Game-Based Training for Human-Intelligence Skills

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ABSTRACT

The U.S. Army increasingly relies on game-based training as a tool for skill development in nontraditional areas such as moral–ethical decision-making, social–cultural awareness, and cognitive reasoning. The use of game-based exercises is nonetheless a novel approach for training human-intelligence tasks. Human-intelligence tasks are the actions related to collecting information from people and other sources (i.e., social networks, print and visual media) to identify elements, intentions, composition, strength, dispositions, tactics, equipment, personnel and capabilities. In U.S. Army, human-intelligence skills are taught in a week-long resident course called the Attack the Network (AtN) course. In order to determine the extent to which game-based training provides a meaningful and effective contribution to the development human-intelligence skills, two forms of scenario-based practical exercises were compared in the AtN. Course performance and perceptions of training were compared across students who completed traditional paper-based practical exercises to students who completed game-based practical exercises in the Army's Enhance Dynamic Geo-social Environment (EDGE) desktop training environment. The EDGE practical exercises did no better in increasing end-of-course test scores than did traditional paper-based practical exercises. In addition, the paper-based practical exercises were perceived as more beneficial to learning and course outcomes as compared to the EDGE practical exercises. These results add to the growing literature that fails to find a relative advantage of game-based training. However, these data as well as insights from AtN instructors were used to determine how EDGE may have a greater impact on human-intelligence skills. These insights may have wider applicability for increasing game-based training effectiveness in other contexts.

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INTRODUCTION

The U.S. Army increasingly relies on game-based training as a tool for skill development in nontraditional areas such as moral–ethical decision-making, social–cultural awareness, and cognitive reasoning. Although, game-based training for war planning and execution has been used for years, the use of game-based training at the small-unit level is nonetheless a novel approach for human-intelligence tasks. Human-intelligence tasks are the actions related to collecting information from people and other sources (i.e., social networks, print and visual media) to identify elements, intentions, composition, strength, dispositions, tactics, equipment, personnel and capabilities. In U.S. Army, human-intelligence skills are taught in the week-long Attack the Network (AtN) course. In order to determine the extent to which game-based learning provides meaningful and effective contribution to the development human-intelligence skills, two forms of scenario-based practical exercises were compared in the AtN. Course performance and perceptions of training were compared across students who completed traditional paper-based practical exercises to students who completed game-based practical exercises in the Army's Enhance Dynamic Geo-social Environment (EDGE) desktop training environment.

Attack the Network and Human-Intelligence Skills

AtN is a Joint Forces operational approach to understanding and operating against a well-defined enemy activity that is enabled by a network of identifiable nodes and links (U.S. Joint Forces Command, 2011). The principles of AtN include (a) understanding the operational environment (OE), (b) understanding the network, (c) organizing the fight, (d) engaging the network, and (e) assess the effects. The goals of AtN is achieved through the focused use of intelligence, surveillance, and reconnaissance assets, critical analytical methodologies, and dynamic or deliberate targeting means. The human-intelligence skills that support AtN operations involve the ability to actively gather information from multiple sources, to interpret information and reflect on the meaning, to collaborate and share information, and to consider second order effects (i.e., systems thinking). The Army AtN course focusses on developing these abilities in the context of staff-level information gathering and reporting.

The Army AtN course is a 3-day program of instruction that introduces the fundamentals of human intelligence collection and mission planning for targeting social network activities to battle staff personnel and their supporting Company Intelligence Support Team (CoIST). The targeting principles taught in the AtN course apply to intelligence collections of various social networks (i.e., criminal, friendly, belligerent) with the end state of disrupting enemy network operations. Utilizing ten blocks of instructions, Soldiers are introduced to methodologies and lethal/non-lethal targeting methods to defeat or influence networks in the Area of Operations (AO). A number of practical exercises provide an opportunity for Soldiers to apply human-intelligence skills received during the class.

