Proceedings of the 2015 Winter Simulation Conference
L. Yilmaz, W. K. V. Chan, I. Moon, T. M. K. Roeder, C. Macal, and M. D. Rossetti, eds.

MAKE IT USABLE: HIGHLIGHTING THE IMPORTANCE OF IMPROVING THE INTUITIVENESS AND USABILITY OF A COMPUTER-BASED TRAINING SIMULATION

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ABSTRACT

Usability refers to the ease-of-use, learnability, and satisfaction of an individual's interactions with an interface. With the increased fielding of constructive simulation and personal computer-based simulation for training, there is a growing need for proper usability evaluations during the developmental phase of a product's lifecycle to ensure higher rates of effective use, understanding, and trust from targeted users. The Linguistic Geometry Real-time Adversarial Intelligence and Decision-making (LG-RAID) computer-based training simulation was designed as a training simulation for Army personnel undergoing training on the development of tactically correct courses of action. A heuristic evaluation was conducted to identify strengths and weaknesses of LG-RAID's User Interface (UI) design. Results are presented and discussed with a focus on the importance of being mindful of the cognitive capabilities of the user when designing UIs, understanding and executing simulation design needs based on these capabilities, and the benefits of integrating those design changes during development.

1 INTRODUCTION

Simulation-based training continues to become an increasing focus on training development efforts. The capability of Personal Computers (PCs) today allows for these types of simulations to move from larger-scale physical trainers to lightweight desktop applications. This has led to an overall increase in the number of PC game-inspired simulations in a number of training and educational domains. This is due mainly to the fact that computer-based simulation offers a relatively safe practice environment that is free of negative consequences due to live training (e.g., nuclear waste handling, firefighting procedural training, field medic training, etc.). Trainees are able to practice and, if necessary, reenact a scenario under the same set of parameters as many times as they like, without the fear of real-life negative consequences (Trybus 2012).

Unfortunately, typical analyses of non-leisure software design has primarily focused on functionality and performance, with interface design relegated as a secondary concern (Johnson and Wiles 2003). While this approach is not recommended by UI professionals, it will simply not work for military gaming simulations, as user feedback is commonly collected and acted upon by the Army. A poorly designed game interface will cause loss of user interest, resulting in game rejection (Steinberg and Blume 2013). For the Army, and in general, there is an additional financial cost incurred once resources are expended to correct poor design. In response to this, recent research has explored the efficacy of military game-based interface modalities and HCI frameworks that attempt to optimize the degree of transfer to the trainee (Griffith et al. 2013), as well as the effect of adopting commercial video game attributes and features to design (Deterding et al. 2011). This paper contributes to this growing body of knowledge.

Adherence to good design principles is critical in order for users to perform their tasks efficiently and effectively (Cappel and Huang 2007). Numerous usability studies have reinforced this finding (Brower 2004; Altaboli and Lin 2011; Salimun, et al. 2010; Saini 2013) with the resultant outcome of greater upfront adherence to good design principles by game designers. This paper employs a heuristic evaluative approach to both evaluate and subsequently improve a military game-based simulation's interface in order to increase its utilization throughout the Army.

The Linguistic Geometry Real-time Adversarial Intelligence and Decision-making (LG-RAID) is a updated, light-weight simulation that employs novel game theory to generate intelligent, predictive and tactically-correct Courses Of Action (COAs) for military exercise participants, originating from work by Stilman and Yakhnis (2003). LG-RAID is a game-based application that provides an environment that allows leaders and staffs to practice and develop major combat operation planning and execution skills. This game-based simulation is being developed by the Army Research Laboratory (ARL) and is intended to provide a rapid COA analysis and digital rehearsal capability for the end-user. LG-RAID entities include friendly, enemy, and civilian forces; the targeted training echelon is at the company level and below. LG-RAID provides the user with accurate units, behaviors, and battlefield effects in a gaming environment.

