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Conventional Training Versus
Game-Based Training

Navy Serious Games for Training (N-SGT) Methodology and Toolkit

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Section 1.0

Overview

The United States needs the best Navy possible – one that can demonstrate, innovate, and perform with expertise throughout the ranks. Yet the Navy, as with many organizations, finds itself needing to do more (e.g., better and faster) with fewer resources. Interestingly, this can be a time for innovation where we more closely define and develop the most effective performance.

As part of the U.S. Navy's *Revolution in Training* Report (*Executive Review of Navy Training*, August 8, 2001), there is a call to incorporate new technologies in order to increase readiness and training quality. Game-based training, or *serious games*, has emerged as one approach to revolutionize training. Serious games take advantage of the cognitive complexity and authenticity of entertainment games, as well as ease-of-use and affordability of their development environments. They also facilitate a range of Human Performance Improvement (HPI) issues, that include training as well as other solutions that result in effective workplace performance (Appelman & Wilson, in press). For example, a serious game may serve as a way to improve processes or as a way to improve motivation.

Yet, there is limited research comparing specific variables of game-based learning with variables of traditional learning approaches (e.g., motivation, interaction, engagement, transfer), or how games can be effectively integrated with traditional training approaches. Few guidelines exist to guide the decision-making process for determining when a game-based approach is the most appropriate and effective way to support learners in reaching specific training objectives.

To address this issue, our team has developed the **Navy-Serious Games for Training (N-SGT) Methodology and Toolkit**. This Toolkit consists of the following:

1. A methodology for choosing when to use a serious game, that is based on theory and research on science of learning (e.g., expertise, decision-making, and problem solving), human performance training (HPT), instructional design methodologies/strategies (e.g., problem based learning, scaffolding), along with the core strengths that serious games have to offer (e.g., complexity, visualization, interaction).
2. A multidimensional taxonomy/matrix that maps training objectives and learning processes with game characteristics, in order to inform and guide decision-making processes for choosing and using specific game-based training approaches;
3. Guidelines for using the methodology and taxonomy/matrix to choose game-based training solutions, or to design new games and/or approaches; and
4. An authoring tool prototype that provides guidance for developing game-based training solutions.

The goal of these products is to provide decision-makers in the U.S. Navy with the analysis processes and decision-making tools necessary to determine when a serious game is an effective training tool that is also cost- effective and efficient.

The N-SGT Methodology and Toolkit will solve a significant problem in training both within DoD and the larger training community. As game-based approaches to training are rapidly adopted, organizations are struggling to determine not only when it's the best approach, but also how and when to make the decision to use them. This product will help address both of these problems by providing a systematic way to analyze the relevant variables and make informed decisions about when games are an appropriate part of the learning environment and how they may best be integrated. This should result in cost savings and improved training impact as better decisions are made.

The foundation of the N-SGT Methodology and Toolkit is based on scientifically valid data that informs decision-making processes. However, as serious games research continues to evolve and further studies are conducted, these outcomes need to be integrated into the N-SGT framework. In fact, the N-SGT authoring tool addresses this issue by providing links to relevant research summaries. Additionally, our team would contribute to this research by conducting a study of the use of a serious game within a Marine Corps course that orients NCOs on command operation center (COC) operations. The design, development and implementation of this game will be documented, and its learning effectiveness will be researched and examined in detail. This will contribute to Navy's understanding of how to most effectively design and use games to support effective and efficient learning, as well as return on investment.

The next sections provide a literature review on the relevant aspects that support understanding issues of game-based versus traditional training. Also, the Methodology, Toolkit and COC game effort are also described.

Section 2.0

N-SGT Methodology

2.1 Introduction

In the following section, the N-SGT Methodology is provided as a set of guidelines that support decision-makers in the U.S. Navy with the process of analyzing and choosing whether or not to use a game-based training approach. The intention of this methodology is not to provide automatic *yes* or *no* answers. Instead, the goal is to lead the decision-maker through an analysis process to determine whether using a serious game is the best approach to support Human Performance Improvement (HPI). As part of the HPI process, factors other than training are considered as part of the decision-making process.

Unlike other methodologies that focus almost exclusively on selecting media based on analyzing learning objectives, this methodology considers the decision-maker's priorities. This is critical since Sugrue and Clark (2001) have found that media selection decisions are often made for economic and practical reasons rather than based on an analysis of learning factors. In fact, it is quite rare that we hear that an instructional designer went through a media selection process and determined that using a serious game would better support meeting specific learning objectives better than other media-based approaches. Instead, what often drives the use of serious games are the practical and economic reasons. This may include increasing learner motivation, providing greater access to instruction, enabling a more complex and interactive learning experience, or helping an organization serve as a leader or innovator. In choosing and using game-based training approaches, a wide range of real world factors must be considered. While this methodology is not exhaustive of all factors, it serves as a model that can be continually expanded and updated based on emergent issues and research in the area of game-based training.

2.2 Reasons for Using a Serious Game

As explained above, there are many reasons both practical and economical. As one example, Roberts, Diller, & Schmitt (2006) examines reasons why the DARWARS game, *Ambush!,* has been adopted and used by a wide range of users, from the National Guard to the Emergency Operations Center at Ft. Polk. The reasons given were:

- The focus of the game (e.g., small unit operations) was an underserved training niche not being addressed by other training initiatives

- The type of training was judged to be critical by troops who had been deployed
- The game had a short game development and deployment cycle
- The game could serve as a supplementary training tool
- It was well-tested and had a well-documented training approach
- Developers could modify scenarios
- It could amplify other forms of training, such as field training
- It provided support to training community
- Organizational support helped maintain the game's visibility (e.g., organizational marketing of the game)

Additionally, they also examined obstacles given by those who did not use the game. These obstacles included high turnover of command staff, difficulties with installation on government hardware and networks, and misperceptions that the game was a trainer in and of itself rather than a stage where learning occurs. While this is only one study, it does point to the fact that adoption (or lack of adoption) of game-based training is often less about research on how to best support learning and more about factors that relate to organizational and strategic change. This is not to say that meeting specified learning objectives is not important. In fact, many instructional design guidelines focus heavily on determining whether a specific medium will support the learner in meeting specified learning objectives. However, it may be the case that this is not the primary determinant for choosing a technological medium, even for instructional designers.

Another problem may be with the models themselves. In a 1981 study of media selection models conducted for the U.S. Army Research Institute, Gagne, Reiser & Larsen found that the majority of instructional designers stated that they did not often use media selection models because they were too difficult and complex. However, there may be two reasons for this. First, it may be the case that the media selection approach is not the initial driving force to choosing whether a game-based training approach will be used or not. Second, it may be that, as Sugrue and Clark (2000) state, even with media selection models available, decision-makers may hold inaccurate assumptions about learners and learning processes,

Even if we had the perfect media selection model, we are now challenged to expand our notions of how we define learning and assessment, particularly within a game-based environment where knowledge cannot be easily separated into facts, concepts, and procedures. Instead, serious games are often based on real world scenarios where complex problem solving and decision-making actions are required. It is also an environment where the *process* of learning is as important as the *product* of learning. Because serious games often reflect real-world contexts and problems, there is often no one right answer. Instead, context- and domain-specific knowledge become central to defining what is being learned and what should be learned. Hence, dissecting serious games into a series of simplistic learning objectives (e.g., recall, recognize) and assessing using these same means fails to capitalize on the strengths of learning that game-based training offers.

In summary, as part of the development of the N-SGT methodology, it was important that we address these multiple factors contributing to the selection of media to include variables of organizational and strategic change, and build on the key strengths of games as both an instructional and learning approach.

2.3 Game-Based Training versus Traditional Training

Since the use of serious games is a relatively new approach for training, many persons in different jobs and fields, particularly the military, are regularly requesting calls for more research, specifically on *whether game-based training is better than traditional training*. This calls to light some important points that need clarification.

1. Each time a new technology emerges to support learning, there is a wave of cries from users to compare one medium to another to see which one is best (e.g*., is e-learning better than classroom*). However, simply comparing *game-based training* with *traditional training* without any specification of the types of instructional methods or variables to be examined is asking the wrong question. Why? Several decades of educational research has indicated that types of *instructional methods* influence learning far more than type of media used. To summarize this research, Clark (2001) analyzed both media comparison studies as well as meta-analyses of these studies and found no significant difference when only media were compared. However, significant differences were found with comparisons of instructional methods. (Instructional methods define the types of teaching and learning activities that are distinguished by a pattern of communication among teacher, learner, and different types of materials (Molenda & Pershing, 2006). In fact, Shaffer (2006) has argued that in comparison studies, we need to examine specific variables (e.g., interaction, motivation) or attributes of media (e.g., fidelity) rather than whether two types of media are inherently different with regard to supporting learning. Without specifying the methods as well as the design of the instruction, the issue is difficult to examine. In fact, Duffy & Kirkley (2001) argue that it is the design of the instruction that is critical for learning effectiveness. However, it is true that different types of media have different attributes (e.g., providing access to those at a distance, providing more efficient delivery costs), so those factors can be and should be examined as well.
2. Using a game-based training is not a panacea to cure all performance problems nor is it the root of all evil with regard to sacrificing learning for fun. Each time a new technology emerges, people often debate the extremes until the technology or medium gains acceptance. It is important to remember that game-based training is but one form of training, and not all performance problems can be solved through training. In fact, from the HPI literature, training is said to arise as a performance problem only 12 percent of the time (CHIPS – The Department of the Navy Information Technology Magazine, April 2006). In fact, Wile (1996) defines seven different sources of performance shortfalls, which are: 1) inherent abilities; 2) skills and knowledge; 3) physical environment; 4) tools; 5) cognitive support; 6) incentives; and 7) organizational systems. This means that when people fail, they often lack: 1) basic qualifications such as intelligence or strength; 2) specific knowledge, skills, and attitudes; and 3) surrounding that support their ability to do their work (e.g., noisy, unsafe). The U.S. Navy's investment in human performance improvement-based solutions has demonstrated an organizational commitment to considering solutions other than training. This not only provides strong guidance with defining the end goal for optimal performance and establishes a framework that supports the pursuit of this optimal performance. We define this as expertise, which is addressed in more detail later in this paper. Because the HPI framework represents a broader performance-based view of a job or task than traditional definitions of knowledge, skills, and attitude (KSAs) often describe. Thus, this perspective actually helps support the Navy to use game-based training to support trainees in developing these models.
3. There is a developing body of research on game-based training, and researchers are starting to provide summaries of research efforts in an effort to compile various outcomes. However, this is challenging as research is scattered among military, academia, and corporate training resources, so compiling outcomes is difficult. As part of any methodology development, it is important to address research outcomes as a way to ensure that the methodological approach is current with the latest research in game-based

training. The N-SGT methodology focused on this, and was developed to continue to expand knowledge through the development of a prototype authoring tool.

4. While there is a developing body of research on game-based training, there have been hundreds of educational research studies conducted on multimedia and computer based learning that is relevant to game-based training. One example is Richard Mayer's body of research on the impact of multimedia on learning. In a review of eight studies concerning whether multimedia instruction is effective, Mayer (1997) found that students who received coordinated presentation of explanations in verbal and visual format (multiple representation group) generated a median of over 75% more creative solutions on problem-solving transfer tests than did students who received verbal explanations alone (single representation group). In a review of 10 studies concerning the effectiveness of multimedia instruction, Mayer found that students generated a median of over 50% more creative solutions to transfer problems when verbal and visual explanations were coordinated than when they were not coordinated. Mayer and his colleagues have conducted many studies in this area, and his work as well as others needs to be examined in light of developing research questions related to success of game-based training.

In summary, these core issues form the foundation for examining research on game-based training and informs the choice of a game as a training technology and instructional approach. In the following section, we will: 1) provide a research summary on game-based training; 2) examine definitions of games as well as game characteristics and genres; 3) examine learning goals and objectives; and 4) present the N-SGT Methodology.

2.4 Game-Based Training: A Research Perspective

The purpose of providing a brief overview of the research on game-based training is to provide an overall awareness of types of research questions and outcomes, as well as specific variables that have been examined with regard to designing and researching the most effective game-based training innovations.

There are a wide range of variables that can potentially be examined, but the research in this area is emergent and in its early stage. As far as defining future research to be conducted, Sanchez, Cannon-Bowers, & Bowers (under review) have recently compiled an excellent overview of the research variables related to the use of video games that need further examination. Some examples of potential variables addressed in their article include: emotional intensity, engagement/emotional context, embodiment, personalization and engagement, self-efficacy, metacognition and self-regulation, collaboration and social learning.

For this research overview, we will specifically address the following research related to serious games or game-based training:

1. Learner Motivation
2. Learner Characteristics
3. Learning Effectiveness

These variables were chosen because these are often the main issues that are considered as part of the decision with whether to use a game-based training approach. Additionally, this literature review combines results from both game designers and researchers as well as instructional designers and researchers. This had the added benefit of helping both types of designers understand each other's terminology, perspectives, and ways of examining games from their respective fields. This is a critical goal as one common complaint is that both types of designers need to study each other's area more in order to design games that are more effective for learning and motivation (Kirkley, Kirkley, Heneghan, in press).

2.4.1 Learner Motivation

Motivation is the great promise of using games and one of the primary reasons that so much interest has been generated in using game-based training. Games are seen as motivating because they are fun and engaging. Rouse (2005) identifies several key factors that motivate players to play games. He states that players want a challenge, to socialize, a dynamic solitary experience, bragging rights, an emotional experience, to explore, to fantasize, and to interact. In fact, Malone (1980) identifies challenge, curiosity, and fantasy as the key characteristics which make games fun. Games also enable players to experiment and to fail in a safe environment.

Research on motivation has indicated that under certain conditions, external rewards and competition can increase intrinsic motivation (Reeve & Deci, 1996). But when an activity is seen as challenging, the user can gain feelings of competence, and thus intrinsic motivation can be enhanced (Sanchez, Cannon-Bowers, and Bowers, under review.) This is a critical aspect of examining game-based training that needs further exploration. Yee (in press) conducted a survey of 3000 online game players to determine a model for player motivations. His model is presented in Table 1.

Table 1.

The subcomponents revealed by the factor analysis are grouped by the main component they fall under.

Achievements	Social	Immersion
Advancement Progress, Power, Accumulation, Status	**Socializing** Casual Chat, Helping Others, Making Friends	**Discovery** Exploration, Lore, Finding Hidden Things
Mechanics Numbers, Optimization, Templating, Analysis	**Relationship** Personal, Self-Disclosure, Find and Give Support	**Role-Playing** Story Line, Character History, Roles, Fantasy
Competition Challenging Others, Provocation, Domination	**Teamwork** Collaboration, Groups, Group Achievements	**Customization** Appearances, Accessories, Style, Color Schemes
		Escapism Relax, Escape from RL, Avoid RL Problems

As part of understanding motivation, flow theory has been identified as a way to understand engagement. Flow state is reached when a person achieves a balance between challenge and frustration, becoming so focused on the end goal that he becomes totally engaged and distractions and hindrances fall away (Csikszentmihalyi, 1992). Csikszentmihalyi defines the components of a flow producing activity as:

1. Being up to the activity.
2. Being able to concentrate on the activity.
3. Activity has clear goals.
4. Activity has direct feedback.

5. We control the activity.
6. Worries and concerns disappear.
7. Our subjective experience of time is altered.

Not all of these components need to be present together for *flow* to be experienced (Chen, 2007). However, maintaining dynamic balance between ability and challenge is critical to having a fun experience. The element of flow will continue to serve as a perspective to be examined, in particular how it impacts learning effectiveness of games. Can a player become so immersed that she or he does not effectively learn, or does flow enhance the learning capabilities of a serious game?

Self-efficacy is defined as the learner's belief that she or he has the necessary competence to accomplish a task or produce a performance that exercises influence over events that affect his or her life (Bandura, 1977; 1986; 1994). Studies indicate that learners with high self-efficacy perform better than those with low self-efficacy. Therefore, it seems that game-based training that supports the development or maintenance of a learner's self-efficacy would be more successful than those that do not.

For serious games, it is important to consider that efficacy is not only related to performing tasks in specific domains but is also related to playing video games or working in teams. This is also a factor to consider that is related to analyzing learner characteristics.

2.4.2 Learner Characteristics

One question that has been of interest with game-based training is the variety of ways to categorize learners and players based on characteristics. In the game design world, learners are characterized by various frameworks. As one example, Bartle (1996) categorized MUD players into four categories:1) achievers (driven by in-game goals); 2) explorers (driven to find out about the virtual world); 3) socializers (driven to communicate and roleplay with other players), and 4) killers (gain satisfaction by killing other players' characters). Lindley (2005) then summarized Kim's player types based on live-action and table-top role playing games which include the *dramatist*, who enjoys a compelling storyline, the *gamist* who enjoys fair challenges for the players, and the *simulationist*, who values resolving game events based solely on in-game concerns, ignoring any meta-game issues. These are interesting perspectives on the characteristics of learners as, most importantly, it seems to indicate that not all players are the same and may take on different roles in games that they might not take on in life.

For instructional designers, learner analyses are used to define background, prior knowledge or experience, and motivation or attitudes. These are used to tailor the design of the instruction to better meet the learner's needs. Over the past several decades, there has been a growing focus of learning styles research that have focused on a variety of frameworks, such as instructional preferences, cognitive or learning styles, and information processing styles (Curry, 1987). However, recent systematic reviews of literature in this area (Coffield, et al, 2004a, 2004b) has critically examined this body of literature and found the lack of a common framework to be problematic as well as the underlying assumptions that personal traits or the dominance of certain sensory channels (e.g., visual, auditory) are fixed or determined by genetic traits. While it is likely that these types of research questions will continue to be examined in both instruction design and gaming, it is important, as with all research issues, that we maintain a critical eye on the assumptions we make about learners.

With this said, there are some practical differences with learners that are important to understand as part of choosing a game-based training approach, and this is their experience or lack of experience with video games, particularly with certain types of genres. Studies have shown that video game experience does make a difference in learner performance. If learners do not have enough experience, it is important to provide structured support until they can use the learning resources with confidence.

