Developing Game-Based training for the Military: Challenges and Opportunities

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ABSTRACT

Interest in using game technologies to improve workplace skills has been growing in recent years. While there are several potential advantages for a game-based training approach (cf. Cannon-Bowers & Bowers, 2011), a number of challenges confront developers who seek to create the technology. The greatest challenge is the need to rethink and integrate several traditional processes and resources, including front-end analysis, developing and managing art assets, programing within a game engine, play testing prototype versions of the game, and ultimately measuring training effectiveness. Each of these must be balanced against cost and schedule constraints. In this paper, we discuss an innovative, comprehensive approach to developing game based training on a large scale for the Navy's Littoral Combat Ship, and demonstrate how it can be generalized to other applications.

ABOUT THE AUTHORS

Bill Rebarick PhD, General Manager of CALS, is a current organizational executive who has dedicated himself to helping the Navy and Cubic develop high-performers through innovative learning solutions. His goal is to develop and deploy game-based training to improve learning and work performance across a variety of fields.

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WHY GAME-BASED TRAINING?

Many modern workplaces are characterized by the requirement to operate and maintain complex, dynamic systems. Often these systems are difficult to learn, especially in the numerous contexts in which they must be used. In the past, many organizations have relied on on-the-job training to train new workers, but it is often not a viable strategy due to the time required and inconsistency of results. Coupled with increasing demands to cut training budgets, new approaches and methods for training complex skills are required. Hence, the onus is on training researchers and developers to identify new training environments that can be used to deliver training in an effective, yet cost-managed, way.

One approach that is being explored to meet these challenges is the use of game-based training. Game-based training is a type of training that uses commercial game engines to deliver some or all of the learning content. Researchers have articulated several factors that might be advantages for game-based training. For example, it has been suggested that games are inherently motivating. This increase in motivation can result in greater time-on-task and, subsequently, greater learning (Cannon-Bowers & Bowers, 2009). Others have suggested that game-based training tools allow "situated learning." That is, it allows trainees to acquire knowledge and skill in the context in which it will be applied. Situated learning is thought to lead to superior knowledge organization and long-term retention (Gee, 2003). Finally, in many situations, game technologies can allow trainees to derive many of the benefits of simulator-based practice at a low cost. This is particularly true for those tasks where the fidelity of haptic cues is not essential to performance (Cannon-Bowers & Bowers, 2008). For example, Wouters and colleagues demonstrated that that game-based training resulted in 61% greater learning and retention than did conventional training. Further, recent research has (Schatz, et al., 2012) asserted that game-based training performed in the trainees workplace environment may reduce training costs by as much as 98%, due in some part to manpower reductions as great as 95%. The authors point to several case studies. When the Tactical Action Officer Intelligent Tutoring System (TAO-ITS) was integrated with an existing system, the Surface Warfare Officer's School reduced the number of instructors per 42-student class from 21 (a 1:2 teacher:student ratio) to 2 (1:21). Similarly, The IATS shipboard maintenance training environment reduced the cost per seat from $1,172 to $28 per year (Madni, Sorensen, & Madni, 2005).

The potential of these benefits contributed to the U.S. Navy's decision to adopt game-based training for the new Littoral Combat Ship (LCS), which is largest game-based training development program in history. The goal is to embed 10,000 hours of training content into a game-based format. As this effort moves forward, a team of learning experts, game developers, instructional designers and others are working together to combine the state-of-the-art in learning science with the best gaming technologies to create effective training (Howard, 2013). In so doing, the team has confronted several challenges. In this paper we will discuss some of those challenges and how we are attempting to overcome them.

THE LITTORAL COMBAT SHIP: TRAINING CHALLENGES

The LCS is a new US Navy warship that is designed to be used relatively close to shore. The innovative design of the LCS imposes a number of challenges for training. First, there are two different variants of the ship being developed. As such, trainers must understand the numerous differences between the two versions and develop training that is equally effective for each. Second, due to minimal manning requirements, LCS sailors will not have the opportunity to receive any on-the-job training when they report to the ship. Instead, sailors must be fully trained prior to beginning their tour. A third challenge for training is that the LCS is designed to be modular, accommodating multiple missions, such as Anti-Surface Warfare, Intelligence, Special Operations, and so forth. Each of these missions imposes different training demands on the crew. The crew that operates the ships must work with the mission module operates, placing a further demand on team training. Obviously, training designers must also consider the implications of these multiple roles. Furthermore, there are training demands associated with the actual change-over of the ship from one mission package to another.

Finally, it is important to point out that the LCS is conceptualized as a new element in naval warfare. Therefore, there are few subject matter experts, little strategic knowledge, and no historical scenarios upon which to draw. Training designers must try to anticipate future performance issues to develop the initial training for the ship. Furthermore, they must develop a system that allows easy, inexpensive integration of new training material as it becomes available.