Game-Based Training in Military Tasks

Games have long been used to train military decision making. The first widely-known military decision-making game was introduced in 1644, and simulations of unit size, terrain, visualization of movement and actions, and rate of individual or unit speed appeared in the early 1800s (Gray, 1995). As commercial off-the-shelf video game technologies were applied to training games, the complexity and "realism" of game-based training has increased. In general, games used for military training are based on role play in which an individual must complete a task as if it were live action. Game-based training has been used to develop military operational knowledge and skills such as planning and decision making and other leadership skills (Beal 2007; Belanich, Silbey, & Orvis, 2004). What is more, games can be used to train both individual skills and collective tasks.

In a sense, military games are simulations of the real world. However, the use of video-game technology offers a low-cost alternative to full simulation or constructive training environments (e.g., Ratwani, Orvis, & Knerr, 2010). In addition to cost, the primary advantage of game-based training appears to increase motivation to train (Dickey, 2007; Ryan, Rigby & Przybylski, 2006; Vogel, Greenwood-Ericksen, Cannon-Bowers, & Bowers, 2006). Learners perceive game-based training as more challenging and engaging than traditional modes of training (Beal, 2007; Belanich, et al., 2004; Ratwani et al.). Game-based training also provides several pedagogical characteristics such as self-paced or individually-adaptive training (Blankenbeckler, Graves, & Wampler, 2013), training complexity (Singer, Long, Stahl, & Kusumoto, 2008; Wolfe, 1997), and higher operational relevance (Lampton, Clark, & Knerr, 2003) that are not easily achieved in traditional modes of training.

However, it is not clear if the apparent benefits of game-based training translate to actual increases in learning or performance compared to traditional modes of training (Topolski et al., 2010). Most research on game-based training effectiveness simply analyzes the increase in performance from a baseline (i.e., absolute effectiveness) as opposed analyzing the increase in performance compared to another mode of training (i.e., relative effectiveness). For example, there are few results that show that game-based training provided larger increases in training performance or retention than direct instruction or paper-based exercises (Hays, 2005). There is also little evidence to suggest that game-based training transfers to actual task execution (Hays; Temby, Stephens, & Whitney, 2008). The lack of research on relative effectiveness and the lack of evidence for task transfer make it difficult to determine if game-based training would be effective for human-intelligence skills. On the one hand, game-based training may be especially suited for human-intelligence skills because complex and ambiguous decision situations can be readily produced in a game environment. On the other hand, the type of reflection and interpretation skills required for effective human-intelligence decisions may not depend on the modality or method of information gathering recreated in game-based training.

Enhanced Dynamic Geo-social Environment

EDGE is a training game developed for the U.S. Army that utilizes a commercial game engine as well as traditional simulation and game industry standards (Dwyer, Griffith & Maxwell, 2011). EDGE allows players to control their in-game first-person avatar in a virtual Operational environment (see Figure 1). Players can navigate terrain, interact with other in-game entities, and use vehicles, equipment and tools to engage in authentic tasks that address training objectives. During a 2013 pilot, first responders from across jurisdictions and other emergency workers (e.g., Homeland Security, police dispatchers) used EDGE to execute on-site interactions and procedures. The results indicated that trainees believed the game play was realistic and prepared them for actual task performance (Dwyer, et al.).

Figure 1. EDGE Avatar in the Operating Environment

The potential advantages to using EDGE to train human-intelligence skills are based on the interactivity of the game. Players can freely move around the AO to interact with host-nation citizens. This capability allows players to formulate a collection plan and react to information provided by in-game actors. What is more, players can observe and react to environmental cues such as the objects in a given area or the behaviors of personnel in a given area. All of these cues can be used both as intelligence information and as indicators for additional intelligence gathering. By providing a context for problem solving and critical thinking, EDGE should enhance the training of human-intelligence skills. In addition, EDGE offers in-game resources such as maps, pull-down menus, non-player avatars, and help functions in order to support the development of skills.