2.4.3 Learning Outcomes

The examination of the effectiveness of learning outcomes in game-based training has a strong foundation and is growing rapidly. Examination of learning, decision-making, performance, as well as a host of other factors continues to emerge from a range of game-based learning efforts. In order to summarize some of the higher quality and most cited studies, Egenfeldt-Nielsen (2006) conducted a review over 300 references to examine the effectiveness of educational video games. In this summary, they found many studies that reported positive impact of video games on motivation (Betz, 1995; Sedighian & Sedighian, 1996), problem solving abilities, retention of knowledge, on students believing that they learn more (McMullen, 1987), and self efficacy (Thomas et al, 1997).

Within the DoD specifically, tactical decision-making simulations (TDSs) have been adapted from commercial, off the shelf games, such as *Close Combat Marine*. These have been examined in use in various training situations, where it has been found that users of TDSs, as compared with tactical decision games, had high levels of motivation as well as being better at execution of knowledge and team coordination (Baxter, Ross, Phillips, Sahfer, & Fowlkes, 2004). However, the TDG users demonstrated mental simulation, planning, and mission focus. This study in particular provides a nice comparison of a traditional game versus a computer game, as they both demonstrate similar approaches.

However, not all studies have been positive about the impact of using video games for learning. A report by Fletcher and Tobias' (2006) lists several studies that found the design of the entertainment aspects of some educational games resulted in negative impacts on the learning outcomes of those games. Fowlkes, Dwyer, Oser, and Salas (1998) have argued that the same elements that make complex simulation-based environments exciting and engaging also create unique challenges with their use as training tools. First, their unpredictability can impede the control of training variables. Second, outcome feedback is not always provided in a way that can be used to help trainees improve performance (van den Bosch & Riemersma, 2004). Even with well-designed learning environments, design tensions exist between learning and doing or immersion versus instruction. Additionally, Kirkley (2006) found no significant learning gains were made by soldiers in the U.S. Army on decision-making or learning effectiveness of simulation vignettes focusing on the topic of urban operations, even with special scaffolds designed and embedded to support learning

One critically important point is made by Gee (2003) : what is learned from a game is a function of the *design* of the game. This is also the belief held by instructional designers. In fact, Duffy and Kirkley (2004) have stated that it is the design of the instruction rather than the technology that impacts learning. Therefore, it follows that clearly defining the game's educational goals by the learning objectives it supports is important. In fact, Gee (2003) identified 36 learning principles or outcomes that can result from playing video games. This richness of learning principles illustrates the strong power of games for training. However, it is critical that we remember that assessments and evaluations must be conducted in order to determine if learning and transfer occurred, and steps must be taken to examine what aspects of the serious game supported learning effectiveness and transfer.

In summary, this research overview provided a summary of research issues related to motivation, learning characteristics, and effectiveness of video games. In the following section, we will provide a taxonomy of game genres, definitions, and characteristics, and learning approaches.

Then we will address learning objectives in more detail as way to begin bringing gaming and instructional design closer together.

2.5 Defining Game Characteristics, Genres, Learning, and Learning Objectives

In examining games, there are several approaches to categorizing them, these include issues of defining what a game is (versus a simulation), the characteristics of a game as well as it's format, structure, content, and learning goals.

2.5.1 Defining a Game and Characteristics of a Game

Defining Games versus Simulations. Some of the most fervent arguments heard at conferences and in conversations among designers are those defining what a game is versus a simulation. This seems particularly true in the military where there is a long, rich history of using simulations for training. A common categorization of educational video games is by differentiating between games and simulations. Particularly for the military, this is an important distinction, even though the lines between the two are being blurred. First, Prensky (2001) identified six structural factors that define games: 1) rules; 2) goals and objectives; 3) outcomes and feedback; 4) conflict/competition/challenge/opposition; 5) interaction, and 6) representation or story. He states that simulations are not games as they do not adhere to all of these factors. He states that simulations are not focused on fun, but they can be made into games by adding the missing structural features.

Salen and Zimmerman (2004) compared eight different definitions of the term "game", from representatives of a variety of fields and came up with the following definition: "A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (p. 80). This broad definition applies to all kinds of games, including sports and board games, and not just video games. They also reviewed several definitions of simulation to come up with: "A simulation is a procedural representation of aspects of 'reality'" (Salen & Zimmerman, 2004). They state that there are certainly simulations that are not games and games which are not simulations, but that simulation games do exist with varying levels of fidelity.

Quinn (2005) defines simulations as relying on underlying models, not prescriptive branches, and games as simply being simulations that focus on creating optimal engagement. Aldrich (2005) also places games as a sub-set of simulations, stating that game-based models are one type of educational learning simulation. Ellington, Gordon, and Fowlie (1998) recognize the inter-relatedness of games and simulations. They refer to previous definitions of each, while pointing out their shortcomings, which state that games must have rules and competition, while simulations must represent a real situation and be dynamic. They present the spectrum of pure games, pure simulations, and hybrid simulation/games.

The key differences between simulations and games are primarily highlighted in terms of the amount of focus on engagement and reality, while some also argue that simulations are more dynamic and system-model based. It is clear that simulations and games are related in general and even more closely related when used for educational purposes. While there is substantial literature focusing on the differences between the terms, they are still often used interchangeably or with little discrimination in much of the literature.

2.5.2 Categorizing Games by Genre, Characteristics, and Attributes

Game Characteristics. Defining the characteristics of a game is a critical first step of beginning to map how certain elements of a game may potentially impact learning outcomes and effectiveness. Game characteristics include many types of structural characteristics (e.g., sound, visuals) as well as those involving story (e.g., setting, background) and interactions (e.g., multi-player).

As one example of defining game characteristics, Wood, Griffiths, Chappell, and Davies (2004) examined the structural characteristics that induce gaming in a group of self-selected video-gamers. The structural variables examined were: sound, graphics, background/setting, rate of play, duration and advancement rate, character development, winning/losing features, brand assurance, use of humor, control options, and multiplayer features.

Appelman & Wilson (2006) offer the following list of simulation-game characteristics based on a human performance technology framework: 1) challenges; 2) models; 3) control; 4) manipulation; 5) authenticity, and 6) consequences. They state that games characteristics have the capabilities to support an HPT framework though innovative use of games for training.

Game characteristics are used to describe the specific elements of a game, and also as a way to dissect how a game is designed. This is useful for both game designers and instructional designers as they develop shared understandings of the elements that make up a serious game.

Game Genres. The vast majority of discussions of categories of educational games focus on game genres. Game genres were one of the first ways that game designers and the general public described a game. The strengths of having game genres is that they provide a common language for game designers and instructional designers as well as trainers and learners. Though many games do not neatly fall into one category, most anyone who grew up playing video games can distinguish between a first-person shooter and fantasy game, or between a sports game and a puzzle game. However, many games are more complex and often represent a mixture of genres.

Using only game genres to describe learning approaches has been criticized as being too limited. Perhaps discussing genres and how they may or may not impact learning objectives may be a good place to start to help game and instructional designers develop a more shared terminology. By developing this shared terminology, they can better describe and define how specific aspects of a game (e.g., characteristics within a genre) can potentially impact learning effectiveness. In fact, Quinn (2005) makes this very point, stating that the use of genres can be beneficial in understanding differences in games and types of engagement and in providing templates for game or simulation design. He also stated that genres can be beneficial in understanding differences in games and types of engagement and in providing templates for game or simulation design.

As an example of game genre classification system, Bergeron (2006) lists standard genres "used to define entertainment and serious games" (pp. 146-147) as: action, adventure, arcade (retro), combat (fighting), driving, first-person shooter, military shooter, multiplayer, puzzle, real-time simulation, role playing game, shooter, simulation, sneaker, sports, strategy, third-person shooter, trivia, and turn-based. Quinn's (2005) list of game genres includes: action, fighting, driving or flying, sports, 3D shooter, card or board, strategy, fantasy role playing, adventure, multiplayer, massively multiplayer online role-playing game (MMORPG), and combinations of multiple genres. Prensky (2001) also identifies similar game genres, which he says can often overlap: action, adventure, fighting, puzzle, role-playing, simulation, sports, and strategy. Also, Dempsey and colleagues (1996) also provided a genre framework for instructional games: simulation, puzzle, adventure, experimental, motivational, modeling, and other. Kirriemuir and McFarlane's (2004) note that every year games come out which do not fit into these genres.

Game Attributes. Apperley (2006) argues against the current use of genres to classify games. He claims that standard game genres categorize games by their representational characteristics or visual aesthetics. He argues instead for categorizing games by focusing on the type of interaction the game requires of the player. While still categorizing video games with typical genre labels, such as role-playing, simulation, and adventure, Apperley's focus is on the type of interaction rather than the visual representation of the game.

The Game Ontology Project (GOP) also argues against the use of genres to classify games, instead advocating an ontological approach. Their approach focuses on the major attributes at play in a game's design (Zagal, Mateas, Fernández-Vara, Hochhalter, & Lichti, 2005). The ontology consists of five high level elements:

- Interface - refers to how players and the game interact
- Rules - indicate what is possible and not possible in the game
- Goals - define what the objectives of the game are and what determines success
- Entities - refers to what actions are available either to the player or game entities within the game

This Game Ontology Project is has identified over 150 different elements identified to this point (Zagal, et al., 2005).

The combinations of multiple genres and the listing of general categories for games that do not fit within these genres is evidence of the dissatisfaction with the use of genres in the field of general game research. With the additional complexities and design requirements of educational games, the use of traditional video game genres is insufficient to help designers communicate their design concepts. For educational video games, it would make more sense to focus on the learning approach or outcomes of the game rather than the game genre and there is some literature to support this.

2.5.3 Categorizing by Learning Approach

In the gaming literature, there are reports on the categorization of educational games by the learning approach in which they utilize. Prensky (2001) identifies the following learning techniques that have already been used in educational video games: "practice and feedback, learning by doing, learning from mistakes, goal-oriented learning, discovery learning and guided discovery, task-based learning, question-led learning, role playing, coaching, constructivist learning, accelerated (multi-sense) learning, selecting from learning objects, and intelligent tutoring" (p. 157). Similarly, in their review of instructional video games, Dempsey and colleagues (1996) categorized the games they reviewed by the following learning approaches: "tutor, amuse, learn new skills, promote self-esteem, practice existing skills, drill existing skills, change attitude, other, and not able to determine" (p. 10).

There has been a focus on categorizing games with regard to how they are used as part of different types of learning approaches. For example, Ellington and colleagues (1998) categorized games and simulations by how much they involved case studies in their instructional approach. Similarly, Kiili (2005) promoted using educational games to implement experiential learning. Maxwell and colleagues (2004) describe developing an educational game that utilized problem-based learning (PBL). Also, Rieber (1996) advocates for situated learning, and self-regulated learning within a microworld. All of these are similar in that they view games in light of a larger methodological approach rather than just a teaching strategy. This is an important point as the key strength of using these types of methodologies is that they provide structured frameworks an process for learning and assessment.

Appelman (2005) has developed the Experiential Mode Framework (EMF) as a way to understand and research a player's level of engagement, fun, frustration, elation, or disappointment within the affective domain, and levels of learning, understanding of game play, and development of strategies within the cognitive domain are nearly impossible to observe (Figure 1). However, armed with a framework that acknowledges these mental states along with the choices and actions the player perceives to have, and then couples these to the content and affordances within the environment of the game structure, a strategy for game play analysis methodology can be defined. It is such a methodology that the Experiential Mode Framework (EMF) can facilitate.

The EMF approaches the game play analysis from the Player's Experience (PX), and a definition of the Game Structure (GS). By definition these two foci are mutually independent in that the GS exists whether or not the player plays it, and the PX is defined by his or her own unique experience traversing the environment of the game. The EMF attempts to allow the researcher to define couplings of a specific PX with a specific GS in the hopes that correlations between them can be identified. Should such correlations arise, designers of game environments could increase the chances of building game structures that foster specific Player Experiences.

The 4 primary categories of PX are:

1. Cognition – encompassing all cognition in both cognitive and affective domains
2. Metacognition – encompassing all that the player is aware of, including what is perceived by vision, audio, olfactory, kinesthetic, and haptic senses, plus an awareness of time and any objects, content or information that is encountered.
3. Choice – encompassing the player's perception of degree of control, and access to, variables and information during game play.
4. Action – encompassing the player's perception that they can do things such as interact with objects and elements within the game, that they have a degree of control of these objects and elements, that they have a degree of mobility to move through the virtual environment, and that the control interface allows their psychomotor capabilities to effect change.

The 3 primary categories of GS are:

1. Content – the story, the context, the amount of information available, the degree of concreteness or abstraction of the content, the authenticity, and its variability
2. Environment – the virtual spaces and boundaries, the objects within these spaces and their functionality capabilities, plus any time limits imposed by the game
3. Affordances – encompassing the abilities made available within the game for the player to change, manipulate, and/or to seek alternatives or information.

In summary, Appelman's EMF Framework provides a valuable way to join media attributes with instructional approaches. It not only serves as a tool to educate game and instruction designers, but it also is a valuable tool for researching serious games.

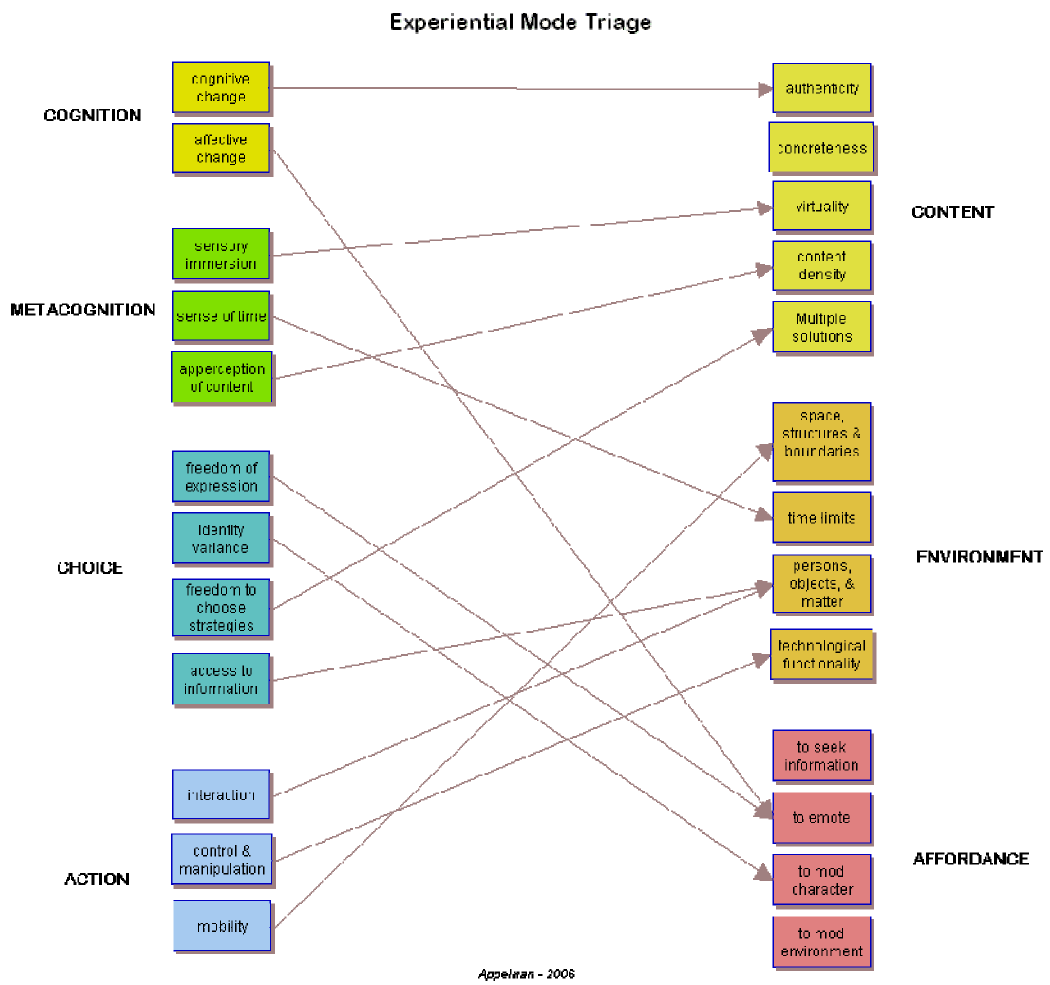

Figure 1. The Experiential Mode Framework. Player Perceptions are depicted by the left column(PX), while attributes of Game Structure are depicted by the right column(GS).

2.5.4 Categorizing Games by Learning Outcomes/Objectives

Educational games can also be categorized by the type of learning outcome or objective the learner is expected to gain by playing the game There are clearly varied instructional approaches embedded within all types of games. These approaches range from the drill-and-practice approach where the games act as little more than interactive flash cards, to complex, virtual environments where learners are expected to interact and experiment with the game and use decision-making and problem solving skills to develop and reflect on their own learning.

In a review of educational games, Dempsey and colleagues (1996) categorized games by the following types of learning outcomes: attitude, motor skills, cognitive strategy, problem solving, rules, defined concepts, concrete concepts, verbal information, other, and not able to determine. The fact that they could not identify a large number of the educational games' learning outcomes may be an indication of the importance of including instructional designers in the design process. They noted the positive outcome as being the large number of games that focused on higher-order thinking skills and attitudinal learning as opposed to verbal knowledge outcomes (Dempsey, et al., 1996). Prensky (2001) listed the following types of learning: "facts, skills, judgment, behaviors, theories, reasoning, process, procedures, creativity, language, systems, observation, and communication. He also provides a table where he ties these learning outcomes to the type of traditional game genres that might be most appropriate for acquiring the learning.

However, these classifications of learning outcomes are more reflective of game designers' perspective of learning objectives than that of the instructional designer. From an instructional design perspective, the most universal classification of learning objectives is Bloom's Taxonomy (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956; Bloom, 1984). The six levels of Bloom's Taxonomy are:

1. Knowledge – the starting point that includes both the acquisition of information and the ability to recall information when needed.
2. Comprehension - the basic level of understanding. It involves the ability to know what is being communicated in order to make use of the information.
3. Application - the ability to use a learned skill in a new situation.
4. Analysis - the ability to break content into components in order to identify parts, see relationships among them, and recognize organizational principles.
5. Synthesis - the ability to combine existing elements in order to create something original.
6. Evaluation - the ability to make a judgment about the value of something by using a standard.