While LG-RAID has proven to be an effective driver of other simulations due to its accurate algorithms (Stevens et al. 2014), what is still unknown is whether the technology is effective when employed in a stand-alone manner, similar to a game. Multiple user feedback sessions have revealed that the game's interface has proven to be complex, resulting in lower utilization than desired by the project sponsor, ARL. As a result of overly complex design, an effort was initiated to redesign the game's interface with the subsequent goal to increase utilization throughout the Army. This process is nearly complete and the highlights of our interface evaluation of the game are presented in this paper.

2 BACKGROUND AND SUPPORT

Military simulations and simulators present a rich environment for interface improvements, generally through the emulation and adoption of commercial game best design practices. Toth and Christensen (2012) outline how their efforts to improve the Army's Topodef scenario generation tool were successful by emulating commercial game graphical user interface best practices. Onal etl al. (2014) determined that user interface had a significant effect on collective performance, specifically trust and cooperation, in a strategy-centric gaming environment. This represents a highly pertinent topic of research for the military. Fidopiastis and Griffith (2013) examined the effect, and potential benefits, of integrating low-cost, commercial Brain-Computer Interfaces (BCI) in military gaming simulation. In their experiment, all participants were able to successfully navigate in a popular three-dimensional gaming environment using a BCI. Wortley (2014) highlights how increasingly intuitive interfaces in gaming have increased the level of immersion of these training simulations. While the relationship between immersion and performance is still unclear, the military is extremely interested in further exploration of this topic.

2.1 The Value of Usability Assessment

The user interface is the first point of interaction between a product and its desired audience. If this interaction is difficult, problematic, or confusing to its specified uses, it is likely that the product will not achieve its purpose or goal (Barnum 2011). This makes an intuitive user interface invaluable; to be treated as a long-term payoff for simulation and game-based training systems. Fortunately, tools exist that allow for the carrying out of in-depth evaluations aimed at streamlining the overall user interaction and experience in order to improve performance, usability, and satisfaction with the User Interface (UI).

A popular method for improving usability is conducting an expert/heuristic review and evaluation. A heuristic evaluation is the process in which a usability expert will conduct a systematic evaluation of a product or interface design in order to assess its functional usability based on specific human-centered design guidelines (Wickens et al. 2004). Heuristics, in this sense, are a set of design and behavioral

principles derived from various aspects of cognitive psychology and perceptual processes of the human sensory system (Te'eni, Carey, and Zhang 2007; Barnum 2011). These heuristics provide "rules of thumb" that are used by experienced individuals to recognize UI design shortcomings and recommend changes to make interactions with a system more intuitive and pleasant.

A heuristic evaluation is a relatively low-cost, high-benefit approach to improving UI design that is becoming increasingly popular among user experience practitioners (Atkinson et al. 2007). As such, a number of heuristic-based guidelines have been developed to account for various approaches to interface design. For example, Nielsen (1994) and Shneiderman (1998) have each proposed a number of usability heuristics or design principles. While these two approaches overlap in many design-related areas, each adds some unique design concepts that are not directly expressed in the other. The availability of multiple usability heuristics has allowed for successful UI evaluations and improvements for numerous products in countless domains, such as special and age-related population usability (Arnhold, Quade, and Kirch 2014), game-based patient learning tools (Brown-Johnson, Berrean, and Cataldo 2015), wearable military training systems (Taylor and Barnett 2013), and e-learning training for new employees (Chang 2011).

2.2 Focus on the User

The popularity of heuristic evaluations for assessing the usability of an interface is largely due to the effectiveness they have at identifying shortcomings and improving the user interaction in a relatively short time period at a relatively low cost. Usability heuristics are effective because they are largely based on the capabilities, expectations, and limitations of the human cognitive-perceptual systems. People are generally limited on the amount of information they can effectively process at any given time (Baddeley 1992; Mayer 2009). In fact, an individual is only able to maintain very small amounts of information in working memory before the information decays or is forgotten. Providing too much information or requiring a large number of steps to accomplish a task risks overloading the user's cognitive resources, which leads to frustration and ineffective use. Similarly, providing too little information or minimal system responses to user input creates a sense of frustration in the user (Nielsen 1994). Usability heuristics provide the user-focused approach that helps to account for these factors.