METHOD

The basic methodology consisted of collecting pre-test and post-test scores and survey data from Soldiers completing the AtN course using either paper-based exercises (i.e., Control Group; *n* = 100) or game-based exercises (i.e., EDGE Group; *n* = 89). Classroom instruction was constant between the groups and only the types of practical exercise varied between experimental conditions. Data was collected at seven Army installations, which were a combination of active component, reserve component, and National Guard in both the contiguous United States and outside the contiguous United States. Each AtN class was quasi-randomly assigned to one of the two experimental conditions (i.e., Control or EDGE). Because the entire class participated in the same condition, the two experimental groups somewhat differed on the number and types of military occupation specialty. In addition to the student data, AtN instructors were interviewed to get their post-training reactions to the EDGE exercise.

Materials

Pre-test and Post-test

The AtN course test consists of 27 completion (i.e., "fill-in-the-blank") items for six problem-based themes: (1) Understanding the mission; (2) Understanding the Operational Environment; (3) Understanding Networks; (4) Organize for the Fight and Engage the Network; (5) Targeting; (6) Assessment (e.g., was End State achieved?). The course test was used as the post-test, and an alternate form of the course test was developed by course managers to be used as the pre-test. Both tests addressed the six course themes and assessed the same type of information but differed in specific content. The tests were scored by AtN course instructors according to the approved course scoring rubric. There were a total of 100 points possible on each test.

Paper-Based Practical Exercise

Students were divided into small groups depending on class size and remained with their assigned group through completion of the Practical Exercise. The paper-based AtN Practical Exercise consisted of an introduction and a four-part scenario-based problem. Each part had a specific goal for the group to complete (e.g. determine any critical gaps in information) that corresponded to the four blocks of instruction (i.e., Operational Environment Analysis, Pattern Analysis, Network Analysis, and Targeting and Assessment). The scenario for each part was provided in a written hand-out, and each group was given a booklet with information about the AO (i.e., an intelligence brief). The groups were required to justify their decisions for each part during back briefs to the commander role-player in the classroom and were given feedback on those decisions. The paper-based practical exercises required students to develop and use a pattern-analysis tool and an activity matrix in order to monitoring network actors (e.g. bomb makers, planners, and videographers) and network locations (e.g. auto shops and shopping markets).

EDGE Practical Exercise

Students were divided into small groups depending on class size and remained with their assigned group through completion of the Practical Exercise. The entire class was introduced to the EDGE game (e.g., using action menu and controls) and completed familiarization with the action menu. The EDGE-based Practical Exercise consisted of six virtual-world days of human-intelligence activities in a fictitious country. After the introduction, students began game-play by entering the virtual OE, were directed to reference materials (e.g., pattern-analysis tools), received an OE brief and operations order from a Commander avatar, and were directed to pay attention to the descriptions of the operational variables and civil considerations in the AO. The goal of the game was to interact with friendly, neutral and hostile avatars in the OE, collect and disseminate information between group members, and collaborate on decisions to support, monitor, or neutralize networks. Specific task challenges and decision-making events were conducted during virtual Days 1 – 6. These task challenges mirrored the blocks of instruction (i.e., Operational Environment Analysis, Pattern Analysis, Network Analysis, and Targeting and Assessment). On virtual Day 7, each group received a virtual After Actions Review (i.e., feedback) on courses of actions and the first-order effects and second-order effects of their decisions.

AtN Post-Training Questionnaire

The AtN Post-Training Questionnaire captured participants' post-training perceptions of the AtN practical exercises. The questionnaire contained 16 items to capture perceptions of how the practical exercises influenced learning of specific AtN skills and of overall understanding of AtN concepts. The items were rated on a 4-point Likert-type scale with anchors at "strongly agree" and "strongly disagree."

AtN Instructors Interview

The ATN instructors interview consisted of open-ended questions on EDGE benefits, challenges, and lessons learned. Each of the four instructors who used EDGE for practical exercises were interviewed. The interview occurred one-week after course completion and lasted about three hours. The instructors, to the best of their ability, provided candid answers to interview questions. Responses where sorted by themes across all questions, and particularly salient responses were noted.