Bloom's Taxonomy was later expanded beyond the cognitive catgory to include affective (growth in mental skills) and psychomotor (manual or physical skills). Over time, learning processes became more central in focus. In fact, Anderson and Krathwohl (2001) later revised Bloom's taxonomy to incorporate the kind of knowledge to be learned (knowledge dimension) with the processes used to learn (Table 2). The purpose of this was to improve the alignment of objectives with assessment techniques. This is a particular strength of this taxonomy.

Table 2.

Anderson and Krathwohls Taxonomy Table

The Knowledge Dimension	The Cognitive Process Dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Meta-cognitive Knowledge						

Bloom's Taxonomy is still commonly used throughout training and education because of the ease with which one can use it to describe the components and processes of learning. It is particularly helpful for ensuring that learning objectives are aligned with assessment objectives. However, as instructional designers who are also game designers, we do not find Bloom's taxonomy to be as helpful for designing serious games. The problem is that Bloom's divides and compartmentalizes the types of knowledge and knowledge processes as a grocery list. Thus, there is focus on the design of *content* so that it is easy to learn. This does not map easily to the authentic, situational, holistic aspects of human performance or expert performance in a job or domain area. (Note that we have found it to be a somewhat helpful tool for dissecting and analyzing the specific types of learning objectives in a post-design phase as well as a guide to help ensure that assessment and learning objectives are in alignment.) Lauren Resnick (1987) offered an alternative perspective of learning content; instead, learning should be focused on the goals and activities of the learner rather than on the presentation of content. This is reflective of constructivist (Savery and Duffy, 2000) theories of learning, which focus on learners actively constructing knowledge in context of the culture and situations in which they are participating.

With regard to problem solving classifications, one framework that provides a useful taxonomy of problem types is one developed by Jonassen (2004), where he provides a taxonomy of problem types: logical problems, algorithms, story problems, rule-using problems, decision-making, trouble-shooting, diagnosis-solution, tactical-strategic performance, situated case, designs, and dilemmas. Within this classification, he also describes the outcome of the problem type, the problem itself, a description of the solution, the context, an example, and the structureness and abstractness of the problem type.

Another framework that serves as an interesting approach for considering learner processes is the learner-centered scaffolding framework developed by Quintana, Soloway, and Krajcik (2002). In this, they summarized three challenges that learners face:

1. Process management—the ability to engage in and regulate processes and activities needed for inquiry;
2. Sense making—the ability of learners to make sense of their work and find a direction;
3. Articulation—the ability to state the problem and articulate a solution or a path to a solution.

Within each of these categories, Quintana et al. (2002) provided scaffolding guidelines and examples that elicit the processes above and support learners in learning with and manage complex types of environments.

In summary, these types of frameworks are helpful for instructional and game designers as part of the process of developing ways to classify what is under the hood of a serious game. In fact, Ross, Phillips, and Klein (2005) recommend that system developers articulate learning objectives at the front end of the development cycle in an effort to improve the learning value of the technologies used for training.

2.5.5 N-SGT Taxonomy/Matrix

As part of an effort to integrate game design and instructional design so as to design more effective serious games, we have been developing a taxonomy/matrix linking game characteristics with learning objectives and processes. We have designed this matrix as a multi-dimensional matrix, which can accommodate newly emerging classification frameworks cross-referenced to existing dimensions. Thus, the format of the N-SGT Taxonomy/Matrix should be flexible, adaptive, and continually growing.

To develop this N-SGT Taxonomy/Matrix and Methodology, we used methods of participatory design and conducted informal heuristic evaluations with 11 persons who were either professional game designers and/or instructional designers. All of the instructional designers had advanced degrees in instructional design, and one person had an advanced degree in telecommunications and had experience as a game designer.

The overall N-SGT development process focused on spiral design approaches and user-centered instructional design models (Dillon & Watson, 1996; Nielsen & Molich, 1990; Tripp & Bichelemeyer, 1990). This enabled our team to engage in an iterative cycle of design and improvement based on user feedback. Potential users of the N-SGT methodology were engaged with us in individual sessions of participatory design (Schuler & Namioka, 1993). These sessions lasted approximately 1.5-2 hours each. This development approach was valuable as it enabled us to obtain user input and expertise in the development process. This was critical given the lack of shared terminology among game designers and instructional designers. Hence, this effort was as much about communicating game and instructional design concepts as it was about linking concepts into a common framework.

In Table 3, one example of a two-dimensional view of elements from the N-SGT Taxonomy/Matrix is provided. Note that here different game characteristics and learning objectives or design frameworks are cross-referenced in order to build stronger linkages between game design and instructional design. Additionally, in the Game Analysis Database and Wiki that we are developing (see Section 3), the multiple dimensions of the matrix is present and will be linked to rich descriptions, images and video clips of serious game play that demonstrates one or both concepts provided in the Taxonomy/Matrix. For instance, where we have the Game Examples in the table, the database will provide rich data related to that game. From the other perspective, one could query the database for all games that are tagged as demonstrating "Jonassen's problem type: Tactical" or "Bloom's: analysis". This should serve to enable personnel to understand the meanings of the categories and dimensions on the matrices.

Table 3.

Example of the N-SGT Taxonomy/Matrix

Game Characteristics	***Problem Solving Types (Jonassen, 2004)***	***Problem Solving Types (Jonassen, 2004)***
Goal	Tactical-strategic performance (Bloom's classification=evaluation; action verb=to choose)	Diagnosis-Solution (Bloom's classification=analysis; action verb=to deduce)
Context	Real world scenarios/decisions made under stress	Real world, technical, mostly closed system
Structuredness	Finite outcomes	Finite faults and outcomes
Abstractness	Personally situated	Problem situated
Game Example	*Close Combat Marines*	*Battle Stations 21*

2.5.6 Training With SGs—What is our Educational Goal

It is clear that there are various learning objectives which educational games seek to help learners reach. However, the question that is perhaps most critical, especially at this point in time, is: "For the U.S Navy, what is the most important and critical goal for training?" This question is not about learning outcomes, objectives, or even about serious games. This is a much higher level ontological question with regard to what is the big goal for training.

Traditionally, the majority of educational games have focused on declarative knowledge through drill-and-practice approaches, but it appears that newer games are seeking to maximize the potential of educational games and move towards higher-order thinking. Higher-order thinking focuses on developing critical thinking skills and true understanding rather than rote knowledge. Problem-based, experiential learning and the constructivist concept of a microworld are instructional frameworks which match well with utilizing educational games to promote higher-order thinking skills. In fact, Dempsey and colleagues (1996) found that problem-solving video games were the largest specific learning outcome discussed in the articles they reviewed.

Expertise has become increasingly valued in our society, where ongoing learning, analysis, adaptation, and innovation are needed in order to respond to complex situations and problems. This is particularly true with regard to job performance in the military – the seamen and soldiers who win awards are those who excel, adapt, and innovate.

Expertise includes the capabilities that are not only domain-specific but also those associated with higher order skills such as developing plans, managing people, and solving problems. This high level of familiarity with a domain area results in the ability to understand deeply, think flexibly, and solve complex problems at a high level of performance (Ericsson & Lehmann, 1996). Thus, the goal for using serious games for the U.S. Navy should be viewed as an investment in developing expertise. In fact, Ross, Philips, Klein, & Cohn (2005) developed a framework for the Navy to address how to use technology-based training to create expertise. This is particularly relevant to serious games as their very complexity and situatedness present opportunities to gain expertise through engagement and interaction with real world-like elements.

Expertise is developed by extensive engagement and practice in an area or domain (Van Gog, Ericsson, Rikers, & Paas, 2005). Through rich engagement and practice, learners solve real-world problems, and as they do so, they develop rich patterns of understanding about their domain. This includes developing domain-specific knowledge as well as knowledge of the processes used to solve problems (e.g., expert strategies).

In fact, the *real worldliness* provides needed complexity for grounding the learning process. Spiro, Feltovich, Jacobson, and Coulson (1992) have stated that much of our curricula and training methods do not support learners as it simplifies and abstracts the complexities of a domain. As a result, learners do not develop conceptual complexity needed to perform, and they even develop misconceptions. Additionally, the knowledge developed is often inert knowledge (Whitehead, 1929) that cannot be applied in any way. For example, memorizing a list of steps for assessing a patient needing first aid does not necessarily result in developing the *understanding* that enables one to provide first aid to a real patient in a real-world setting, such as a situation where a patient has multiple injuries and pre-existing conditions like diabetes that impact how first aid is given. These complexities, once organized into a coherent framework of core-domain problem models, can be used to design education and training that lead to greater expertise. Given this perspective, the goal for education is to design environments that support learners in developing expertise, which includes domain-specific skills as well as competencies of analysis, flexible thinking, and creativity (Sternberg, 1999). To do this, we need coherent methodologies that can be used as frameworks to design learning that results in greater expertise.

Expertise is defined as having an increasing familiarity with objects of one's trade (Bereiter & Scardamalia, 1993), which can be described as competencies. van Merrienböer (2001) states that competencies are bound to a particular domain or profession and consist of complex cognitive and interpersonal skills and attitudes that demonstrate advanced capabilities within a particular domain or profession. These capabilities include not only domain-specific skills but also the associated higher order skills such as developing plans, managing people, and solving problems. This high level of familiarity with a domain area results in the ability to understand deeply, think flexibly, and solve complex problems at a high level of performance (Ericsson & Lehmann, 1996).

The role of context in the development of higher-level skills changed dramatically in the 1970s. Researchers began to find that problem solving completed in labs did not necessarily generalize to complex, real world settings, and that problem-solving processes differed by domain areas (Frensch & Funke, 1995). There began a focus on understanding expertise and how it develops in naturalistic knowledge domains, such as chess (Chase & Simon, 1973) and physics (Chi, Feltovich, & Glaser, 1981). In these studies, researchers found that experts:

1. Have a developed knowledge base on domain-specific knowledge;
2. Recognize situations rapidly and where patterns apply; and
3. Use their recognition to reason toward a solution by working with patterns.

As expert profiles have been developed, researchers have amassed a range of evidence on the differences between experts and novices (see Table 4).

Table 4.

Summary of the Research Findings on Differences between Experts and Novices

Area of Emphasis	Experts	Novices
Domain Understanding	Experts have a rich base of domain-specific understandings as well as robust and consistent models of core frameworks within a domain	Novices lack a rich base of domain-specific understandings and often have robust and consistent models of naïve explanations
Explanations	Experts' explanations demonstrate decentralized thinking, multiple causes, and the use of equilibration processes	Novices often have a "centralized mindset," preferring explanations that assume central control and single causality
Problem Representation	Experts represent problems at a deeper level than novices do because of their superior conceptual understanding	Novices have a superficial understanding of problems due to the lack of conceptual understanding
Organization of Knowledge	Experts organize various elements of a configuration that are related by an underlying function or strategy within a domain, such as core concepts, big ideas, and approaches to solve the problems	Since novices lack highly organized structure for a domain, they organize problems by their surface attributes such as facts and concepts
Perception of Meaningful Patterns	Experts perceive meaningful patterns in their domain of expertise, reflecting a well-organized knowledge base	Novices are less likely to organize understanding around meaningful configurations
Automaticity	Experts are fast and accurate at solving complex problems within their domain because with practice, many skills have become automated, freeing up cognitive resources for processing other aspects of the task	Novices are less accurate at solving complex problems because they must rely on generic problem-solving strategies rather than domain-specific strategies

Area of Emphasis	Experts	Novices
Strategic Knowledge	Experts are more likely to realize the strategic implications of situations	Novices focus on more superficial aspects of a domain rather than strategic implications
Characteristics of Explanations	Experts' explanations demonstrate decentralized thinking, multiple causes, and the use of equilibration processes	Novices tend to favor simple causality, central control, and predictability
Decision making	Experts solve problems by quickly recognizing patterns and exemplars within a known class of problems or situations, and they choose and develop a reasonable solution rather than deliberating among all available options	Novices tend to organize situations around surface-level attributes, tend to rely on generic problem-solving strategies and consider several alternatives before choosing one

[Note. This table was developed by the researcher to serve as a tool for designing the methodology for expert/novice scaffolds. A literature review was first conducted, and then it was summarized into this tabular format to aid in the development of the methodology for scaffolding. It is based on studies by Chi, Glaser and Farr (1988); Chi, Resnick, and Wilensky (1998); Chi (2005); Jacobsen (2001); and Klein (1981).]

2.6 N-SGT Methodology: Choosing Whether or Not to Use a Game Based Training Approach

The N-SGT Methodology is based on a seven-part model of factors to consider in choosing whether or not to use a game-based training approach. As stated previously, most media selection models are focused on the analysis of learning objectives and strategies as a way to examine whether a specific media would support meeting stated objectives using stated strategies. However, game-based training is more complex, and a host of factors must be considered as part of the process. This is particularly true for a training organization such as the U.S. Navy, which has to be adaptive and flexible in order to respond to needs very quickly.

In the following section, each of the seven categories are briefly described, and then guidance along with key questions. The purpose of this methodology is to guide the decision-maker with considering the most critical factors relevant to his or her potential use of game-based training.

A. **Organizational Factors**

B. Motivational Factors

C. Cognitive Development

D. Interpersonal Development

E. Instructional Strategies/Design

F. Game Attributes

G. Return on Investment (ROI)

In each category, there are some key questions that would either support using a game-based training approach, or not. After responding to each set of questions, count the number of questions to which you responded *yes* and *no*, and tally those up. Record the number of yes and no responses at the bottom of each category. Note: Each of these factors have specific questions, that when answered in the N-SGT Authoring Kit, provides recommendations and guidance in a visual format that helps the decision-maker determine whether or not game-based training is the best approach given their context and variables. In addition, the Toolkit links to reference materials that will help the decision-maker as they answer these questions (see Section 3).

Category A: Organizational Factors

a. Does your organization support using a game-based training approach?
b. Does your organization see value in using game-based training?
c. Are there negative frame factors that would prevent you from using a game-based training approach?
d. Are there positive frame factors that would prevent you from using a game-based training approach?
e. Is it possible that a game-based training approach could be implemented within the organizational context in which you are operating?
f. Is it possible that a game-based training approach would meet your training requirements regarding time and location?

Yes responses ____ / No responses ___

Category B: Motivational Factors

1. Do you currently have motivation problems with trainees?
2. Do you anticipate that a game-based training approach provide adequate motivation for learners?
3. Would a game-based training effort provide a necessary level of engagement needed to support immersive learning?

Yes responses ____ / No responses ___

Category C: Interpersonal Development

1. Would a game-based training effort address interpersonal development skills required for the training?
2. Can a game-based training effort provide the necessary communication tools and processes that would support effective development of specific interpersonal skills (e.g, negotiation)?
3. Does the game-based training effort meet required language capabilities?

Yes responses ____ / No responses ___

Category D: Cognitive Development

1. Would a game-based training effort be able to adequately support learners in meeting stated learning objectives?
2. Would a game-based training effort be able to adequately support learners in required knowledge, skills, and attitudes (KSAs)?
3. Would a game-based training effort be able to adequately support learners in meeting stated assessment objectives?

4. Would the game-based training effort support transfer of knowledge to work environment?
5. Does the game-based training effort address human performance improvement issues?
6. Would a serious game be able to provide necessary feedback in order to advance learners' development and to meet learning objectives?

Yes responses ____ / No responses ___

Category E: Instructional Strategies/Design
1. Would a game-based approach use the types of instructional strategies that are appropriate to meet learning objectives?
2. Would the instructional strategies required for learning be able to be used in the game?
3. Does the game-based approach enable learners to experience different types of learning objectives?
4. Does the game-based approach support facilitators with using appropriate instructional strategies?
5. Will the use of a game be supported by trainers/instructors?
6. Will the use of a game be supported by the organization at large?

Yes responses ____ / No responses ___

Category F: Game Attributes
1. Would a game-based approach provide the necessary sensory requirements (e.g., touch, taste and smell) needed for the training?
2. Would a game-based approach provide the fidelity required to meet learning objectives?
3. Would the game characteristics support levels of required fidelity?

Yes responses ____ / No responses ___

Category G: Serious Game-Return on Investment (SG-ROI)
(Note that specific guidance on calculating the SG-ROI is in the following section.)

1. Would a game-based approach provide a positive return on investment?
2. Would a game-based approach provide non-value based positive outcomes (e.g. repurposeable learning objects)?

Yes responses ____ / No responses ___

Final Decision: Should I use a Game-based Training Approach or Not?

In summary, the final step in the methodology is to examine your own analysis of whether or now you should use a game-based training approach. As stated earlier, the purpose of this framework is to provide a process for analyzing a range of factors that are associated with game-based learning. Therefore, please answer each of the questions below, please rate your answer as follows:

<u>Key to Ratings and Rankings:</u>
Ratings: 1-SA (strongly agree) 2 – A (agree) 3- U (undecided) 4 – D (disagree) 5 –SD strongly disagree
Priority Ratings: 1 – High Priority 2 - Medium Priority 3 – Low Priority U - Unknown

Questions	Ratings	Priority
1. Will using a game- based approach support meeting specified learning objectives or outcomes (e.g., KSAs)?	*1-SA 2-A 3-U 4-D 5-SD*	*1 2 3 U*
2. Will using a game-based approach support the effective use of instructional strategies that enable the achievement of learning objectives or outcomes?	*1-SA 2-A 3-U 4-D 5-SD*	*1 2 3 U*
3. Will using a game-based approach support the effective use of media attributes?	*1-SA 2-A 3-U 4-D 5-SD*	*1 2 3 U*
4. Will using a game-based approach support in positive organizational change?	*1-SA 2-A 3-U 4-D 5-SD*	*1 2 3 U*
5. Will using a game-based approach support in positive return on investment?	*1-SA 2-A 3-U 4-D 5-SD*	*1 2 3 U*

2.6.1 Detailed Description of Serious Game-Return on Investment (SG-ROI)

Background
*Serious Game-Return on Investment (SG-ROI***)** is an approach used to calculate predicted future or past financial benefit that a group or organization obtains from designing, developing, implementing, and using/reusing a serious game for training. It has been developed as part of the N-SGT Methodology and Toolkit.