Additionally, individual or cultural experiences can create expectations from users and affect the way they approach their interactions with a system's UI (Wallace, et al. 2013; Barnum 2011). This is because people heavily rely on past experiences when learning or performing new tasks (Kneebone et al. 2006). Addressing the target user group's expectations and experiences helps to aid in effective UI design (Barnum 2011).

2.3 The Present Effort

The evaluation undertaken for this effort included the examination of the major user interaction controls and functions necessary for intended usage of LG-RAID. The evaluation's main focus was on addressing UI design from a cognitive-perceptual standpoint, utilizing available usability heuristics. Particular focus was applied towards evaluating the UI from a military perspective, as military culture is often considered very different than that of civilian culture in many regards (Hall 2011).

The chief user interactions focused on in this report included the act of creating COA plans in the game-like interface and the methods used to communicate and share assignments and individual progress. These focus areas were selected due to their inherent importance regarding the effective usage and, ultimately, positive learning outcomes associated directly to the usability of the system.

3 EVALUATION METHOD

3.1 LG-RAID Simulation

LG-RAID is designed as a thin-client simulation, accessible via most current web-browser technologies. End-user devices will typically connect to a dedicated server to run their simulated COA, however a connection is not necessary, as the application can compute simulations on the local machine as well.

The current UI is contained within a web browser that provides users with all of the menus, options, and functions necessary for complete interaction with the system (i.e., no other tools are required for interaction). The main window presents the user with a map layout on the screen (Figure 1). The map is movable and scalable. Control, editor, and function buttons are located along the top-left (containing all major COA editor options, file management, and communication options), the top-right (consisting of a map layer button), and bottom-pane of the browser window (containing additional help and COA review controls). Users create, edit, view, save, and share their COA plans via these controls.

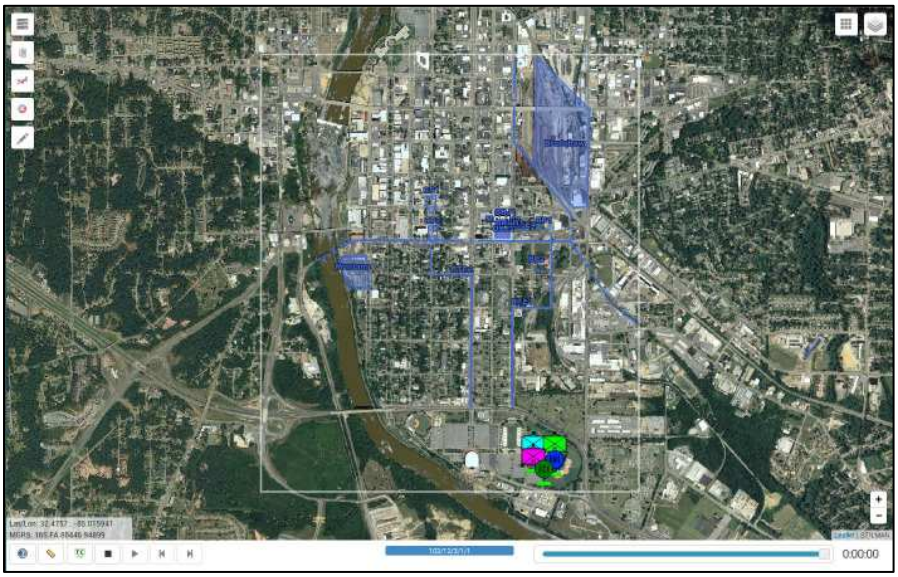


Figure 1: This is representation of the overview of the LG-RAID interface.

