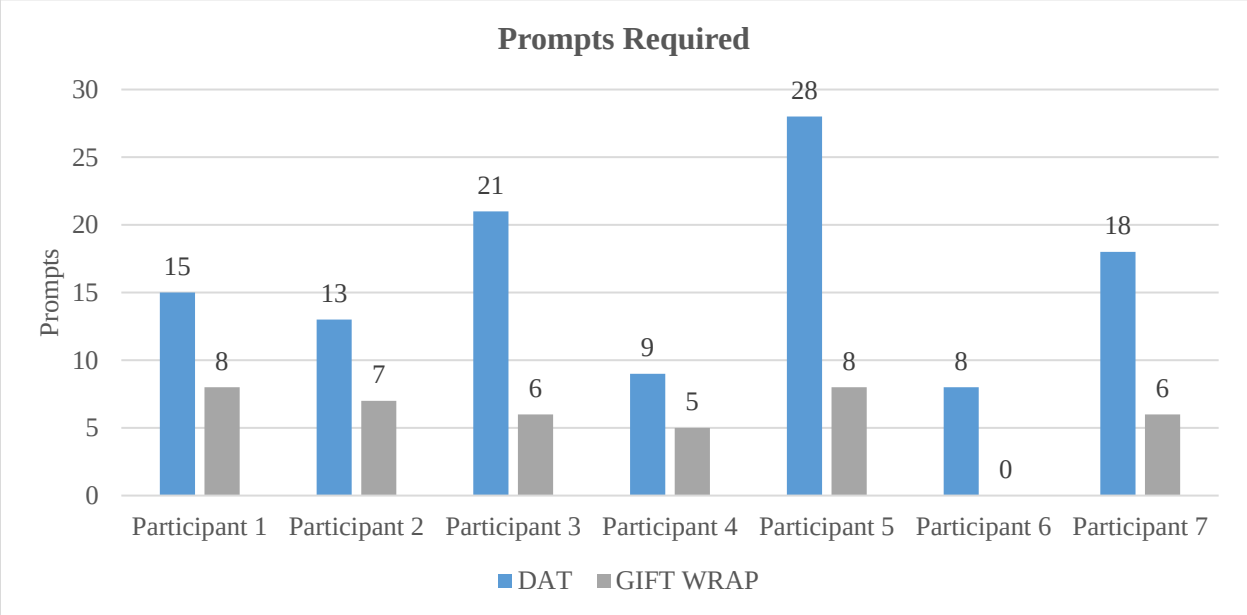

Figure 9. Prompt Count by Participant by Tool

Participant Feedback & Other Observations

Table 1 below summarizes the participant feedback collected immediately following each test session as well as other observations captured by the test facilitators during the usability testing.

Table 1. Participant Feedback & Other Observations

	GIFT Wrap	DAT
Common Usability Issues	• Determining how to add a new concept • Remembering to complete the end trigger • Determining how to rename items (e.g., Concepts) • Recognizing horizontal panels/tabs (e.g., Strategy panel)	• Save and exit errors (i.e., accidental close out of DAT with the intent of saving) • Determining how to set-up and assign waypoints • Determining how to set-up and complete strategies and/or state transitions • Determining how to add sub-concepts • Confusion about end trigger at start of authoring a task, prompted with need to return to it later
Users Liked *Best* about the Tool	• Layout • Intuitiveness, Simplicity • Process flow (i.e., tree menu structure) • Only relevant info presented to user	• More features and options apparent • Descriptive (e.g., tool-tip-text, instructions) • UI "Style" (e.g., colors)
Users Liked *Least* about the Tool	• Fewer instructions at interface • Fewer apparent options	• Confusing, Not intuitive • Frustrating flow • Not user friendly, hard for soldiers to use • Lots of clutter and/or information on interface

Taken together, the results of this usability test indicate that users perceive GIFT Wrap to require less effort and to be more user friendly than the DAT, legacy GIFT authoring tool. Furthermore, the participants were able to complete the tasks much quicker and with less assistance with GIFT Wrap than the DAT.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The third generation of GIFT Wrap successfully incorporated additional DAT functionality into a more user-friendly design and extended GIFT's authoring capabilities to a new training application with the LandNavHD Unity game. Furthermore, usability testing demonstrated that GIFT Wrap is much more user-friendly than legacy authoring tools making GIFT more accessible to the average user without eliminating the important features power users need. However, while GIFT Wrap's design outscored and outperformed the DAT, the test results showed that many design features could be improved. Future developers of GIFT Wrap should take these findings into account as they strive to iteratively improve the design.

GIFT Wrap is now capable of supporting the authoring of land navigation training across multiple training applications (i.e., ARES, LandNavHD). These authoring tools and real-time assessment capabilities are easily extendable to new applications including training in live environments via integration with mobile devices. Efforts are currently underway to determine the "back-end" functionality necessary for GIFT to communicate with mobile devices to retrieve real-time assessment data and to push instructional interventions to learners via a mobile tutor UI. This initial proof-of-concept will aim to layer GIFT's tutoring capabilities on top of an existing live terrain walk exercises conducted at the United States Military Academy at West Point.

The lessons learned from the first three generations of GIFT Wrap will be used to inform and guide the development of the fourth generation of GIFT Wrap. Near term GIFT Wrap research and development efforts will focus on developing new, user-friendly authoring capabilities that will be integrated with web mapping services (e.g., Google Maps) to create a new authoring layer. Work will also be done to apply existing capabilities to this new environment and to develop authoring tools for terrain walk specific real-time assessments (e.g., pace count, plotting routes). This fourth generation of GIFT Wrap will eventually provide training developers with the tools they need to easily create land navigation training using the GIFT ITS to scaffold the learner's phased skill development across three complimentary training environments

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