In general, ROI can be based on a simple calculation such as:

<u>(total benefit - total costs)</u> = ________ x 100 = ROI

However, investing in Serious Games has some unique considerations with regard to game design and development, whether one chooses to custom develop a game or to use an existing government and commercial off-the-shelf (GOTS/COTS) games. Additionally, considerations of how using game-based training can potentially change the design of the overall learning environment also need to be considered. This includes practical as well as issues of learning design. For example, on a practical level, using a game-based training approach may mean equipment upgrades are needed. With regard to learning, using a game-based approach may mean other instructional and assessment materials need to be redesigned in order to ensure that learning objectives, instructional strategies, and assessment approaches are in alignment.

To provide a more detailed method to estimate ROI, we have combined traditional methods of calculating ROI, as well as cost modeling approaches developed by the TLT Flashlight Project (Ehrmann & Milam, 1999). Additionally, we have also provided game-specific issues that need to be considered as part of the costing process. The model also addresses both financial and non-financial value costs (e.g., being seen as an innovator in the field, development of shareable content objects). After obtaining the estimated ROI, one can adjust the estimated cost and return based on factors that have high positive or negative value that are difficult to capture in traditional ROI models.

As either a user or developer of serious games, it is important to understand the FULL costs of developing or using a serious game. In the design and/or adoption of any technological approach, there are often hidden costs with design, delivery, or implementation of a serious game. Thus, this model provides additional steps where we provide guidance with gathering detailed data from people who are participating in the design, development, or delivery process. However, to obtain this data, the cost model process needs to be mainstreamed into the work flow processes (Tucker & Kirkley, 2003). One example of this is having internal training staff document the amounts of time spent on specific activities and tasks, such as design of a game-based training module. *If this level of detail is not desired, one may skip the steps related to defining activities and tasks.* The strength of this model is that one can adjust the granularity of the data collected as needed.

It is important to note that the SG-ROI can be estimated before a game is used to calculate costs or after a game is used. However, it is important that the correct data be defined and gathered ahead of time in order for this to occur.

The SG-ROI Model process follows in the next section, and the SG-ROI calculator will, in the future, be designed and embedded into the N-SGT Authoring Tool as a way to directly support estimating return on investment for serious games.

2.6.1.1 Guidelines for Determining SG-ROI

As part of the overall SG-ROI process, we provide specific questions that you need to consider as part of developing your expected ROI. The SG-ROI process consists of the following eight steps. For each step, questions are provided that will help you with analyzing and determining how to estimate the cost versus investment of a serious game.

In summary, the steps are as follows:

- Step 1. Identify the ROI related questions you want to answer.
- Step 2. Identify key outputs.
- Step 3. Identify the cost of activities
- Step 4. Identify the units/organizations.
- Step 5. Identify resources used by these units.
- Step 6. Calculate costs for all activities.
- Step 7. Examine and adjust ROI based on items of non-financial value.

It is important to note that we have used the same language as used by Ehrmann & Milam (1999) in an effort to support decision-makers who want to delve more deeply into the Flashlight Cost Model process. Following are some terms and definitions to help better define their process:

- Activity – what is done
- Organizational units – who is involved
- Inputs – resources needed to carry out the activity
- Outputs – results of the activities (Ehrmann & Milam, p. 6)

In the following section, we provide the SG-ROI process.

Step 1. Identify the specific ROI questions or concerns you want to answer with regard to design or use of serious games.

1.1 Before gathering data, you must first determine what specific questions you are asking with regard to understanding, calculating, and evaluating your SG-ROI. In this section, you will identify what question or questions you specifically want to address as part of your SG-ROI.

1.2 First, you should define your overall goals for using game-based training. Is your overall goal to determine development costs, to contain costs, or to determine the best use of resources? Defining your overall goal will help you develop your specific questions (see next step) that will guide the SG-ROI process.

Define your overall goal:

____
____

1.3 Second, you should determine the specific question you want to address. For example, do you want to simply measure costs of designing or using a game-based approach, or do you want to compare costs of using a game-based approach with a traditional approach? If you choose to custom develop a game, you may wish to delineate costs such as asking how much cost is spent on design versus development or costs for implementing the game? For both designers and decision-makers, this offers a valuable approach for using cost as part of the picture as part of the process of also examining learning effectiveness or impact of specific types of media attributes (e.g., low fidelity graphics versus high fidelity graphics).

Some examples of specific questions you might ask are:

- What is the cost of using a game-based training approach in a specific course?
- What is the cost of developing a custom game versus using a GOTS/COTS game?
- What is the cost difference between using a game-based training module versus a traditionally taught training module?
- What is the cost of facilitating a game-based course versus a traditional course?

Define your key questions and concerns:

____
____
____
____

Now that you have identified your key questions, you can begin to gather data to estimate your SG-ROI.

Step 2. Identify specific outputs.

2.1 In this section of the SG-ROI, you will identify and define your specific outputs. For example, if you plan to develop a custom game (estimated play time at 1 hour per user), you will need to define this specifically. You will also identify any associated costs, such as development of manuals for instructors and students, cost of facilitators, and cost of licenses or seat fees.

2.2 If you are making a comparison of outputs (e.g., game-based versus traditional classroom), you will want to define specific performance measures for each output as part of this comparison and compare the similarities and differences (Ehrmann & Milam, p. 12).

Key Outputs:

____
____
____
____

Step 3. Identify the activities required to produce outputs (e.g., design, development, implementation).

3.1 Some specific examples of activities required to produce products are design, development, and delivery. These activities must be defined in this step as a way to gather more detailed data on the costs of specific aspects of using a serious game.

3.2 If you question is about the costs of designing or developing a game or adapting a COTS/GOTS game, you will need to first understand the various types of games and their characteristics. Earlier in this document, we provided, from the literature, a variety of game classification and genre listings. If you are unfamiliar with the type of game you want to use, you may wish to consult this information and begin thinking about how this will impact cost differences.

Clark Aldrich (March, 2006 posting to Serious Games discussion list) has recommended one approach for thinking about the cost as well as the trainee's estimated length of time using specific genres of games. For each genre of game listed below, you will need to first define the type of game. You can do this by examining the literature presented earlier, or you can define your own genre or classification system. If you are custom-developing a game, the goal of this step is to communicate with designers so that you can get a rough estimate of the costs associated with different types of serious games. Then you will need to define the length of time a trainee will spend with the game. This is meant to be a rough estimate to help define and bound the length of the game. This can be done by talking with game designers or users to get a more accurate view of the time it takes to work through the serious game.

Type of Game	Short (30 minutes)	Medium (1 hour)	Long (4 hours)
Branching story (custom)			
Branching story (off-the-shelf)			
Interactive spreadsheet (custom)			
Interactive spreadsheet (off-the-shelf)			
Mini game (custom)			
Mini game (off-the-shelf)			
Virtual lab (custom)			
Virtual lab (off-the-shelf)			
Practiceware (custom)			
Practiceware (off-the-shelf)			
Add Other Type of Games if desired			

If you are trying to decide which approach to use, you can compare different types of games as well as examine custom development versus use of COTS.

(NOTE: In Phase II, we will seek to identify genre categories that are most useful for Navy serious game projects. The N-SGT Toolkit will provide tools for entering/selecting these genres.)

3.2 Next, you will need to determine the cost of the game per student per hour. (If doing a comparison, note that it is important to ensure that the cost of each item is calculated in the same way and using the same metrics.)

Cost per student per hour:

____

____

3.3 Now that you have calculated the cost of the game by student, you will need to consider other factors that might impact the cost of your serious game.

- What is the cost of site licenses?
- How long are the site licenses valid?
- What is the cost of facilitation?
- Are there special costs with training the instructor/trainer?
- Are there special hardware costs?
- Are there special costs for manuals, resources, etc.
- Are there other costs you have not considered?

Document and add these costs together.

Activities	Costs
Game Development Total Content development Art Interactive tools Special effects Physics capabilities Special features	
Hardware purchases or upgrades	
Add Others as appropriate	
TOTAL	

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3.4 Next, you should then define the performance measures for each item that has a fee and record it below.

Resource	Performance Measure	Costs
TOTAL		

3.5 Calculate the total amount of costs defined in this section.

Total Costs:

____

____

Step 4. Identify the units/organizations that are part of the design, delivery, and implementation the serious game.

The purpose of this step is to identify units/organization involved with the design, development, and implementation of the serious game in order to document who is involved and the organizational costs and resources to be used. Note that this is a more detailed process than traditional ROI usually requires, and this also requires cooperation.

4.1 Identify the units and organizations that will participate in the game-based training effort. In doing a more simplistic ROI, it is often the case that many costs go undocumented. For example, if developing a serious game will require 30 hours of subject matter expertise, this time should also be documented. However, it is often the case that some of these costs are overlooked. This step helps ensure that all costs are documented by unit and organization as well as by person.

Time Spent	**Unit 1, Person 1: Time Spent**	**Unit 2, Person 2: Time Spent**
Activity 1: Game Module - Task 1: Design - Task 2: Development	 40 hours 5 hours	 6 hours 25 hours
TOTALS		

Step 5. Identify the resources used by organizations/units in the activities.

In this step, you will identify any resources (e.g., printing fees, mailing of CD-ROMs) that are part of the budget for developing or using the serious game. This may also include travel, equipment, and any type of materials. [TIP: Be sure to account for direct and indirect costs.] Once you identify these costs, document these expenses in a table below.

Document Resources and Costs.

Organization/Unit	**Resources**	**Costs**

Step 6. Calculate costs for all activities to determine your output costs.

In order to calculate total output costs for your SG-ROI, you will need to look at cost drivers and tally those these activity-based costs.

Activity-based costs	**Game Designer**	**Game Developer**	**Total**
Salary for SG tasks (percentage)			A
Benefits			B=A x 24
Salaries and Benefits			C=A + B
Activity hours (% of annual hours)			D
Total Activity Compensation			E=C X D
Resources costs			F
TOTAL COSTS			G = E + F

You should then divide this amount by the number of students per hour. An example Summary Matrix is provided below.

	Traditional Course	Serious Game	Equation
Total Costs			A
Trainee enrollment			B
Headcount enrollment of trainees			C
S-G hours per week for trainees			D
Weekly trainee S-G hours			E=(BxCxD)
Cost per weekly trainee course hour			F=A/E

*Note: Cost summary matrix adapted from Ehrmann & Milam's *Flashlight Cost Analysis Handbook* (1999).

Once you determine the final costs, you can either use this data to answer your key questions defined in Step 1, or you can move on to Step 8 and consider the non-financial value of various factors.

To calculate your estimated ROI, which will provide you with the total financial benefit your organization draws from a serious game, you subtract total costs from the total investment made to develop, produce, and/or deliver a serious game.

Step 7. Examine non-financial gains and losses in order to determine if there are factors you should consider as part of the overall decision in whether to use a serious game.

Part of the challenge with examining non-financial gains and losses is to place a value on those factors. This can often be done by asking key stakeholders to assign approximate values for each item in order to help delineate importance of various factors.

<u>Examples of Non-Financial Gains</u>

- Elements of the game can be used as a shareable learning object in other courses or games
- Subject matter expertise data can be used in design of other serious games
- Trainee satisfaction
- Being seen as a leader in the field
- Having more accurate and better trained workers
- Does the S-G support an innovative performance?

<u>Examples of Non Financial Losses</u>

- Lack of reusability of game-based objects
- Game not accepted by trainers

Once you examine these factors, you may wish to adjust ROI based on non-financial gains or losses. If you chose any of the non-financial factors, you should definitely recalculate ROI based on non-financial services and report both costs to key stakeholders. This may help aid in decision-making with regard to the impact of non-financial values, such as the worth of being seen as having an innovative serious game training program.

In summary, this combined ROI, cost model approach to estimating the SG-ROI provides one approach to examining key costs related to choosing and using game-based training.

In the following section, the N-SGT Authoring Toolkit will be described, with some screen samples provided that also illustrate the instantiation of the N-SGT Methodology.

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Section 3.0

N-SGT Authoring Toolkit

In the previous session, the N-SGT Methodology was described. Our second primary task was to devise a set of tools that would help Navy personnel and contractors use the Methodology effectively; we call this the N-SGT Authoring Toolkit (or Toolkit). Our team took the Methodology and conducted a workflow analysis based on expected prototypical use cases and examination of the Navy/DoD instructional systems design processes. Figure 2 provides a high-level view of the system which has three primary components:

1. N-SGT Toolkit. The core of the Toolkit is a series of tools that enable the user to identify the training needs and learning objectives, input data as specified in the Methodology, review recommendations based on the data input, and, if a game-based approach is selected, determine the general approach that should be considered in the instructional design and development.
2. Resources. As a person is using the N-SGT Tools, they may need help understanding how to answer a question or to refer to background information that will help them make informed decisions. Resources, while optional to use, will play an important role in helping people use the methodology and make decisions. There are two basic types of resources. The first type is a Game Analysis Database and Wiki. This is a searchable resource that contains analyses of different games across a range of dimensions which provide text descriptions, video from games being played, and analyses from experts. A subset of this is data specifically about officially sanctioned DoD and Navy Games. The second type of resource is data about game effectiveness. The primary and preferred source of data is from scientifically rigorous research on game-based learning and other relevant topics. However, since the serious game field is relatively new, and needed data will often not be in the research literature, we are building in the capability to enter data about expert opinion on various topics relevant to the Methodology.
3. Administration Tools. Underlying both the Toolkit and Resources are Administration and management tools. The Toolkit and Resources will constantly evolve as the field evolves, new scientific discoveries are made, new technologies are introduced, and new games are developed.

The remainder of this section contains flow charts of the expected workflow, top-level functionality, interface prototypes of the tool and a use case. The tool, while it can be used stand-alone, is being built as a module within our company's instructional game design authoring

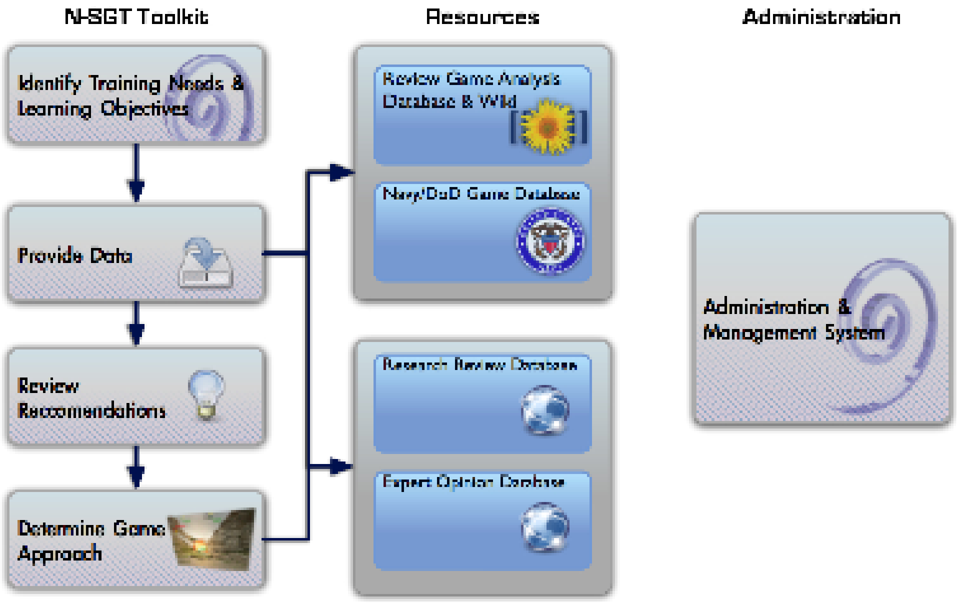


Figure 2. Overview of the N-SGT Authoring Toolkit environment.

platform called IIPI CREATE. This integration will provide Navy training personnel with the ability to easily take data and decisions from the N-SGT Toolkit and integrate it further down the instructional design pipeline such as when actual game design begins. It also reduces our development costs because we can leverage an extensive amount of design and programming effort.

3.1 Integration with Navy ISD Processes

A concern of developing any new methodology or tool is how well it integrates into existing organizational structures and practices. As such, we examined Navy and DoD Instructional Systems Design (ISD) processes to best understand where in the process our Methodology and Toolkit would be used. For instance, in examining the Navy Integrated Learning Environment (Naval Personnel Development Command, 2005), we determined that before beginning to work in the Toolkit that the users would have already conducted their analyses (e.g., tasks, terminal and enabling learning objectives, performance standards) and that this data would serve as part of the basis for using the Toolkit. Therefore, we have not sought to replicate or replace those established processes in the Toolkit. We are positioning the Toolkit between this early stage and the actual design of course materials. In this gap, a training manager or instructional designer is determining the course structure, media that is most appropriate for teaching the content, and specific assessment mechanisms that will be utilized.

While we are positioning the use of the Toolkit at this juncture in the process, we realize that true instructional design is not linear and that often information gathered and the rationale for decisions made at earlier stages can be lost as the ISD process progresses through the various steps. Therefore, our design assumes an iterative design process in which initial decisions about whether to use a game-based approach are revisited as the instructional design matures. Therefore, the Toolkit provides design features that support documenting and sharing decisions and the rationale behind those decisions.

3.1 Building on the IIPI CREATE Platform

Although beyond the scope of this STTR project, there is a significant need to provide instructional designers with tools that enable them to design blended learning instruction which effectively integrates new technologies such as games, mobile computers, online tools, and mixed reality as well as traditional technologies (Kirkley and Kirkley, 2006). Our team prototyped the IIPI CREATE authoring tool for this purpose under a Phase II SBIR for the U.S. Army Research Institute (Kirkley, Kirkley, Myers, Tomblin, Borland, et al, 2006). A high-level diagram in Figure 3 illustrates how we approached the authoring tool. Our focus with this prototype tool is on supporting the design of next generation blended learning environments which may include a wide range of media and approaches (e.g., games, online learning, classroom lecture) but not the actual production of the materials because of the wide variety of tools that might be used. For instance, with game-based learning there are numerous game engines, modeling tools, AI engines, and so on. Our goal is to support the design team in using the best available technology by providing design and documentation support that is independent of any single technology.