3.2 Multiple Heuristic Evaluation

LG-RAID was evaluated using the Multiple Heuristics Evaluation Table (MHET; Atkinson et al. 2007). The MHET provides a collective list of evaluative heuristics based on aspects of other major heuristic-based evaluations mentioned earlier (i.e., Nielsen's Ten Usability Heuristics; The Eight Golden Rules; etc.). Atkinson et al.'s (2007) work identified 12 design heuristics for evaluation of UIs that combine aspects from other, widely accepted heuristic approaches into a single comprehensive evaluation template. Table 1 provides an overview of each of the usability heuristics identified in the MHET.

3.3 Procedure

After becoming familiar with the controls and aesthetics of the LG-RAID UI, the evaluator followed a task-oriented approach for a typical user task flow in order to identify any key usability issues throughout expected user interactions with the system. The evaluator recorded various potential usability issues related to the controls, buttons, menus, sub-menus, and other possible user interactions with the UI (e.g., creating and placing entities on the map). Descriptors (i.e., the "Main Menu" button), the location (i.e., Top-right hand side of the LG-RAID window), and applicable heuristics were recorded.

Table 1: Description of MHET design heuristics.

HEURISTIC	DESCRIPTION
Software-User Interaction	Supports user interaction with the software by providing appropriate and necessary information
Learnability	Aides for timely and efficient learning of features
Cognition Facilitation	Supports the cognitive limitations of the human user
User Control & Software Flexibility	Provides responses to user actions and adaptable
System-Real World Match	Matches user expectations based on user community expertise and similar available products
Graphic Design	Uses graphic elements to convey information and create effects
Navigation & Exiting	Facilitates software exploration and provide outlets to terminate
Consistency	Elements provide standard and reliable terminology, actions, and layouts
Defaults	Provides users with default information
Software-System Interaction	Supports software interaction with hardware components
Help & Documentation	Provides users with help files and documentation to support use of software
Error Management	Prevents, identifies, and diagnoses errors, and offers corrective solutions

4 EVALUATION RESULTS

The evaluation revealed a number of major usability concerns pertaining to typical user interactions with LG-RAID's interface. It is important to note that while this review uncovered a number of UI-related concerns, the list provided here is not exhaustive, but rather presents the usability concerns that were considered to be of the highest priority regarding the overall UI design for LG-RAID. These issues were thought most likely to cause usability problems and are also easily applicable to other UI design approaches. The following sections describe these findings in detail.

4.1.1 User-Created Entity Labels

Users are able to create specified areas, battle positions, routes, and entities and place them anywhere on the map. LG-RAID functionality includes the ability for users to create known Blue Force (BLUEFOR) and Opposition Force (OPFOR) positions, as well as pre-specified routes in order to assign pathways on which entities can travel. For every graphic control measure that is created, LG-RAID will automatically apply an associated label.

However, if multiple areas are created that overlap or are placed close in proximity to each other on the map, the labels for each item or entity begin to overlap making it difficult to determine which label is associated with each specific item (Figure 2). In addition, this characteristic also made it more difficult to select (i.e., click on with the mouse) the desired area, objective, etc., leading to an increase in the number of selection errors committed.

This violates two usability heuristics outlined in the MHET: Graphic Design and Cognitive Facilitation. The graphic design heuristic deals primarily with the presentation of graphical information

on a compact screen that allows for accurate interactions, is easy to understand, and provides enough information to indicate its function or purpose. The cognitive facilitation heuristics states that the design of any UI should adhere to the cognitive limitations of a user (Nielsen 1993; Nielsen 1994). In this instance, the display is highly cluttered and difficult to interpret visually in places where areas and labels overlap.

Figure 2: An example of text labels for overlapping areas, presenting readability problems.

A UI that is not presented in a clear and understandable manner is considered to have poor aesthetics. This, in turn, has been shown to increase levels of frustration from the user towards the system (Tuch et al. 2012). In addition, lower perceived aesthetics can actually lead to lower levels of acceptance from users, regardless of the overall usability of the system (Lidwell, Holden, and Butler 2010) and to general avoidance and lack of use.