INTEGRATING LEARNING SCIENCE AND GAME DESIGN

The use of gaming technologies to deploy training systems is in its infancy. For the most part, game-based training systems have been developed with R&D funding for relatively limited tasks, simply to examine the possible effectiveness of the approach. Consequently, these systems have often been developed by computer professionals who are not well aware of contemporary findings from learning science. Research has uncovered that firms rooted in learning sciences are not always equipped to build virtual learning environments, and that gaming-oriented organizations are also not equipped to create useful game-based training (Squire, 2013). Instructional designers and other training professionals are often unaware of many game features or their appropriate use in the training context. These two groups must work together to accomplish all of the tasks required for the overall program to be successful. In the following sections, we discuss some of the issues that have confronted the LCS team as we work through each stage of the training development process.

Training Needs Analysis

Training needs analysis is the process by which training designers identify the required content for training. (Moore & Dutton, 1978). These analyses are often accomplished by using established operating procedures, expert opinions, and so forth. Although these are available to some extent in for the LCS, the ships are undergoing extensive changes as initial sea trials and deployments are completed. Because the ship class is so new, there is also a lack of experienced LCS sailors to serve as SMEs. These factors have caused us to develop flexible data collection techniques to accommodate the instability of task- and ship-related data. In addition, our architecture decouples the physical ship model from the human task network so that changes to either can be accomplished independently.

Another important aspect of training needs analysis is consideration of the learner, or "person analysis" (Goldstein & Ford, 2002) to determine how best to tailor the trainees' needs. An interesting aspect of game-based training is that its effectiveness seems to be somewhat dependent upon learners' beliefs about their ability to play games (Ortiz, et al. 2014). Therefore, it is important to assess these beliefs and to design the training to increase the learner's perceived ability to interact with games. This might take the form of graduated tutorials or other "success experiences" designed to increase self-efficacy early in training. Our plan for the LCS game-based training is to implement such a strategy.

By the same token, an organizational analysis is typically conducted to understand the context in which the training will be conducted. This type of analysis reveals the conditions that may facilitate or hinder training success. In the case of LCS, some of the considerations that we have addressed involve the physical set up of classrooms, whether after-hours lab time will be available and how instructors will be trained. Regarding this last consideration, we are developing and implementing a train the trainer course to introduce instructors to the course. This will entail familiarizing instructors with the game and the manner in which trainees interact with it; introducing instructors to the instructor-operator station with which they will interact to deliver instruction; and providing instructors with details about how their time and expertise is best allocated in a game-based training environment. The course will be delivered as a simulated student environment where the instructor will be faced with the challenges of managing students in a virtual environment. We believe that this is a crucial success factor in the training system's ultimate effectiveness.

Similarly, it is important to assess attitudes towards game-based training. It has been demonstrated that trainees' expectations about training are an important predictor of that training's eventual success (Tannenbaum et al., 1991). If trainees have poor expectations about "games," these may lead to negative learning outcomes. Therefore, there is a need to assess these attitudes and to share information about the effectiveness of game-based training when required. This goes for instructors and administrators as well.

Media Selection & Game Design

After completing the training needs analysis, training developers must identify a set of learning objectives. For each objective, the designer is required to identify the optimal media to accomplish the objective. This typically takes the form of selecting between traditional training approaches such as lecture, demonstration, and so forth. In the case of game-based training, this takes the form of identifying the specific game features that support the learning objective. Procci and Bowers (in press) have recently reviewed the research in this area, and that research is informing the LCS effort. Specifically, we have complied a list of learning strategies—for example, scaffolding, hints, cues and other forms of guidance; worked examples; interactive demonstrations; practice strategies; etc.—and for each of these have identified clips from entertainment video games that instantiate that strategy. The result is a large matrix that defines a set of discrete instructional interventions, along with a description of when the strategy can be used and a video clip that demonstrates it concretely in a game. In this way, our game-based learning scientists are able to communicate with the design teams (which consist of instructional designers and SMEs) and also with the game programmers in a very specific way.

Game elements can also be used to augment feedback. For example, game designers often reward players for effective performance by giving them "badges" or other tokens of achievement. Blair (2011) demonstrated that these achievements can be used to improve learning outcomes if applied correctly. He demonstrated that game-based achievements could be used to deliver immediate feedback without the distraction effects normally associated with that approach. This immediate feedback leads to better learning and retention. For LCS, we will not necessarily reward learners with badges, but intend to investigate alternatives that are appropriate for Navy sailors.