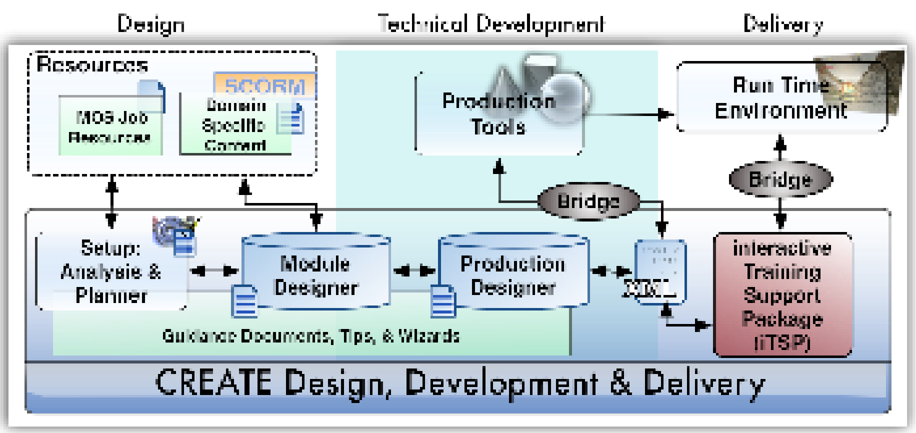


Figure 3. The IIPI CREATE Authoring Platform provides support for the design of next generation blended learning and support for trainers using the instructional package.

Building on the IIPI CREATE platform offers the Navy the opportunity to both reduce costs of development of the prototype N-SGT Toolkit and to leverage additional tools that could benefit the entire ISD process when designing game-based instruction. Our plan is that in Phase II we will build the N-SGT Toolkit as a module within the CREATE platform thereby leveraging existing technical assets (e.g., source code) and relevant interface design conventions that will benefit this project. For Phase II, we will eliminate other modules that are not specifically used in the N-SGT Methodology. However, in Phase III, pending feedback and interest from the Navy we may fully integrate the N-SGT Toolkit with the entire CREATE platform so that an end-to-end solution can be provided for serious game design.

3.1.1 Sample Screens from IIPI CREATE Prototype

The following screens provide images from the existing prototype developed for the U.S. Army under a previous SBIR Phase II contract. These will serve to illustrate core functionality that may be leveraged in Phase II and III. These will also serve as a basis for understanding the look-and-feel of the tool. It should be noted that these screenshots are from an Army specific version of the tool which is mapped to their terminology. Later in Section 3, initial concept images of the N-SGT Toolkit are provided.

The Training Matrix is illustrated in Figure 4. The matrix enables the instructional designer to create and link Tasks, Terminal Learning Objectives, Enabling Learning Objectives and Performance Expectations. The area labeled [1] shows a hierarchical view of all the items and how they are linked. Area [2] is the pool of all items available. This is where new learning objectives are developed. Area [3] provides detailed information on the item selected in the top half of the screen. Although not labeled, the left side of the screen is the navigation for an entire module. As we can see in this image, the designer has created various analyses documents which if clicked will be opened. The Training Matrix <u>will</u> be used in the N-SGT Toolkit.

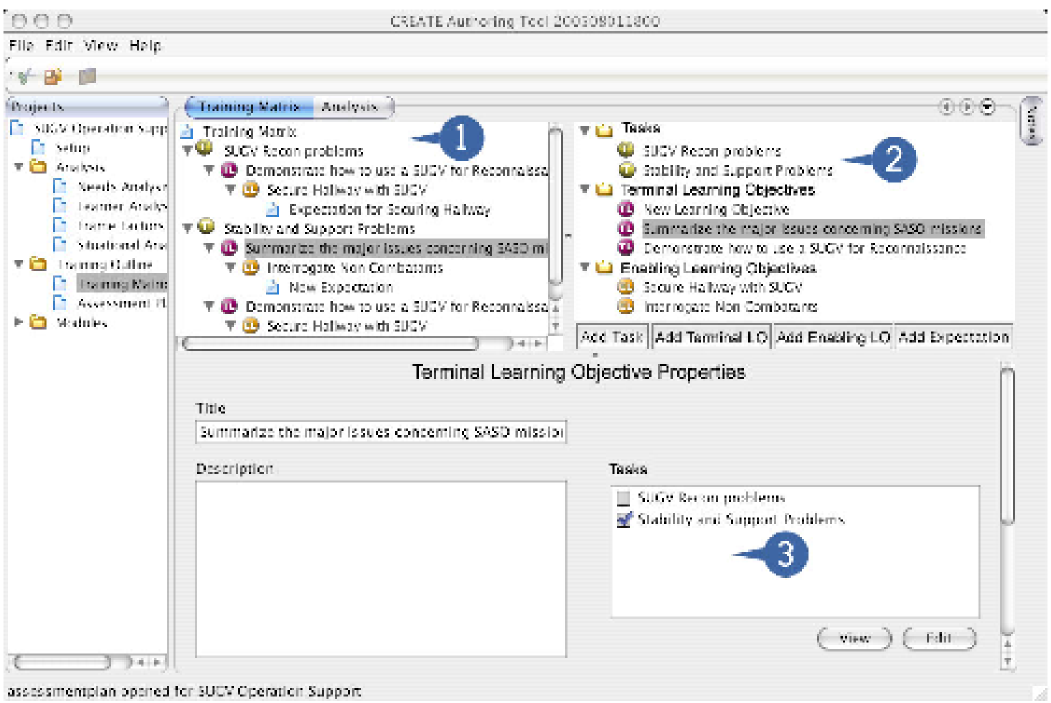


Figure 4. IIPI CREATE Training Matrix

A game design specific view in the Training Matrix is shown in Figure 5. This view uses the same data from Figure 4, but shows how it is linked to an emerging game design. In this illustration, we see that the selected Learning Objective in area [1] is used in Module 1 (area [2]) and that a game storyboard is linked to it. In that storyboard, in area [3] we see the lists of actions and game tasks that will address the learning objective. Selecting one of these shows how performance will be assessed. This data would not be created until after it has been determined that a game-based approach is desired by using the N-SGT Toolkit, therefore it will not be used in our Phase II work.

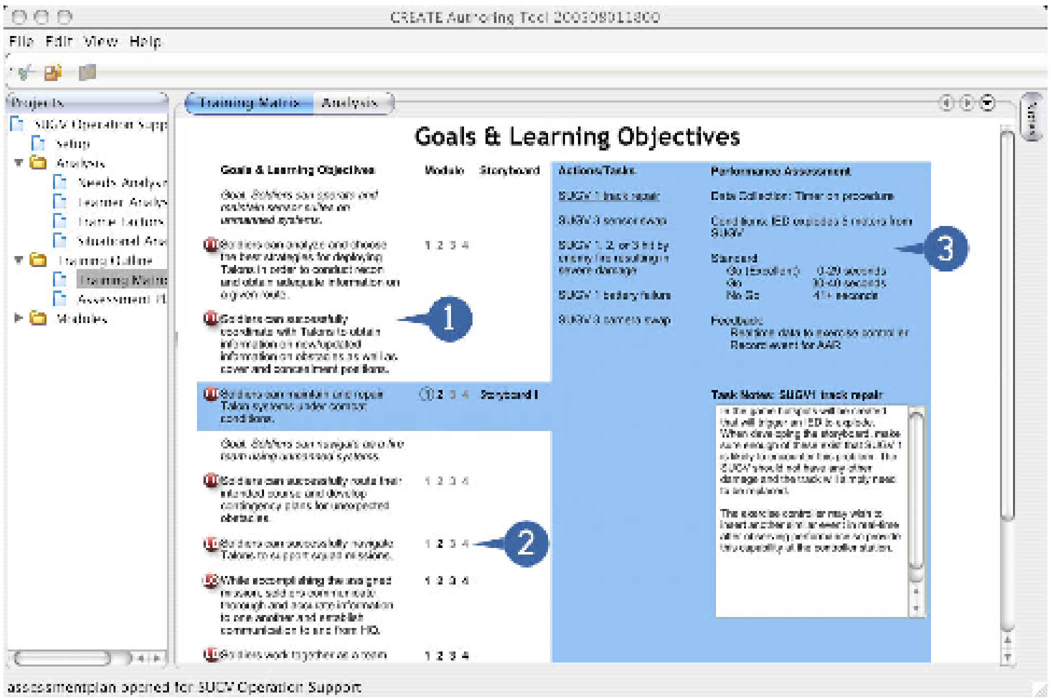


Figure 5. IIPI CREATE Training Matrix view for initial Game Design

The Storyboard Editor is shown in Figure 6. This editor builds on the data shown in Figure 5 but provides graphical layout and other tools to help the instructional and game designers build a visual representation of how a game will be structured. As can be seen in area [1], on each scene there are icons that indicated if a learning objective is tied to that scene (the “LO” icon) or assessment/evaluation (the “E” icon). This enables the game designer to clearly see how the game is tied to learning objectives and assessment mechanisms. In area [2] are notes that the designer has added to the storyboard. Area [3] illustrates tool palettes that can be opened to facilitate creating a storyboard. This feature will not be part of the N-SGT Toolkit but, along with Figure 5, serves as an important example of how the N-SGT could be linked in with a larger set of instructional design tools and data could be shared across the different tools. For instance, data entered into the N-SGT and relevant Resources could be automatically linked into the storyboard to facilitate the design process.

The next sections provide information on how the IIPI CREATE platform will be enhanced to support the N-SGT Methodology.

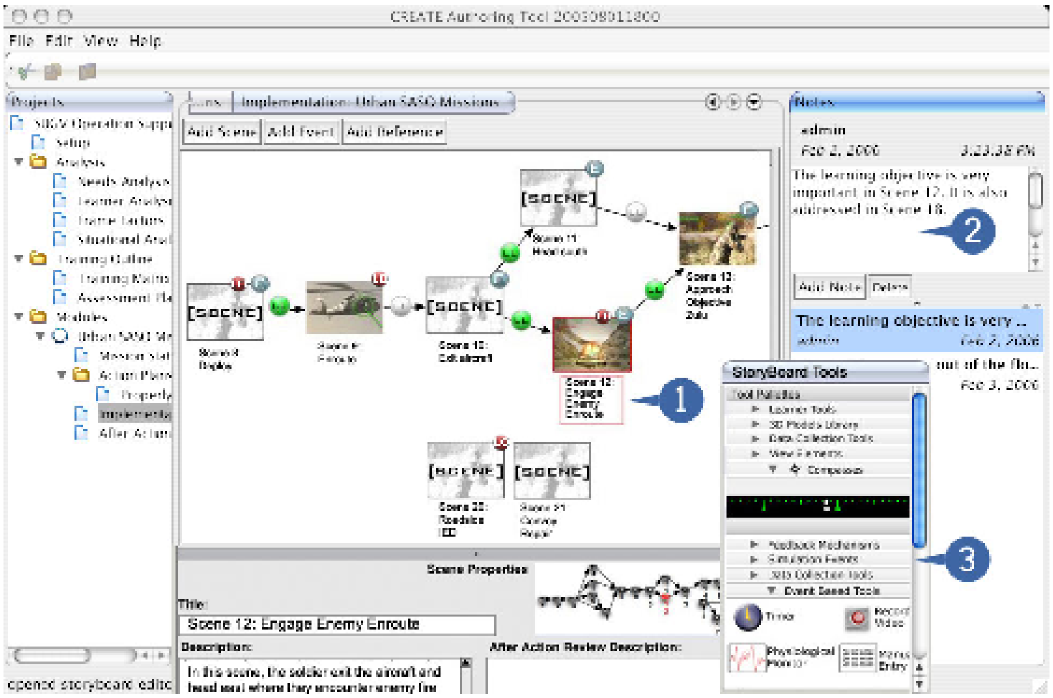


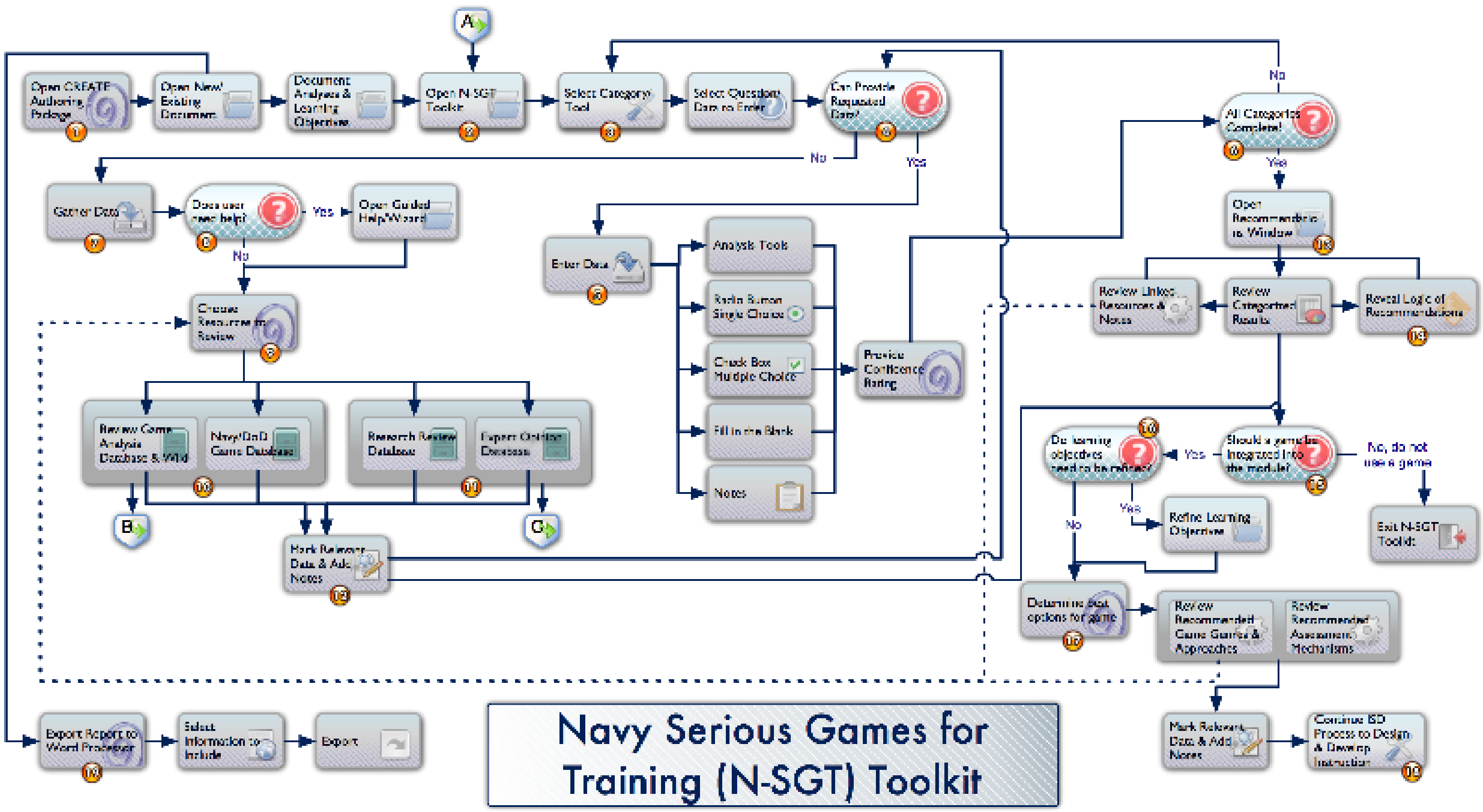
Figure 6. IIPI CREATE Game Storyboard Editor

3.2 Key Features of the N-SGT Authoring Toolkit

During Phase I, the IIPI team worked with instructional designers, game designers and researchers to identify key issues in designing and using games for training. From this research, and examination of existing Navy ISD practices, a workflow analysis was conducted and reviewed. The result of that process is presented in the following workflow description and conceptual screen designs.

The workflow for the Toolkit is outlined in Figure 7. The figure has been enhanced with numbers in circles that will be used to help the reader follow the user case below which describes a hypothetical training manager using the N-SGT Toolkit. Note that conceptual mockup screens are also included to enhance understanding. In the text wherever “WF#” is included, it is reference a number in Figure 7. For instance, WF2 is referring to the part of the workflow where the N-SGT Toolkit is opened.

Bob is a training manager in charge of managing a team of instructional designers and contractors who design training for the Navy. His group has recently been assigned the task of revising a course to teach firefighting onboard ships based on newly issued processes and equipment. Bob has been told that the Navy is interested in using games in their training and that he needs to



Figures 7. Workflow for the N-SGT Toolkit

determine if the revised course should make use of game-based training. Bob's team gathers all the relevant training requirements and conducts the needed analyses (e.g., needs analysis, task analysis, learner analysis) based on the new training requirements.

Beginning at WF1, Bob opens the CREATE Authoring Package and either selects an existing course or creates a new one. If he were using the full CREATE system, he would have already been using the tool during the analysis process. In this case, Bob is only using the N-SGT Toolkit. However, before using those tools, he adds his analysis documents to CREATE and develops his learning objectives, expected performance criteria and high-level information on planned assessment.

3.2.1 Entering Data in the N-SGT Authoring Toolkit

At WF2 in Figure 7, Bob launches the N-SGT Toolkit by selecting the N-SGT link in the Project Navigation area on the left side of the tool window as seen in Figure 8. From the popup menu, he selects the category or tool he wants to use from the Methodology (WF3). The screen then displays the relevant questions or tools from the methodology. Bob selects Question 1 and the field expands to enable him to provide the requested data. The left side of the blue area is the place where he provides the requested data.

The right side contains three additional items. The *confidence* slider bar enables Bob to indicate how confident he is in the answer he is providing. It is assumed that people using the tool will have to guess or estimate at times. This enables them to indicate how much they believe in what they have entered. In addition, a Notes field for this question is available so that Bob can add any additional details that he wishes. Both the Notes and Confidence indicator can be reviewed later in the Recommendations window when Bob is reviewing the results. The Help button will launch a help window and/or a wizard that will assist the user in answering the question. This will contain information from the Methodology.