To remedy the issue involving the entity and area labels, the system needs to recognize when and where area labels and entities may potentially overlap and rearrange them in space so they are both individually visible and spatially representative of their respective areas. This would both decrease confusion and frustration from users attempting to determine which label represents what area or object and increase the ease of interpretation and overall usage of the system.

4.1.2 Sending Completed COA Files to Others

LG-RAID is purposefully designed to allow trainees to work individually or collaboratively. Collaboration that is not collocated in real-time is achieved via the ability to send saved COA files to other users registered on the LG-RAID servers. This action also allows instructors to remotely send assignments and exercises to trainees, as well as for trainees to return completed assignments to the instructors. This works much like an internal email service.

Two usability issues were discovered within this process. First, the UI dialogue box that contains the send-file functionality lacks the ability for users to browse files saved on the system or server that they would like to send. Users are instead required to remember the entire file name and extension in order to successfully attach the correct file to the outgoing message (Figure 3). This violates the system-real world match heuristic, which suggests that UI design should meet user expectations of typical or familiar interactions.

The addition of a file browsing function would alleviate the problems associated with remembering potentially long file names and extensions. The browse function is often seen in various email clients

when searching for file attachments. This is a characteristic that is familiar to most individuals with experience in using email or computers, adhering to the system-real world match heuristic.

The second UI-related issue involved the actions required to send a file. The LG-RAID system does not currently check to ensure that a recipient is denoted and a file is properly selected as an attachment before the "Send File" operation is selected by the user. Once the send command is clicked, purposefully or accidentally, the system reports that the file was sent successfully whether or not a file was actually attached or a recipient was listed. This process violates the software-user interaction and error management heuristics. The software-user interaction heuristics states that an interface should provide adequate and appropriate information regarding its current state or actions. In this case, it is providing inaccurate information, leading users to believe their actions had been executed properly.

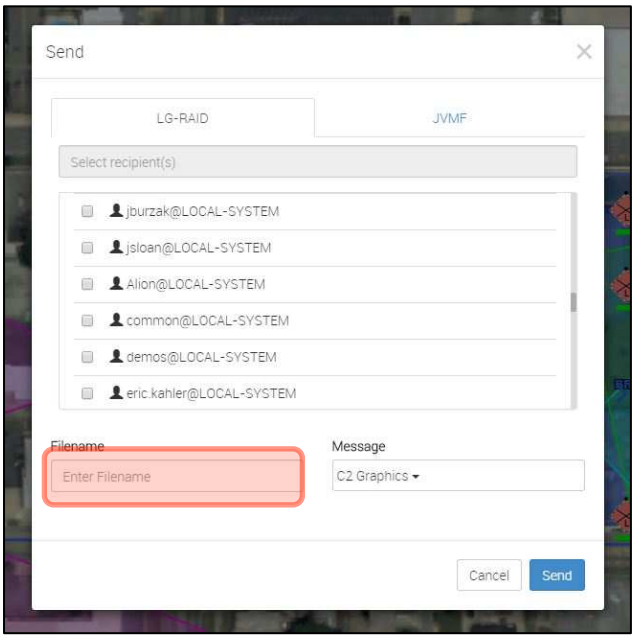


Figure 3: The "Send" file window lacks the option to browse for files.

The inclusion of a system-level feature that checks and warns an individual if either of the steps required for sending a file are incomplete or inaccurate provides adequate information to the user in order to help avoid errors and improves trust in the system.

4.1.3 Left-Pane Function Buttons Click Response Actions

Five function/menu buttons are located along the left-hand window pane in LG-RAID (Figure 4). Each button controls one of the various user options available while editing a COA in LG-RAID. Functions include a main menu (where all map editor and entity creation options are located), a file button (where users can save, load, send, or open recent files), an estimate button (used to run the simulated COA plan for a user-designated length of relative time), an execution matrix button (i.e., a table populated with the current BLUEFOR entity tasking), and a notes button (used to for communication between users and personal note keeping). Clicking on any individual button opens the hidden sub-menu dialogue boxes, actions, and functions associated with that particular function.