Procedure

The pre-test was administered prior to classroom instruction to assess Soldiers' existing level of knowledge on conducting attack-the-network related activities. Soldiers were given 45 minutes to complete the pre-test. Classroom instruction for all students included ten blocks of instructions. Each block of instruction lasted approximately two-hours and introduced students to methodologies and lethal/non-lethal targeting methods to defeat, enable, or influence networks in an AO. Participants in the Control Group were given a paper-based practical exercise at the end of each block of training and completed the practical exercises as previously described. Participants in the EDGE Group were given the game-based practical exercise after the final block of training on the last training day and completed the practical exercise as previously described. As a consequence, the Control Group received distributed practical exercises and feedback while the EDGE Group received a single i.e., blocked) practical exercise and feedback. This procedural confound will be addressed in the Discussion section. A summary of the critical procedural characteristics for each condition is provided in Table 1.

Table 1. Procedural Comparison of Control Group and EDGE Group

	Control Group	EDGE Group
Learning Objectives	•Operational Environment Analysis •Pattern Analysis •Network Analysis •Targeting and Assessment	•Operational Environment Analysis •Pattern Analysis •Network Analysis •Targeting and Assessment
Participation	•Small Groups	•Small Groups
Resources	•Analysis Tools •Activity Matrix •Instructor	•Analysis Tools •Activity Matrix •Embedded Resources
Sources of Information	•Scenario description	•Discovered in Virtual Environment
Frequency of Practical Exercises	•After each block of instruction (4)	•At the end of the course (1)

After the completion of all practical exercises, students were given the post-test. Again, students were given 45 minutes to complete this test. Once the post-test was completed, the AtN Post-Training Questionnaire was administered. Students were given as much time as necessary to complete the questionnaire, and most students finished the questionnaire in about 15 minutes.

RESULTS

Pre-test and Post-test Scores

The percent correct on each AtN course test was compared in a 2 (pre-test, post-test) X 2 (Control Group, EDGE Group) mixed-factors ANOVA at the .05 level of *alpha* error. Even though test scores increased nearly 35% ($F(1, 187) = 636.76$, $MSe = .02$, $p < .01$), there was no difference in test-score increase between the experimental conditions ($F(1, 187) = 2.87$, $MSe = .02$, $p = .09$). Figure 2 presents the percent correct for each test across experimental groups. The results indicated that the course and practical exercises were effective at increasing human-intelligence skills. However, the game-based training did not have unique effect on the improvement of skill. If game-based exercises provided additional benefit to the AtN course, then the EDGE Group should have a greater increase in scores than the Control Group.

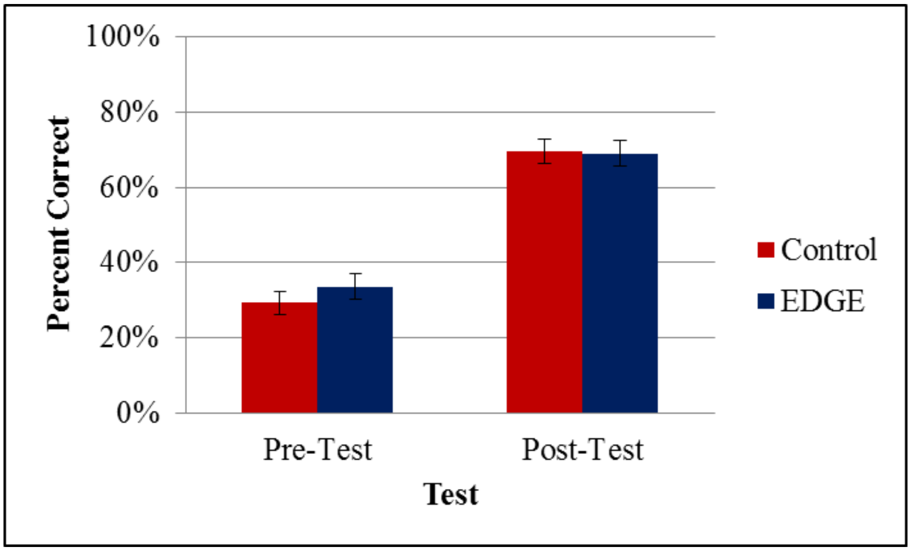

Figure 2. AtN Pre-Test and Post-Test Percent Correct for each Experimental Group. Error bars represent 95% confidence intervals.