Lastly, on the far left side of the blue area next to the question number is a Completion icon. This is used by Bob to indicate if he has partially or fully answered a question. If he has not answered the question, the circle is white. If he has partially answered the question but wants to come back to it, he selects the yellow dash, and if he is finished answering the question, he selects the green checkmark. This provides an easy to understand indicator of progress through each section of the Methodology.

In some cases, as Bob progresses through the different categories and tools, the same data as previously entered may be needed again. For instance, if he has already entered his budget and that number is needed again, it will automatically be entered for him.

Back to WF4, Bob is looking at Question 1 and decides that he knows enough to answer the question so he enters the required information and proceeds to WF5. The type of information entered may vary depending on what is needed such as a discrete choice from a list, multiple answers, fill-in-the-blank or use of a tool that analyzes data. After the question is answered, Bob checks to see if all categories have been completed at WF6. If not, he cycles back to WF3 and selects the next category, tool, or question.

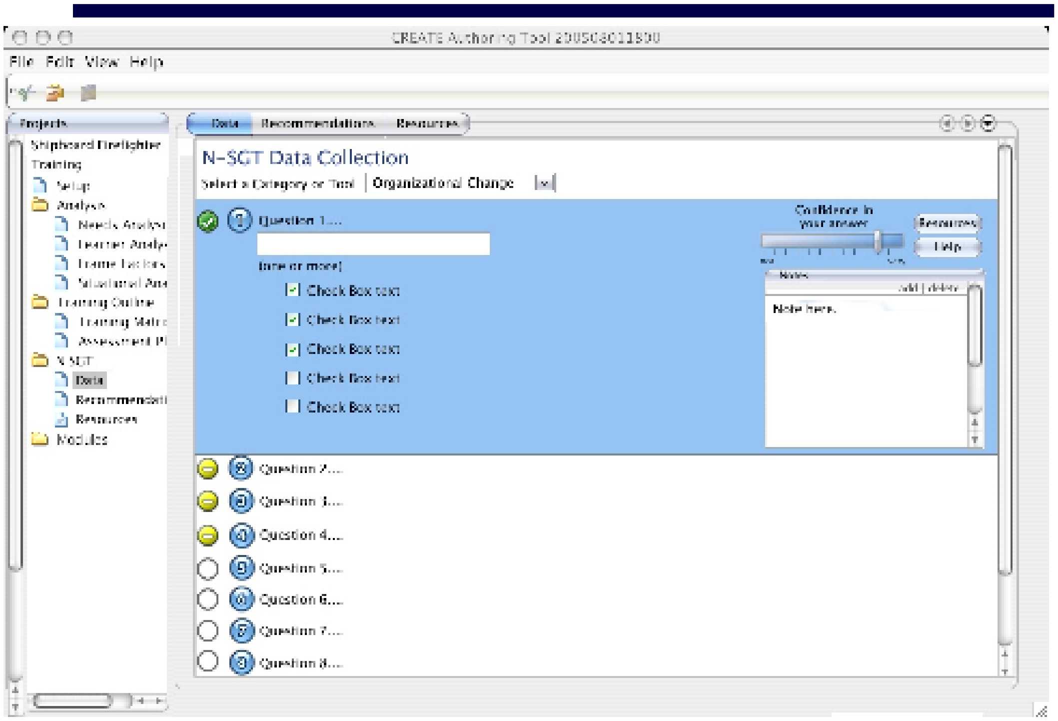


Figure 8. Data Entry Screen in the N-SGT Toolkit

3.2.2 Consulting Resources in the N-SGT Authoring Toolkit

If Bob reaches a question where he does not have enough information to provide an answer or make a decision, he will need to (WF7) gather the needed data. If he needs help (WF8), he will be provided support to gather the needed data with either help/guidance information or possibly a wizard. With or without the help, Bob accesses Resources (WF9) that are made available to help him.

Resources, as described previously, are in the form of a Game Analysis Database and Wiki (WF10) and Research Reviews and Expert Opinion Databases (WF11). These Resources provide a means for Bob to find information relevant to the data he is seeking.

The Game Analysis Database contains various types of analyses of different serious games and commercial video games. A subset of this database are analyses of Navy/DoD sanctioned training games. These analyses are supplemented by video clips and still images from the games being analyzed. We believe that it is critical that Bob and the instructional designers be provided real examples from games to use in their analysis and design work. Use of games is not as simple as saying games are good for this and not good for that. Effectiveness of instruction is a matter of the *design* of the instruction which greatly impact whether training objectives are met. Duffy and Kirkley (2004) state that the effectiveness of learning depends on the design of the learning as well as learner engagement rather than the delivery mode (e.g., a game). Since game designs are interactive and often complex, providing a set of examples to match up with characteristics will help instructional and game designers understand training objectives and how they work.

Providing illustrations of these examples in the N-SGT in an interactive database within the *N-SGT Toolkit* should be an effective way to provide these examples.

For example, Bob is developing training on firefighting aboard a ship. For his training, it is critical that the sailors understand how to visually determine the intensity of a fire and how a fire spreads through the ship. Therefore, when he reviews the database he can look for examples of fire fidelity and the accuracy of the physics driving the fire assets in the example games. From this he may determine that he can not afford the game engines that support the level of fire fidelity required and therefore, based on this data, a game solution becomes less likely.

Of equal importance to good decision-making, Bob may also need to access the Research Review and Expert Opinion Databases. These databases serve the same purpose even though they get their data from different sources. The Research Review Database contains data from scientifically valid game-based learning and other relevant research projects. Consulting this database provides Bob with easy access to high quality data from the scientific literature in an accessible manner. We assume three levels of data presentation: 1) categorized summary statements in a form that a non-researcher can understand and apply which link to 2) one or more abstracts of the research on which the statements are derived which are linked to 3) the official citations and perhaps PDF files of the base research. The goal is to enable Bob to dig as deep as he needs and desires to understand the relevant information.

In many cases, until the serious games field matures over the next decade, there will be lack of research on key variables. A mechanism needs to be provided that will fill this gap between what we need to know to make effective decisions and what research can tell us. Therefore, an Expert Opinion Database will be constructed to capture the opinions of experts on these factors. This database will provide data at two levels: 1) categorized summary statements in the form a non-researcher can understand and apply which link to 2) richer descriptions of the experts' opinions and anecdotal evidence from the research literature. Of course, as new research emerges, that data will need to be added to the Research Review Database and replace the expert opinions. Lastly, the types of experts who are providing the opinion may also be relevant. For instance, if the opinions are generated from a wide variety of sources and it is conflicting, Bob may wish to only see opinions from other Navy personnel.

As Bob is entering data into the Toolkit, the system is dynamically querying all the Resources to identify potentially relevant items that could help him in making his decisions. This dynamic querying can be in the form of preset queries associated with a category of questions or tools, links to specific resources attached to a specific question, and by the system pulling keywords out of the answers Bob is providing to use in generating a search string. As seen in Figure 9, Bob can at any time click on the Resources tab and see a prioritized list of possibly relevant resources based on all the data he has entered up to this point and relevant to the specific task he is performing (e.g., resources relevant to Question 1 or calculating ROI).

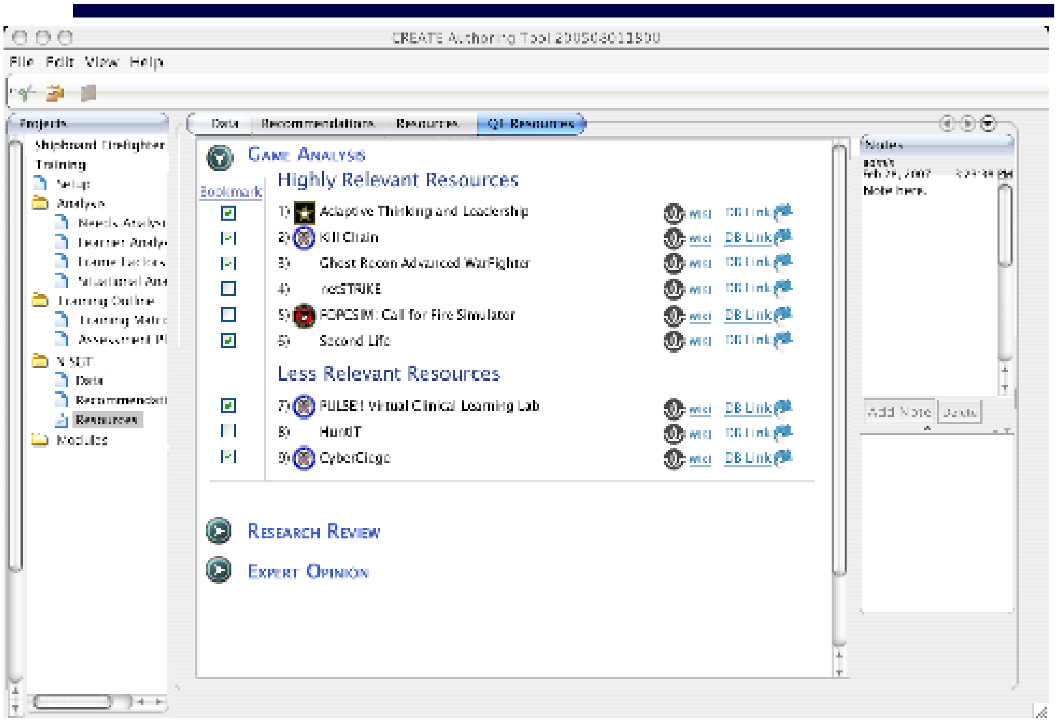


Figure 9. Reviewing the List of Recommended Resources in the N-SGT Toolkit

In Figure 10, Bob has selected one of the resources and a popup window appears with the relevant Resource; in this case, a description of Second Life with an analysis of its physics engine capabilities. If Bob finds this resource useful, he may bookmark it for later use. He may also attach project specific notes to the resource for later use.

The administration tools for the Toolkit and Resources are described in later sections. These tools enable the linkage between tools and questions and for the creation/editing of Resources.

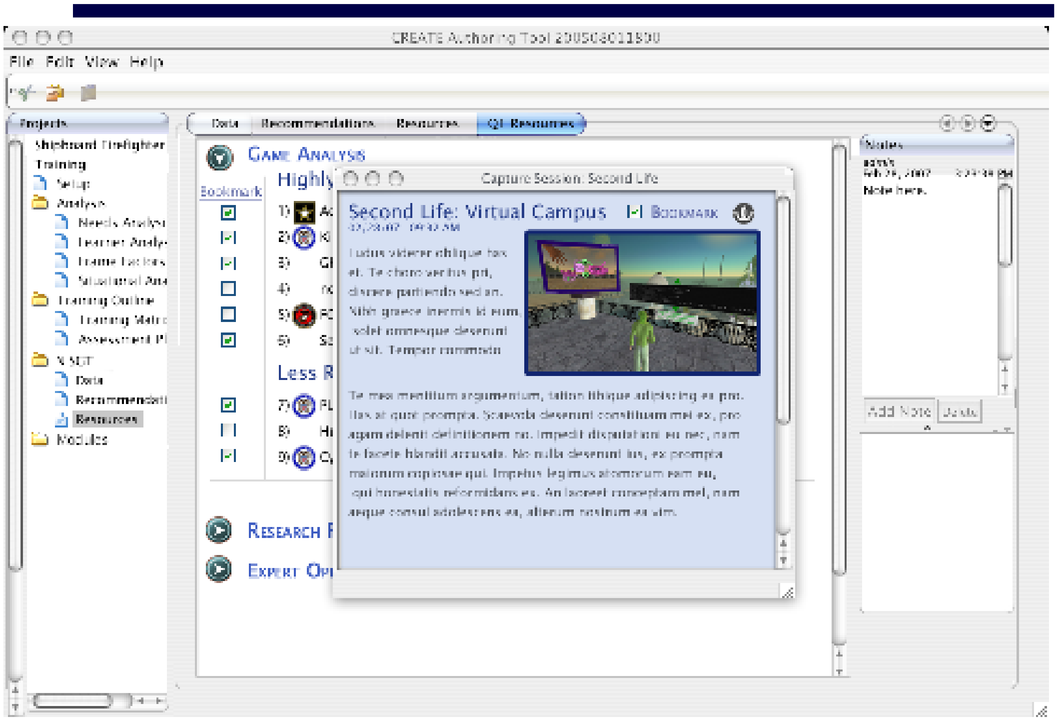


Figure 10. Reviewing one of the Recommended Resources in the N-SGT Toolkit

3.2.3 Viewing Recommendations in the N-SGT Authoring Toolkit

While he can access the Recommendations at any time, after reviewing the Resources and providing the required data for all the questions (WF6), Bob opens the Recommendations window (WF13) as seen in Figure 11. The window appears with categorized results based on the data entered by Bob. In this example, the blue bars indicates the strength of positive indicators of the potential use of games, the red bars indicate the strength of negative indicators. Selecting any of these items will expand that item and reveal subcategories with their own blue and red bars, thus enabling Bob to drill down into the recommendations. These results may be displayed in a number of ways which will be further investigated as this research continues in the next Phase. We have considered ordered lists, bar charts, color coding, iconic representation and tables. These will be examined further and possible displays will be tested with user populations. The goal is for people like Bob to be able to easily interpret the results in order to make a final determination of what the data mean. It should be noted that the tool will not provide a definitive Yes/No answer but rather indicate ranked possibilities and issues to be considered. Making a final determination is both art and science. The science behind game-based learning is not strong enough at this time, and will take years to fully mature.

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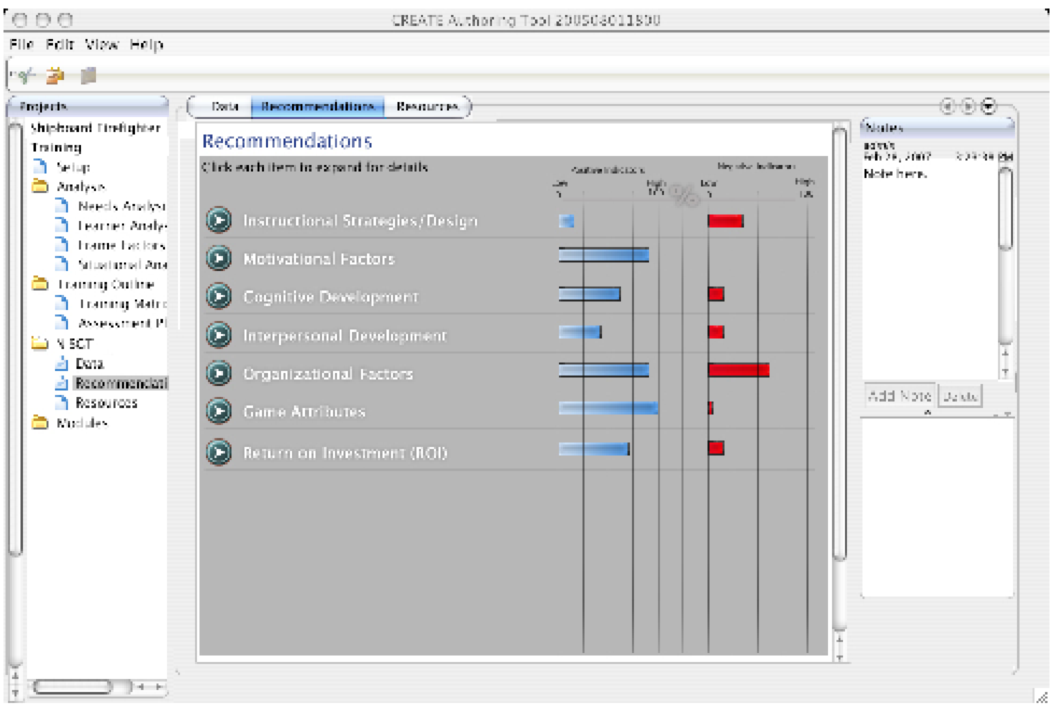
Using the data provided by Bob, cross-referenced to data in the Research Literature Review and Expert Opinion Databases, and using the weighting and validity (see admin tools below) provided to each question, the system can indicate possibilities and levels of relevance. It should be noted that some items will be clear cut answers. For instance, if Bob needs a certain level of fire fidelity but his budget cannot pay to license the only game engine that can provide that level of fidelity, then the answer is clear that he can't meet that requirement.

As Bob reviews the recommendations, he is provided links to relevant Resources that may be helpful in interpreting the recommendations. These may be Resources previously reviewed or new items. In addition, Bob can also access the logic (WF14) behind the recommendations being made. It will likely be important for Bob to understand the reasoning behind the recommendations and the sources of that logic. This can include how questions were weighted (e.g., question 1 is twice as important as question 2), the perceived validity of the underlying data, and the source of the underlying data (e.g., scientific research, opinion). Help provides links to guidance from the Methodology.

Once considering all the Recommendations, Bob makes a final determination of whether to use a game of not (WF15). If he chooses not to use a game, he will exit the N-SGT Toolkit as a game is not appropriate for the training needs. In our case, Bob has decided that using a game is appropriate. He may at this point reconsider if his learning objectives are appropriate given the possibilities for training offered by a game. For instance, if his learning objective focuses on a low-level skill, he may revise it to be more performance based but incorporating the skill. It is not likely that Bob will change the learning objectives but it is a possibility that could be available in an iterative design environment.



Figures 11. Reviewing the Recommendations in the N-SGT Toolkit

Bob has entered significant data into the N-SGT Toolkit. The next step is for him to determine the best options for the game he is recommending the instructional designers produce (WF17). In the Recommendations window he will be provided tools to summarize his decision and provide relevant guidance for the instructional design team. Once again, he may revisit the resources, but this time the reviewed resources may not only help him determine specific courses of action but also provide him the ability to bookmark relevant information that could be useful for his instructional and game design team. For instance, he may bookmark a video clip of the fidelity of fire he desires in the training game or an example of and approach to scaffolding he thinks will work in this situation. The Resources window will present items based on different approaches such as genres.

In addition, Bob can also indicate how the game will fit into the overall assessment plan. Games offer rich environments for a variety of different types of assessment. Again, using the Resources, Bob is able to identify relevant examples that can be bookmarked for the team.