Game-based training also imposes additional demands upon developers. Specifically, there are aspects of games that, although not directly related to learning, influence the effectiveness of these games. For example, researchers have emphasized the importance of narrative in the creation of effective games (Dickey, 2006). Game narratives can be used to create immersion, allow learners to organize new knowledge, draw attention to specific cues and so forth. The effective use of narrative is not typically considered by instructional designers, but may be a critical competency for this new training technology. For the LCS, we are embedded the learning content into a realistic story line that mimics the actual schedule of a ship. We intend to use this narrative to frame the learning, to create a sense of immersion in a realistic environment and to heighten engagement. Within the larger narrative, we will embed story arcs that add challenge and enhance motivation.

Asset & Model Management

The overall LCS training effort requires that thousands of elements be modeled in order for sailors to learn all of the necessary tasks. Managing these assets is a formidable challenge in any large game development effort (Jacobson, Schlenker, & Edwards, 2005). Added to this challenge in the case of LCS training is the need for training developers to be able to articulate which of these assets are required for any given learning event. To our knowledge, this is the first time that this issue has been encountered at this scope. There was a need to create a system that allows training professionals to communicate asset needs to the staff programming the system.

Our approach to confronting this challenge is to use the Ship's written procedures as a point of integration between the art assets, modeled behavior of the ship and learning content. On the one hand, SMEs are using these procedures to identify all equipment (down to specific components) that must be accurately represented and modeled. This component list is matched to videos and still pictures so that artists can render them accurately. These same procedures form the basis of "encoded procedures" which describe the human task progressions necessary to perform the tasks. Finally, encoded procedures are used by design teams to construct instructional flow. Specifically, designers will script dialog by the mentor avatar or other non-player characters by annotating specific points in the procedure. They will also indicate where instructional features are embedded (e.g., adding hints) by indicating this in the encoded procedures.

Multi-component Evaluation

Game-based training requires additional evaluation components that are not common in traditional training. One such requirement is to evaluate *usability*. It has been demonstrated that the usability of an educational game is an important predictor of eventual learning (Schwabe & Goth, 2005). It is important that the user understands the interface and how to use it. Further, the learner must understand how to navigate through the software, understand messages from the system, and recognize critical cues. Olsen, Procci, and Bowers (2010) describe an iterative process for evaluating the usability of serious games. These researchers argue that usability analysis should include a series of small studies in which both observation and subjective assessment is used to identify usability shortcomings. After each of the sessions, designers and programmers work together to create solutions to observed problems. This pattern continues until all pre-established usability metrics have been accomplished. The LCS team will implement this iterative approach to usability so that we ensure success.

A similar, equally important, evaluation need is *playability*. Playability refers to the degree to which learners can understand how to accomplish goals within the game (Dersuvire, Caplan & Toth, 2004). This includes how to move the avatar, how to achieve good scores, how to accomplish assignments within the learning module, and so forth. Playability is frequently accomplished using trained play-testers. Our approach to play testing is to create internships for students who will function part time in our development labs. Many of them are avid gamers and while not very experienced in traditional quality assurance functions, are well suited to play testing.

We have found that a tester that is familiar with gaming is more apt to not only make better playability improvement suggestions, but also provide input on creating techniques that can emphasize a learning objective. This finding is backed by recent research that found a similar correlation amongst students using game-based training that had expectations of positive outcomes (Snow, 2013), whereas individuals pre-disposed to a positive expected outcome will improve their experience.

Of course, there is also a requirement to monitor the learner's performance and learning retention. The system must monitor the learner's behavior, make an assessment about the state of their learning, and provide additional learning content for remediation. This requires creation of an intelligent tutoring capability that will automatically track, diagnose and assess performance. For LCS, we are developing this capability so that learners can receive immediate and/or post exercise feedback, as well as recommendations for remedial activities.

Multi-Disciplinary Team

One of the most important lesson learned from the LCS game-based learning development experience to date is recognition of how important it is to have a well functioning multi-disciplinary team. Perhaps more than any other instructional or system design effort, developing an educational game requires collaboration across disciplines. Our team is comprised of a variety of competencies, including: subject matter experts, instructional designers, artists, game programmers, game designers, game producers, human performance experts, learning scientists, systems engineers, quality assurance experts and program managers/administrators. It was essential that the cultural differences among these disciplines be addressed early in the program, and we continue to look for ways to improve communication and workflow.

Conclusion

At just over one year into the contract for game-based learning for LCS, we have confronted a number of challenges that are unprecedented in more traditional courseware development. For the most part, our attempts to meet these challenges has been successful. We are currently in full production of the first major milestone—Learning Strategy Reports—that communicate the content and associated learning strategies for each lesson. The next phase of production will be creation of Storyboards, which commence in several months. At that time, the integration of all phases of the process will commence as we move into actual game development and on-screen reviews. Overall, we remain confident that our efforts will yield an effective and exciting training system

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