AtN Post-Training Questionnaire

The response frequencies for each of the 16 statements were analyzed with chi-square to determine (a) the perception of the impact of the practical exercises on training effectiveness and (b) experimental group differences in those perceptions. The response frequencies for all 16 statements showed that students overwhelmingly “agreed” (or “strongly agreed”) with all 16 statements. The high level of “agree” responses indicated that the practical exercises were perceived as effective for training. The pattern of responses differed between the two experimental groups for six of the 16 statements. For statements that differed, the Control Group had more “agree”/”strongly agree” responses and fewer “disagree”/”strongly disagree” response than the EDGE Group. Table 2 provides the response frequencies for the questionnaire items that differed between experimental groups.

As with the results for the AtN course tests, the results of students’ perceptions of the practical exercises indicated that the training was effective but there was little difference in effectiveness between experimental groups. The few group differences that emerged in the students’ perceptions data, however, appeared to favor the paper-based exercises as the more effective training. The reason for the more favorable perception of paper-based exercises was unclear. One speculation was that the paper-based exercises required more instructor-student and student-student interactions.

Table 2. Statistically Significant Response Frequencies across Experimental Groups on AtN Post-Training Questionnaire

Item	Group	Strongly Disagree	Disagree	Agree	Strongly Agree	
The Practical Exercises provided challenging experiences.	Control	0	3	49	48	$\chi^2 = 16.51$*
	EDGE	2	13	51	23	
The Practical Exercises had a valuable impact on my decision-making skills.	Control	0	5	55	40	$\chi^2 = 11.77$*
	EDGE	2	12	56	19	
The Practical Exercises helped me focus on Attack the Network mission concepts	Control	1	2	43	54	$\chi^2 = 15.08$*
	EDGE	3	7	54	25	
The Practical Exercises helped me understand information collection and Operational Environment analyses.	Control	0	5	43	52	$\chi^2 = 9.06$*
	EDGE	1	5	55	28	
The Practical Exercises was a valuable learning experience.	Control	0	2	41	57	$\chi^2 = 9.15$*
	EDGE	1	7	46	34	
The Practical Exercises allowed me to practice measuring Attack the Network level of effectiveness	Control	0	2	60	38	$\chi^2 = 12.59$*
	EDGE	0	13	55	21	

AtN Instructors Interview

Seventy-five percent of instructors' responses indicated that the most beneficial aspect of the EDGE practical exercise was encouraging students to "reach back" for handouts and notes. Doing so likely helped to reinforce key points from the class lecture. Twenty-five percent of the responses noted that the embedded queues (e.g., Battle Update Brief) were helpful with feedback that summarized prior in-game actions by both Soldiers and virtual players. The instructors agreed that the biggest challenge with using EDGE was limited access to dedicated fixed training facilities. Because AtN was taught as a mobile-training course, there was difficulty ensuring appropriate power supply and adequate classroom size. In addition, the instructors commented that out-of-date hardware to support software requirements often delayed or interrupted the flow of training. These delays and interruption may had some residual effect on participant's favorability rating of game-base exercise use. While the issues with the training facilities may have been idiosyncratic to AtN, the comments do highlight the fact that game-based training is not immune to environmental effects.

There was general agreement among instructors on lessons learned for using EDGE in AtN that may help improve game-based training in general. The first lesson learned was to provide an opportunity for trainers and learners to play the game often. One noted comment highlighted accessibility or need for on time, anywhere learning (e.g., rehearsal, drills, and refresher) for the soldier. The second lesson learned was to use the game storyline, embedded feedback (e.g., briefings), and other in-game support (e.g., charts and matrices) to gage learning and stimulate recall. The third lesson learned, as previously mentioned, was to ensure the training environment supports the physical requirements of the game system. Classroom design matters when setting-up computer systems for group activities, especially when the game facilitate group interaction.