At this point, Bob has completed all of his work with the N-SGT Toolkit. He has entered relevant data needed by the Methodology, he has reviewed relevant resources, examined recommendations, decided to use a game, and organized his decisions into a form that can be passed onto the instructional design team. They will then use this as they continue the ISD process (WF18).

3.2.4 Exporting

Although the rich set of data Bob has entered is contained in the CREATE database, Bob may chose to export a subset of the data for sharing with his team, managers, or others in the training hierarchy. If so, he will open the Export Report tool (WF19), select the specific information he wishes to include in the report and export it out in a common format such as RTF, PDF or HTML.

3.2.5 Administration Tools for N-SGT Authoring Toolkit

Administration tools are provided for the N-SGT Toolkit and Resources. These may be used to set parameters by organization, for teams or for individual projects. The next sections describe the basic features of the admin tools.

3.2.5.1 Admin Tools for the Data Entry and Recommendations

As seen in Figure 12, the Admin Tools are organized around the Methodology and data requested from the user. The “A” icon shows linkage to Figure 7 which also indicates where this figure links in. The admin tools provide the following capabilities:

- Add a new tool or category for the Methodology
- Add new questions or data linked to tools or categories
- For each question or data entered, adding a relative weighting of its importance when compared to other items (used in Recommendations)
- Adding a validity rating for each source of data used to inform the Recommendations (see example below)
- Linking the categories, tools, questions or data requested to specific resources or entering keywords to be used in dynamically querying the database

A log will be used to track changes made in the Admin Tools in case modifications need to be reverted back to a previous state or for the system to use if an older file is opened but the parameters have since been changed.

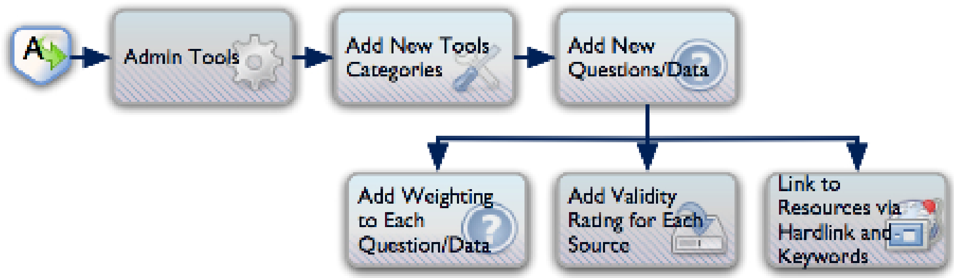


Figure 12. Flow of Admin Tools.

An example of how this *might* work is to consider setting the validity of the data driving recommendations. In this example, a Likert-like scale enables the administrator to indicate how "valid" the underlying data is. Underlying data might be something like "if you have this kind of learning objective with these kinds of learners, using a FPS game is likely to be a good choice". What the training manager needs is an indicator of how valid the recommendation being made by the system is. For instance, the default can be the following hypothetical ratings:

- Scientifically rigorous research, greater than 3 studies, all say same thing = 10
- Scientifically rigorous research, 3 or less studies = 8
- Scientific research, not rigorous, greater than 3 studies, all say same thing = 7
- Scientific research, not rigorous, 3 or less studies = 6
- Strong expert opinion rating and agreement = 4
    - E.g., everyone surveys says they really believe this fact is true
- Average expert opinion rating and agreement = 3
- Weak expert opinion rating and agreement = 1
- Do not give this criteria any rating because there is no expert opinion agreement but its an important judgment call by the instructional designer = 0

The above items might be radio buttons or slider that are selected by an admin level person.

3.2.5.2 Admin and Data Entry Tools for the Game Analysis Database and Wiki

The Game Analysis Database and Wiki is an interlinked set of examples that enable users to see rich and detailed examples of relevant information such as a live video clip of expert problem solving in a game, a discussion of how social interaction and leadership can be promoted in game design, and anything else the instructional designers, game designers, training managers, experts and subject matter experts find useful. It is designed to be a living system in which new games are examined, new questions are asked, and even to support the sharing of divergent views.

The admin tools for the Game Analysis Database and Wiki are illustrated in Figure 13. The "B" icon shows linkage to Figure 7 which also indicates where this figure links in. The tools enable the following core features:

- Segregating off Navy and DoD specific games analyses from the rest of the database
- Creating new forms for new analyses of new or existing games being added to the database
- Creation of new Wiki entries
- Cross-linking of database entries and Wiki entries
- The ability to capture data from various game consoles and PCs and store as digital video and still images
- The ability to create any number of database and Wiki entries that refer to the same digital video or still clip, or subsets of the video. For instance, a two-hour video of a game play session might only have 30 seconds of relevant gameplay for a particular analysis. The person creating the entry could link to just those 30 seconds.

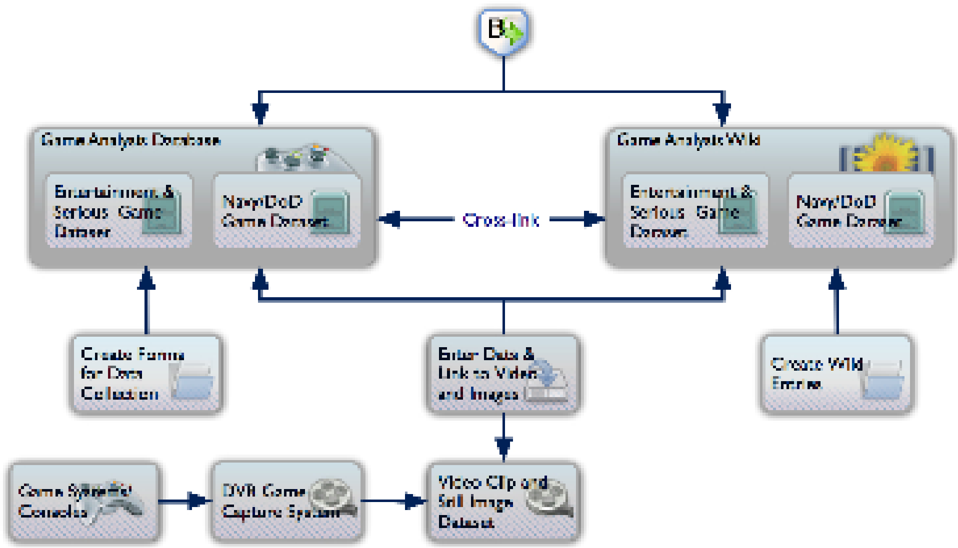


Figure 13. Flow for Game Analysis Database and Wiki.

In addition to conceptual design, we developed a working prototype system for capturing video of video games being played on a variety of platforms (e.g., Windows/Macintosh PC, Xbox360, Xbox, PS3, Nintendo Wii), a Web accessible database for researchers to use in analyzing the game, and a Wiki for discussion of the games. Figure 14 contains a screenshot of one screen in the admin view of the database. In Phase I Option, this system will be refined and populated with data for our testing. Extensive user interface design and testing needs to also be undertaken as the current interface was designed to test system functionality. Access to this system will be provided upon request by writing the Principal Investigator (see cover page).

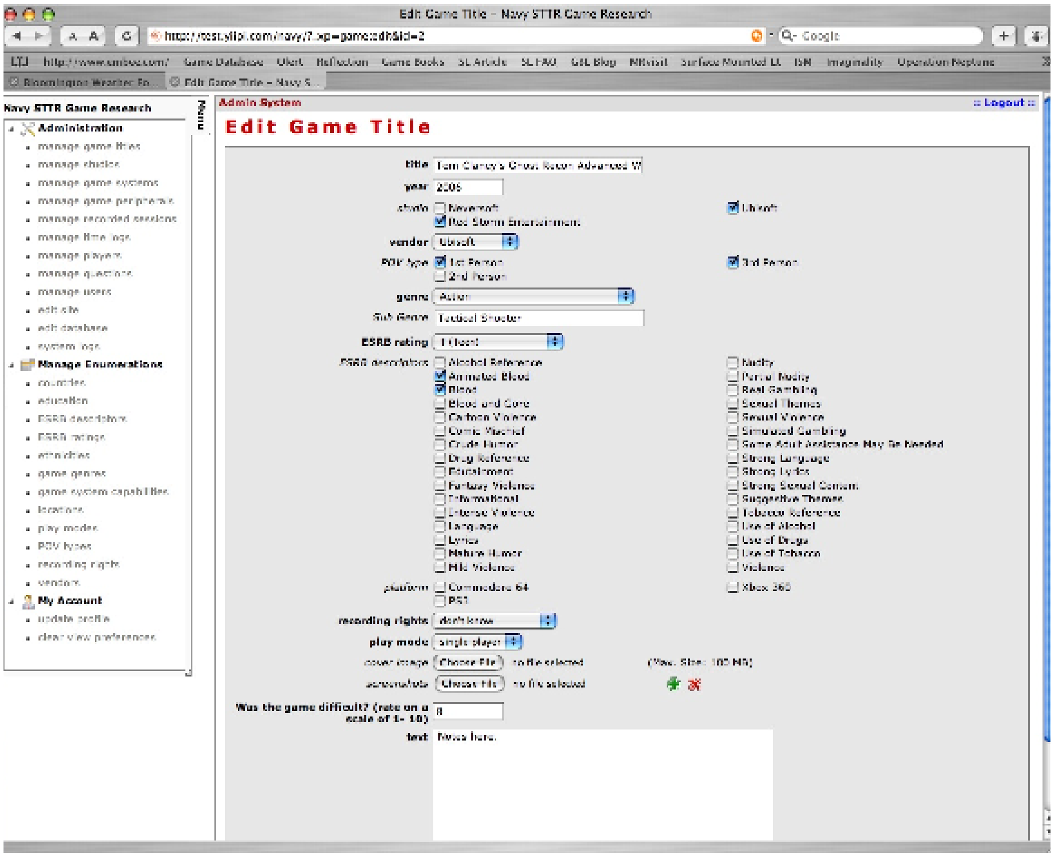


Figure 14. Data Entry Screen from Game Analysis Database Data Entry Screen

3.2.5.3 Admin Tools for the Research Review Database

The Research Review Database provides the decision-maker with access to relevant scientifically valid research that will inform his decisions. The database will also provide data to the Recommendations tool as it uses the data entered by the user to generate recommendations and issues to consider. The core functions of this database are illustrated in Figure 15. The “C” icon shows linkage to Figure 7 which also indicates where this figure links in. Those key features are:

- A citation entry and management system enables new items to be added to the database.
- The literature results screen summarizes the relevant data from an entry (single article) in easy to understand language and in terms the N-SGT Toolkit can use as part of Recommendations.
- The results are linked to richer abstracts of the research (optional).
- The results are linked to the original report if available.
- The results are linked into the Toolkit by being associated with specific categories, tools or questions as well as through keywords.

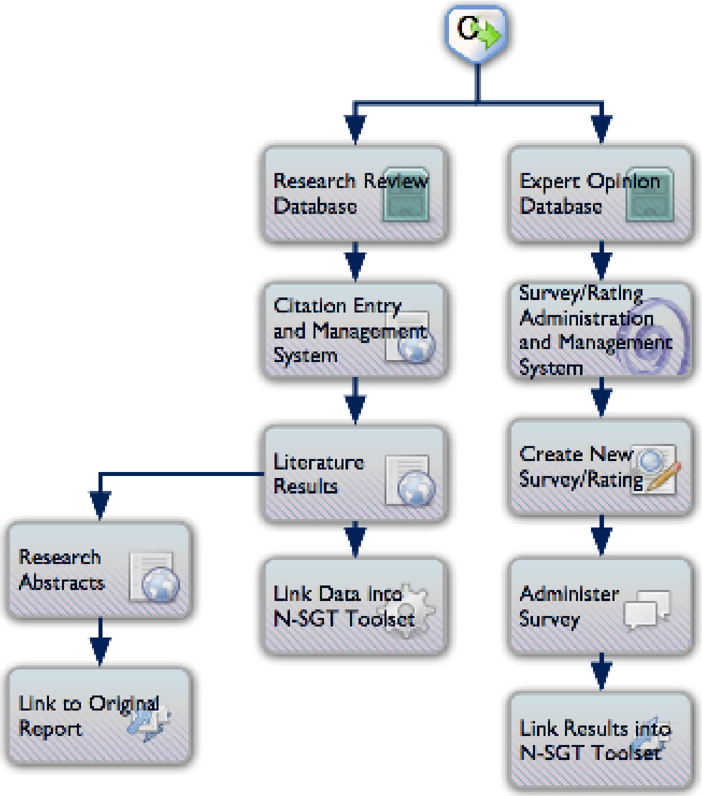


Figure 15. Flow for Research Review and Expert Opinion Database.

3.2.5.4 Admin Tools for the Expert Opinions Database

The admin tools for the Expert Opinions Database helps organize and manage expert opinions and in the collection of those opinions. The initial data screen of the tool will be similar to the Research Review Database and will provide the ability to summarize the information obtained from expert opinion. One unique component of this tool is that it must contain features that enable new surveys or ratings to be developed and for that survey data to be entered into the system in a useful way. Finally, this data must be linked into the N-SGT Toolkit as is the literature review data.

Expert opinion, who to obtain it from, and how many people to obtain it from is organization specific. For example, in some instances a senior training manager may provide the expert opinion. In other examples hundreds or experts across an industry may be surveyed. The way the data is used will remain the same though its validity may differ in these two instances.

3.3 Future Research and Development

As this project progresses through Phase I Option, Phase II, and Phase III, the N-SGT Toolkit and Resources will constantly need to mature. This will include an ever evolving user interface, the addition of new features and the population of the various databases with content.

3.3.1 Phase I Option Work on Toolkit

In Phase I Option, work on the Toolkit and Databases will continue in all areas. However, our primary emphasis will be in two aspects. First, as the COC game is developed and the test plan put into place, we will align that with ensuring that we gather the data needed to include in the N-SGT Toolkit (for instance, to populate the Research Review and Game Analysis Databases) and to help drive decisions on how game-based learning research can be used to drive recommendations for users of the Toolkit.

In addition, our team will begin to populate all the Resources with examples that can be used in our validation and testing in Phase II. This includes not only collecting the data but devising the administration tools that enable this to be entered into the system.

3.3.2 Phase II Work on Toolkit

In Phase II, we will refine the N-SGT Methodology developed in Phase I and validate it with a wide variety of training and instructional design experts within the Navy and corporate training departments. Once validated, the Toolkit will be programmed and testing conducted on effectiveness and usability. In addition, the underlying databases of training game examples and research literature findings will be populated for use within the Toolkit.

Our design and validation process will make use of proven design processes as described in the next section.

3.3.2.1 Rapid Prototyping and User Participatory Design

When exploring the use of any technology, but in particular with new technologies, user centered design approaches are a critical aspect of the design and development process. User centered approaches include rapid prototyping and user testing. Rapid prototyping sessions enable the interface designer to explore and try out a variety of possible interfaces before a large investment in programming has been made. With a typical computer program, the user interface development costs are large, but they will be even greater for mixed reality training environments due to the cutting edge nature of the equipment and lack of understanding on how to best utilize it given its maturity level. In addition, there are no clearly established design guidelines on which to build, such as the windows and folders metaphors used in many desktop operating systems. Additionally, mixed reality interfaces tend to be more unique and specialized than desktop applications. Since many applications are by their nature mobile, they often require traveling to a remote site to test. This is much more costly than testing the typical application that runs on a desktop.

Wilson & Rosenberg (1988) report that 67 percent of development effort is spent adding new features that were not identified in the original specification document, 56 percent of the system errors emerge from failures to identify all of the system requirements initially, and 87 percent of the cost to fix system errors comes from these requirements that were initially overlooked. Wilson & Rosenberg (1988), citing the work of Boehm, Gray, & Seewaldt (1984), state that development time can be reduced by 45 percent when rapid prototyping methods are employed early in the design cycle. Because of the novel nature of mixed reality interfaces, we predict the value of applying rapid prototyping methods to mixed reality interface and instructional design to be even greater. However, there is little information in the literature about how to apply rapid prototyping methods when developing mixed reality interfaces. It is especially important to begin exploring these issues while mixed reality is still in its early stages of development, before interface styles become firmly entrenched.

One of the greatest values of rapid prototyping procedures is using them to elicit valuable formative evaluation and usability during the early stages of development. By informing the designers about instructional requirements, the target users are involved with helping create a more effective instructional system. In the words of Witt & Wager (1994, p.22), “the purpose of rapid prototyping is to quickly demonstrate possibilities.” Through the application of rapid prototyping methods, we can begin to explore more fully, from a user’s perspective, the impact of different types of specific instructional techniques and how they are impacted by MR and VR technologies. This is a critical aspect of our design and development process.

3.3.3 Phase III Transition

In Phase III, our plan is to fully build out the Toolkit and Resources and field them for the Navy. At the Navy’s request, we can fully integrate the N-SGT Toolkit with the CREATE Authoring Platform for full end-to-end training development using game-based learning.

Section 4.0

Marine COC Game

In this project one of the key deliverables is to select a course and introduce a game-based training solution as part of the course. Within this course, our team will conduct scientifically rigorous testing to determine the impact of the game-based training. This will result in data that can be used as part of and to help validate the N-SGT Methodology and Toolkit. In addition, assuming the game is successful at meeting training goals and expected impact, the game will become part of the curriculum of the modified course thereby improving training in the selected domain.

Early in the project, our TPOC, Curtis Conkey, indicated that it may prove difficult to obtain permission to work with a Navy course so if we wanted to leverage a non-Navy course that was acceptable. We therefore had intended to develop hazmat related training to leverage work we are performing for the National Institutes of Health on hazmat training. As the project progressed, Mr. Conkey was contacted by a representation of the Marine Corps TECOM about our team potentially working with a training group at Marine Corps Base Quantico. After a series of discussions and meetings, it was determined that developing a game for training non-commissioned officers in Command Operations Center operations would be an appropriate fit for this STTR research project.