However, the button labelled "Main Menu" behaves differently when clicked than any other menu or function button within LG-RAID. The main menu opens a narrow pane along the left-hand side of the browser window in response to a user click. This options pane is designed with different colors and shape than every other menu or dialogue box (See Figure 5 for comparison). The main menu pane also reacts

differently to further user clicks than any other option window or button. Further advancement into the sub-menu structure of the main menu opens another dialogue box that utilizes the familiar color scheme and action-response to user interaction, while simultaneously closing the first main menu window pane (Figure 6). In contrast, other option windows utilize a dropdown or cascading effect so that newer windows partially stack on top of one another, creating a breadcrumb-like path allowing the user to recognize their location within multi-leveled or multi-paged menus (Pannafino 2012).

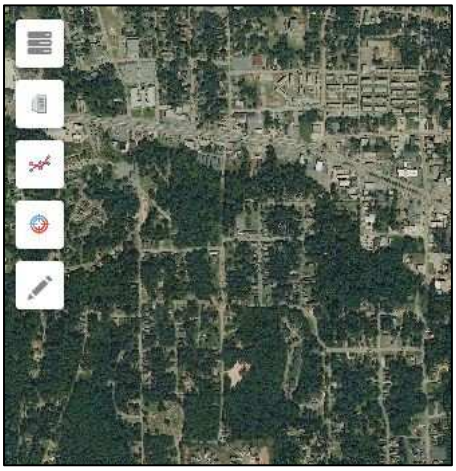
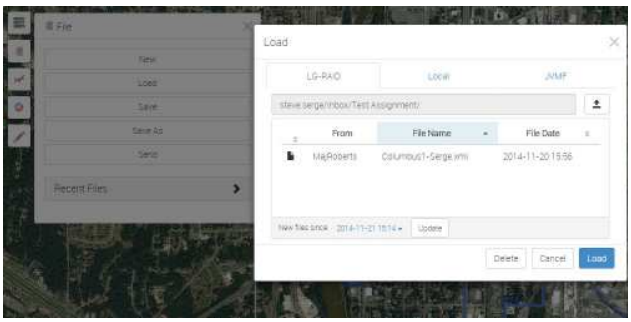


Figure 4: The five menu/function buttons located on the upper left-hand side of the screen.

The initial Main Menu option pane is inconsistent with the rest of the system in terms of both aesthetics and interaction. This violates the Consistency heuristic, which states that design elements should follow a standard and reliable set of actions and layouts (Nielsen 1994; Atkinson et al 2007). The inconsistency in the design of this menu can lead to inappropriate assumptions regarding the actions associated with this particular menu based on the assumptions of interaction results from the other menus in LG-RAID.



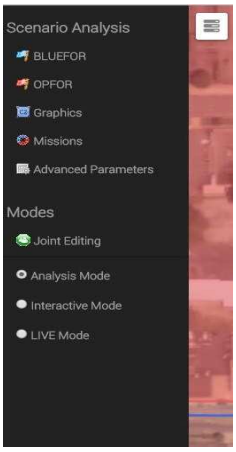


Figure 5: Comparison of system behavior after clicking on one of the five function buttons versus when clicking the "Main Menu" function button.

While this may not seem like a significant UI issue, the creation of a consistent menu design and interaction across the LG-RAID interface lowers the initial time it may take for users to learn how to interact with each menu and sub-menu. Avoiding different menu designs and interactions also helps to

minimize errors that occur as a result of the expectations formed from interactions with other menus in the system. The main menu window should be redesigned to more closely match other menu and option windows that users typically view and interact with while using LG-RAID.