DISCUSSION

Clearly, there was no advantage for game-based training in the present comparison. In this case, EDGE was used to deliver practical exercises as part of the Army's AtN course. The game-based (i.e., EDGE) practical exercises did no better in increasing end-of-course test scores than did traditional paper-based practical exercises. In addition, the paper-based practical exercises were perceived as more beneficial to some learning and course outcomes than the game-based practical exercises.

However, caution should be taken in interpreting these results because of procedural differences in the two training conditions. Students who used paper-based practical exercises completed the exercises after each phase of instruction, while students who used the EDGE practical exercises did so only at the completion of classroom instruction. That is, the paper-based practical exercises were spaced across sessions, whereas the EDGE practical exercises were massed into one session. It may be the case that the students who used paper-based practical exercises received a distributed-practice benefit to decision-making skills (Crowder, 1976; Taylor & Roher, 2010). In addition, the paper-based practical exercises required instructor guidance, and the instructor was involved with answering students' questions. By contrast, EDGE guided the flow of information and the nature of student interactions with minimal instructor involvement. As such, students who used the paper-based practical exercises may have received a benefit from instructor interaction (Thurmond & Wambach, 2004).

In fact, the results highlight the importance of the level of instructor interaction to game-based-training effectiveness. One consistent finding in game-based training research is that games are most effective when used as supplemental training instead of primary training (Beal, 2009; Pleban & Salter, 2001; Ratwani, et al., 2010; Topolsky, et al., 2010). This finding, however, runs counter to the stated advantage of game-based training, i.e., games provide a motivational pull to self-learning (e.g., Ryan et al., 2006). The motivational benefit of game-based training assumes that player engagement and exploration allows the individual to "discover" the learning objectives (Blankenbeckler, et al., 2013; Dean & Kuhn, 2007). This type of discovery learning is only effective with high-performing individuals or with individuals who have familiarity with the task (Hammond & Gibbons, 2001; Hess & Holloway, 1984; Kalyuga, Ayers, Chandler, & Sweller, 2003). By contrast, novices require training material that focuses on surface features of a task that guide the execution of the task (Applebee & Langer, 1983; Ericsson, Krampe & Tesch-Romer, 1993; Palincsar, 1986).

In the case of AtN, the free-play nature of EDGE may not have provided enough structure and guidance for human-intelligence-skill novices. It may be argued that in-game resources (e.g., pull-down menus, and help functions) provide similar types of information and guidance as instructors but are always available. However, the in-game resources may not always have the high-level understanding of the skills or the ability to adapt responses to learners needs. Consequently, more sophisticated models and designs may be needed to develop in-game resources as pedagogical tools (Arbaugh, 2008; Brown & Klein, 2008).

The purpose of the research reported here was to investigate the extent to which game-based training could be used to enhance the training of human-intelligence skills. These results add to the growing literature that fails to find a relative advantage of game-based training (e.g., Topolski, et al., 2010) and highlight the need for more controlled comparisons of game-based training effectiveness. Of course, game-based training may still hold promise for training human-intelligence skills. EDGE supported several functions critical for developing human-intelligence skills. First, EDGE provided performance-feedback on decisions made while in play, which is critical for learning in virtual environments (Blaiwes, Puig, & Regan, 1973; Bransford, Brown, & Cocking, 2000). Second, the simulated multi-day scenario allowed periods of reflection and opportunities for self-learning (Bringle & Hatcher, 1999) that were not available in the paper-based exercises. Third, EDGE provided opportunities for unscripted interactions with host-nation citizens that were not possible in the paper-based exercise. Finally, the visual characteristics of the game environment allow students to develop information from non-verbal cues (Hinde, 1972; Knapp, Hall, & Horgan, 2013). Obviously, the generality of the current results should not be overstated, and additional empirical research is needed to further clarify the potential effects noted here.

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