4.1 Need for COC Training

The U.S. Marine Corps Enlisted Professional Military Education (PME) Curriculum Branch at Marine Corps University (MCU) is responsible for the Advanced Course at Quantico MCB, VA. This course prepares gunnery sergeants and gunnery sergeant selectees for responsibilities befitting an E-7 in the Corps. The curriculum consists of 33 training days for Marines in the regular component and 12 training days for Marine Corps reservists. Successful completion of an Advanced Course Distance Education Program is a prerequisite. The Advanced Course's plan of instruction calls for training on "Command Post Operations and Rear Area Security". This session includes familiarization with the Combat Operations Center (COC), a modular system that can be transported, set up, and operated anywhere a Marine unit is needed on the ground. Although students are career Marines, they may have had little previous exposure to the way command posts work, and especially with the recently adopted COC.

Currently, COC familiarization takes place in a classroom where actual COC equipment is not available, often using paper images to represent real equipment. The students must use more than a little imagination to determine proper message and workflow procedures as they try to picture an unfamiliar environment containing imaginary workstations. What is needed is a game-based approach that immerses students in a virtual environment and helps them to learn proper COC principles of operation in an engaging manner. As this is the culminating block of instruction in the Advanced Course, Marines should graduate from this milestone course with a positive image of their resident training experience and enthusiasm for future training coming out of the Corps, rather than humorous memories of a few paper images and an exercise that seems as though it has been hurriedly cobbled together.

Our approach would allow an instructor to introduce Advanced Course students to the COC with a realistic, fast-paced tactical decision-making simulation showing how the interior of a typical COC might appear. Students might have the opportunity to individually explore the COC on laptops, observing the layout, equipment, and learning about various functional areas from avatars. Then, the instructor could take control of the simulation and facilitate a discussion among the students about what they had learned during their rapid tour. When the instructor is satisfied with students' ability to understand how the functional areas work together to support the commander, an OPORD could be issued to the students. Functional roles would be assigned and students would enter a multi-player phase of the game. There, they would play a game based on the OPORD. At the conclusion of the exercise, they would conduct an After-Action Review (AAR) and share their experiences with other students in order to achieve a better understanding of COC operations.

4.2 Concept

For this project, in Phase II, we will partner with Virtual Heroes, Inc. (VHI) to construct an interactive tactical decision-making simulation, provisionally titled ***COC***, that permits one or more users to simultaneously:

- Learn how a COC works;
- Become familiar with specific roles within a COC;
- Engage in games simulating real-world scenarios, applying knowledge gained in the simulation to earn points and compete.

A Virtual Collaborative Environment (VCE) will be created to accommodate single or multiple simultaneous users, plus instructor-driven sessions in the simulation and game as necessary. Visually, the environment will include, at a minimum, the items and personnel necessary to conduct the training scenarios normally found in a real-world Marine Corps COC at the battalion level.

Figure 16. An example image of previous work by Virtual Heroes

Each user will be able to identify and interactively use the tools within the COC environment, including PC workstations, to view maps, and to plot friendly and enemy positions. They will send and receive communications via FM voice radios, satellite phones, field phones, VOIP and other data links such as text chat. The interface and GUI will correspond to existing Marine COC systems. Users will be able to practice effective face-to-face communication and teamwork with non-player characters (NPCs) and fellow users in the COC environment to successfully complete the game scenarios. Depending on the mode in use—single player or multi-player--interactions with COC personnel may be controlled by either the AI or other users. Users may roam freely throughout the COC interior as needed in the scenario being played (e.g., – the user is assisting a staff officer by supervising personnel at multiple stations within the COC).

After Action Reviews (AARs) can be run during, or upon completion of a scenario for the purposes of evaluating user performance, or to stress teaching points. AARs will include such features as timelines of event schedules and insertions in scenarios, message threads of each relevant communications channel, conversations between users and avatars, journal entries, and individual user keystrokes – all time-stamped. Virtual Heroes has built similar AAR capabilities on the America's Army platform and specifically for the Adaptive Thinking and Leadership game being used at Ft. Bragg (Figure 16).

4.3 GAMEPLAY

Users can experience the simulation in three different ways:

- As a single user, self-pacing through the introduction tutorial and training scenarios;
- With a group of other users, working together to complete the scenarios as a team;
- As an instructor, with the ability to assign user roles to introduce dynamic elements into scenarios on-the-fly for the users to overcome.

A user's experience will be fundamentally the same whether he/she is playing solo or in a multi-player game. The main difference will be whether they interact with artificial intelligence (AI) or fellow human users in the COC. Initially in the game, users might receive an introduction to how COCs work. An example of an introductory scenario is as follows:

The user is brought into the COC just as a "mini-crisis", such as a communications failure or a coordination error, disrupts the routine. The user has only a few minutes to explore the environment, while receiving guidance in the form of recorded dialog from an AI character (or live instruction if an instructor is present). Users will also see context sensitive labels and pop-up menus to help guide them through the initial mini-crisis scenario. After the mini-crisis has been resolved, a normal tutorial might begin, led by the AI, or the live instructor might involve users interactively by asking questions about what they saw, introducing them to further details, and clarifying for them the events and actions experienced during the initial mini-crisis.

From a training point of view, immersing them in a realistic COC environment in which they see its full operations will serve as an organizing framework and stimulus for further learning (Figure 17). As additional content is taught outside and inside the game, the trainees will understand the need for learning the new content and the complexities of performing their function in this environment.

Figure 17. Example of a Real COC

Following the tutorial and any other learning activities we design for the course, users would receive an OPORD, be assigned roles, and play in the game as COC team members in the OPORD for that exercise scenario. An AAR concludes each scenario and provides valuable feedback to users and instructors. Optionally, action can be halted during game play and an AAR snippet played back so that instructors can stress a teaching point.

4.3.1 Scoring

During our full design phase, the IIPI and Virtual Heroes teams will refine the simulation and game components of ***COC***. It is important to note that our team is fully aware that this game needs to be more than just a standard simulation in order to meet the requirements of the STTR. As an example of this, one of the common game mechanics is scoring. Game scoring for individual players in ***COC*** will be performance-based. Following are some examples of how a user might be evaluated:

- Number of objectives successfully completed during the scenario;
- Time to react to a critical situation;
- Time to complete a task or event, against standards;
- Ability to recognize, organize, and synthesize information from apparently disparate data;
- Resource management;
- Penalties for objectives failed.

Team scores among a given class or between classes would enhance competition.

4.4 Key Features

Our team will leverage Virtual Heroes' proven Adaptive Thinking and Learning (ATL) technology to provide ***COC*** with an immersive and beneficial learning environment. The ATL framework is regularly used for U.S. Army projects.

- **Virtual Collaborative Environment (VCE) functionality –** VCE-like functionality will allow instructors to train multiple students at once. Instructors can assign specific roles to each student, choose specific training scenarios, and introduce unexpected elements to scenarios on-the-fly to test students' adaptability. Students will benefit from collaborating with their peers in a simulated real-world COC environment.
- **Full Featured Communications Network – *COC*** will have a network including VOIP and text chat that simulates full-featured communications modes commonly found in a COC environment, such as satellite phones, FM voice radio, and datalink.
- **After Action Review (AAR) –** Virtual Heroes' AAR technology will provide instructors and users with an account of the actions taken by each user during the scenarios, actions that should have been taken, and brief educational information to address knowledge gaps.

4.5 Development of the COC Game in Phase I Option & Phase II

The IIPI and Virtual Heroes teams have developed the above preliminary concepts for the game. We will be leveraging assets of both organizations to cost-effectively develop the game environment for Phase II within the budget available in the Phase II project minus the costs for N-SGT Toolkit development and evaluation and the costs of conducting the game evaluation at Quantico. In the Phase I Option period the detailed research plan will be developed as well as the project plan for developing the game.

4.5.1 Applied Cognitive Task Analysis for Game Design

Traditionally, game designers work with subject matter experts (SMEs) to design the goals, scenarios, and actions within a game. The value of this approach is that it enables game designers to gain information about the domain area, specific training goals and learning objectives, as well as possible game scenarios, interactions, and narratives. Subject matter experts serve as important conveyors and translators of a domain as well as reviewers and evaluators of the game designer's interpretation of the domain. In fact, SMEs provide direct support to the game designer in structuring the game so that it meets specified training goals.

SMEs, by their very nature, have a rich base of domain-specific knowledge that enables them to quickly recognize situations and patterns. They use this recognition to reason toward a solution by working with well-developed patterns (Chase & Simon, 1973; Chi, Feltovich, & Glaser, 1981; Klein, 1981). However, the problem solving and decision-making strategies of experts are sophisticated and often difficult to convey to novices as these strategies are deeply embedded in the context of real world situations (Klein, 1981). This presents a challenge for game designers who lack expertise in the domain that is the focus of the game. This knowledge gap between expert and novice can result in less effective game design.

To address this limitation, IIPI has developed the *Applied CTA for Game Design Framework*. This approach is based on research in complex problem solving (Frensch & Funke, 1981; Jonassen, 2004), recognitional planning model of decision-making (Klein, Calderwood and Clinton-Cirocco, 1989), expertise (Chi, Feltovich, & Glaser, 1981), as well as the use of methods of cognitive task analysis used to identify and map expert/novice differences. This game design framework consists of a five stage model.

1. Identify and conduct interviews with a primary SME to develop a preliminary game design document, including context, characters, game play scenarios, types of interactions, key decision points within the game, and context specific knowledge of the scenarios.
2. Develop prototypes of the key game scenarios and have the master SME evaluate those scenarios in order to identify and make needed improvements.
3. Using the revised game scenarios, conduct a serious of cognitive task analyses (CTA) (Schraagen, Chipman, & Shalin, 2000) with both experts and novices as they review the revised scenarios. To do this, an adapted version of the Critical Decision Method (Klein et al., 1989) was used. As they review each vignette, experts and novices were individually interviewed and were asked a series of questions via a think-aloud method. As they reviewed each scenario, they were asked to define relevant incidents, key decisions, situational cues, and what strategy they would use to address each situation. These think- aloud responses were recorded. Participants were asked whether they agreed or disagreed with the actions being taken, and what other actions should be taken. After each scenario, participants explained what steps they would take next in order to address the current situation.
4. The think aloud data from these interviews were then organized into decision-requirement tables, or DRTs (Phillips, et al., 1998), and these were organized based by each game scenario.
5. The DRTs were analyzed to determine differences between experts and novices. This was then used as the basis for refining and further developing the game scenarios as well as a basis for assessment.

Kirkley (2006) used this method with Soldiers in the U.S. Army to map differences in experts and novices in the domain of military operations in urban terrain (MOUT). This approach was used to develop game-based vignettes on this topic. Specifically, she found that experts with MOUT expertise were consistent in their ability to observe key relationships and/or variables, to see immediate patterns that supported them in organizing and understanding familiar problems, and to quickly develop a plausible solution. For the most part, experts displayed more flexible thinking as well as a holistic understanding of the problem solving strategies within the domain. Also, experts were able to draw on past experience in battle or mission-based training situations. In interviews conducted with novices, she found that even though they displayed a basic understanding of the game scenarios, they did not always understand the strategic implications of specific decisions. Their thinking was two-dimensional and less sophisticated, particularly with regard to interpretation of cues in the environment and the use of domain-specific tactics and expert TTP's. These findings are similar to those Ross, et al. (2003) report on mental models underlying tactical thinking skills.

In summary, this analysis process provides a more scientific approach to the design and development of serious games as well as the ability to concretely define the learning objectives and assessment variables being tested. Using this information, the instructional and game design team will then enter the game design phase as described in the next section.

4.5.2 Designing the Game Play

In previous work on integrating traditional instructional systems design (e.g., the ADDIE model) and traditional game design and problem based training (Kirkley, Tomblin, & Kirkley, 2005), our team has developed the following game design process which will be used in designing the COC game. Although originally called Problem Based Embedded Training as conceptualized for the U.S. Army (Kirkley, Kirkley, Myers, Tomblin, Borland, Pendleton, Borders, and Singer, 2006), we have recently renamed our approach Mission Based Training (MBT) and applied it specifically to game-based learning.

1. Define the backdrop/story using the mission statement. Write a narrative that briefly describes the story and the elements of the story.
2. Using your narrative, develop key scenarios that will be part of the story. A scenario consists of a group of scenes. A scenario is one part of a story line within the larger mission.
3. Develop a list of key scenes that will occur in the game. This can be done by using a storyboard approach by using panels of drawings to indicate the scenes and the order in which they might occur.
4. Develop a list of key events that will occur in the simulation. Once the scenes have been identified, key events can be generated by brainstorming possible actions and interactions. These can be developed using a critical decision method CTA approach (as described above) to help align key events with critical decisions of experts. Additionally, these events need to support learners in achieving competencies, so choose ones that meet this requirement. Note that one scene may have multiple competencies or even subcompetencies. These will need to be defined as the performance requirements become more clear.
5. Order the game events into a flow chart (Figure 18). With each scene are events, which a learner has to complete in order to move on to the next scene. Events may be defined as:
    - <u>learning events</u> - actions that move the scene forward (e.g., you get fired at by an insurgent, and you take him out).
    - <u>non learning</u> events – actions that promote learning or understanding

For learning events, be sure to define the following:

- competencies to be developed
- specific training objectives
- how training objective will be accomplished by learner
- list of content and resources needed

For the learning events, determine which ones will be assessed either as part of an AAR for the game or a final assessment. Assessed events are where learners can perform some sort of task and be assessed as part of the AAR process.

Lastly, determine what types of scaffolding needed. All learning events should have embedded scaffolds that provide guidance or help.

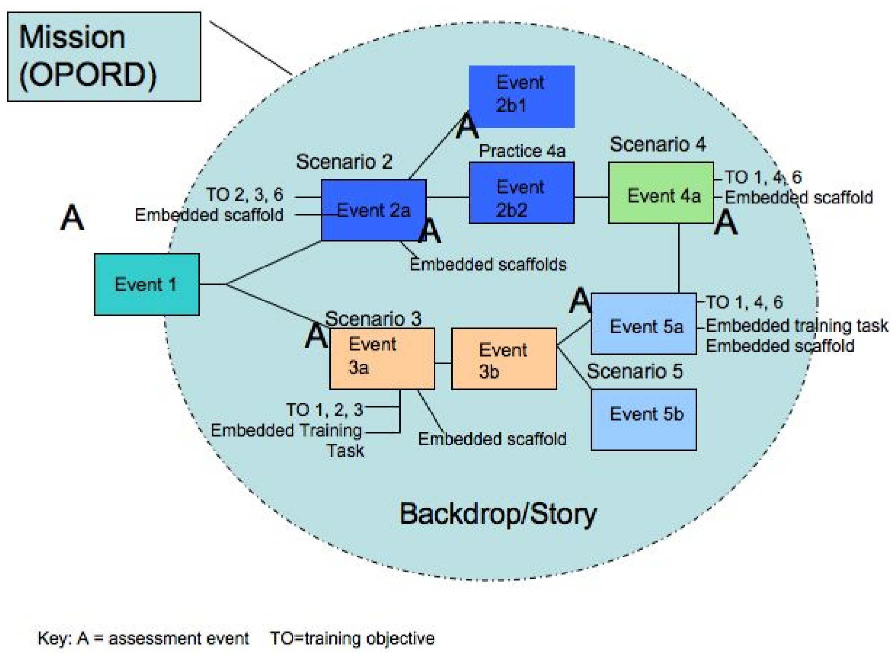


Figure 18. Simplified architecture of a problem-based game.

This architecture helps instructional and game designers better understand the overall structure of a game. This architecture addresses only the surface level components, and there can be much more detail added on both the instructional and game play components. However, the advantage of using this model is that it provides a common ground for understanding how instruction is embedded and defined within a simulation game.

In summary, the MBT game design methodology addresses several critical aspects of how to support game-based training: how to develop expertise in a complex environment by using authentic missions, how to use and design games to support complex learning, and how to design embedded scaffolds and expert/novice help to support varying learner needs within a simulation. We are in the process of adapting PBET Instructional Design and Trainer Guidelines to MBT guidelines for games under a different SBIR contract we have on hazmat training. These will be utilized in Phase II of this STTR to guide our team's work and with the Marine Trainers at Quantico as described in the next section.

4.6 Train-the-Trainer

One of the concerns expressed by the training team at Quantico concerned the ability of their trainers to facilitate game-based learning for COC's in which they were required to facilitate live gameplay as we have planned. In discussions, it was determined that we could have access to the trainers in order to train them on how to properly facilitate COC game operations. Our team has developed and conducted workshops for the defense industry and corporate and education trainers for over 15 years on effective teaching strategies, integrating technologies (including games into the classroom) and on game-based learning. We will develop a train-the trainer module specifically to build proficiency for Marine trainers on using our game in their classroom. Our team will deliver this module at Quantico before our research begins.

Section 5.0

Conclusions

In this report, we have presented the Navy Simulations and Games for Training (N-SGT) Methodology and Toolkit as a tool to help decision-makers choose when to use a game as well as to better understand the factors that impact their priorities with regard to use of game-based training. The N-SGT Methodology and Toolkit consists of:

1. A methodology derived from theory and research on human performance training (HPT), research on learning (e.g., problem-solving, development of expertise, transfer), game design characteristics, and instructional design;
2. A multidimensional taxonomy/matrix that maps training objectives and learning processes with game characteristics, in order to guide decision-making processes for choosing and using specific game-based training approaches;
3. Guidelines for using the methodology and taxonomy/matrix to choose game-based training solutions, or to design new games and/or approaches; and
4. A tool that provides guidance for developing game-based training solutions.

The real challenge with regard to addressing the use of game-based training solutions is to continue to examine, develop, and validate our approaches and methodologies for determining what mix of variables provides the most effective solutions. In fact, having authoring tools such as the prototypes we have described is an important part of the solution as this will enable game designers, instructional designers, and decision-makers to examine an evolving literature as well as the most effective approaches for game based learning to support the U.S. Navy.

In Phase II, we will continue the work described in this feasibility study in the following key areas:

- The Methodology will be refined and extended based on user feedback.
- The Toolkit will be prototyped and tested with members of our target population
- The Game Analysis Database and Wiki and the Literature Review and Expert Opinion Databases will be populated and tested for integration with the Toolkit.

The Marine COC Game will be developed and tested with the results informing the Methodology and being integrated into the Toolkit and databases.

This effort will lay the foundation for Phase III where we providing the Navy and DoD with a validated Methodology and Toolkit, and the Marines a new game-based training component for their courses.

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