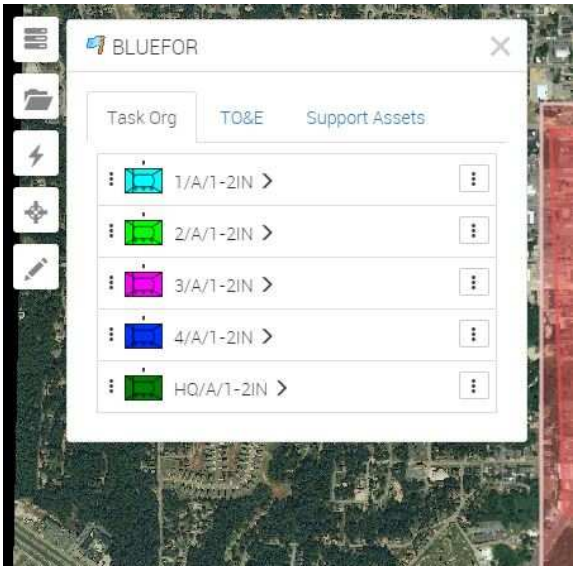


Figure 6: An example of the entity option window that opens in response to a click on "BLUEFOR" in the Main Menu.

4.1.4 COA Analysis and Review

After processing a COA scenario, the system allows the user to review their plan results and provides playback functions and options along the bottom of the LG-RAID window. Users can scroll to specific time frames in their COA, stop and play specific time sequences, and monitor BLUEFOR and OPFOR resources. An additional option allows users to turn on a "Tips and Cues" function during the review (Figure 7). This option presumably provides some insights into possible weaknesses in the current COA and suggests where alternative options should be considered.

Figure 7: The "Tips and Cues" button should provide user feedback after a COA estimate is completed.

However, clicking on the "Tips and Cues" button does not provide the user with any direct information regarding their results. The only feedback the user receives is the fact that the button was indeed clicked. In addition, another dropdown list appears that contains a list of entity indicators, followed by a number. However, the meaning of this list is unclear. This violates the User Control & Software Flexibility and the Software-User Interaction heuristics. According to these two heuristics, the system should provide adequate information regarding user input in order to keep the user informed of the

current system status. The system should also avoid making users feel as though more action is required to complete a response when no further actions are available.

This problem is easily addressed by first ensuring all system features work and respond as intended. In this particular case, the system should provide feedback regarding performance (e.g., actual tips) why certain objects are included in its dropdown list. Redesigning this feature to clearly respond and present information to the user regarding their COA development will help to improve overall usability of this function.

5 DISCUSSION

The military's increasing reliance on simulation for training is partially motivated by the potential cost savings offered by these applications. Thus good design is imperative for military simulation-based training so as to both gain user acceptance as well as achieve the desired utilization of these devices. Much like a first impression, the level of usability often dictates how a trainee perceives their interaction with the system and whether or not they are likely to use that system again. Unfortunately, interface design is often times an afterthought to simulation system performance and features. Research has shown, however, that this may not be the most beneficial approach to instill acceptability and trust in the user regarding the system. UI design considerations, with a specific focus on the end-user's abilities and expectations, should operate concurrently with game or simulation feature and programming development, utilizing a cooperative and iterative design approach.

The use of gaming simulation for training is explicitly called for in the Army Learning Model due to both its generally low cost as well as its proven demonstration of training transfer. Execution of this learning model will not be possible if poorly designed gaming interfaces cause game rejection by soldiers. Similar to above, good usability design is critical to achieve user acceptance of this class of simulation. Interface design must be addressed thoroughly and early in the gaming simulation's development cycle.

In this paper, we conducted a heuristic evaluation of the LG-RAID gaming simulation's interface. We employed Atkinson et al.'s (2007) Multiple Heuristics Evaluation Table to evaluate the simulation's user interface. The usability evaluation of LG-RAID uncovered a wide range of issues that were not considered during the design phases of some specific features and functions in the UI, highlighting the need and importance of usability evaluation during development. We identified four critical shortcomings of the gaming simulation, that when corrected in the next incremental development build, we believe will significantly enhance the user's experience. This in turn will both increase user acceptance as well as subsequent utilization of the application.

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