A GAME-BASED TRAINING MODEL
DEVELOPMENT, APPLICATION, AND EVALUATION

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ABSTRACT

A shift in military training is underway from a traditional emphasis on classroom instruction to a more learner-centric model of training. In this approach, where training may be delivered "anytime, anywhere," trainees are often dispersed, and there is a greater responsibility on the learner to maintain motivation for his or her own learning. Although instructional games can provide a learning environment that actively engages the learner, this remains a relatively new instructional technology with limited empirical support.

Several studies have examined the effects of game-based instructional programs on learning. For example, both Whitehall and McDonald (1993) and Ricci, Salas, and Cannon-Bowers (1996) found that instruction incorporating game features led to improved learning. In addition, Ricci, et. al (1996) proposed that instruction that incorporated game features enhanced student motivation, which led to greater attention to training content and greater retention.

There is an implicit model of learning that is inherent in these studies. First, the goal is to design an instructional program that incorporates certain features or characteristics of games. Second, these features trigger a game cycle, a repeating cycle of user judgments, behavior, and feedback that characterizes the game player's self-motivated engagement and task persistence (Garris, Ahlers, and Driskell, 2001). To the extent that training designers are successful in pairing instructional content with appropriate game features, this engagement in game play leads to the achievement of training objectives and specific learning outcomes.

Although many have noted the potential benefits that may be gained from incorporating game characteristics into instructional applications, there is clearly little consensus regarding what the essential characteristics are and how they should be implemented. Based on a review of the literature about games, motivational training, and motivation-related constructs, we synthesized a model of motivational training using game features and predicted training and motivation outcomes. In this paper, we describe essential game features, how they were implemented for this research, and report a subset of the results of an empirical study to assess the effectiveness of a game-based trainer to enhance submarine technical skills and the effects of the training approach on student motivation. Bottom Gun, a game-based periscope trainer developed in support of this research, is a simulation-based game that incorporates simulated contacts, a high rate of interactivity, scoring, and visual and sound effects. The control training condition provided the same contacts within the same scenarios minus the game characteristics.

The proposed approach to designing and evaluating the effectiveness of games was generally supported. Despite holding training objectives and content constant, Bottom Gun was perceived as more game-like than the control condition. Results indicated that both training conditions resulted in significant improvements in accuracy in calling angle-on-the-bow, a difficult visual perception task. However, the game-based training resulted in smaller visual estimation errors than the control training condition. Additionally, four context-specific measures of components of motivation, including locus of control, self-efficacy, valence, and goal commitment were found to have shifted in a positive direction at the post-test.

ABOUT THE AUTHORS

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DEMAND FOR LEARNER-CENTRIC TRAINING

"Let the journey begin," the Navy's promise of adventure to potential recruits, suggests an alternative to additional schooling or direct entry into the work world. However, the first journey after boot camp is likely to be to an electronic classroom for technical training. Currently, classroom instructors provide fleet relevance and social support to try to motivate students to maintain interest in dry technical instruction. With the Navy-wide move toward distance and distributed learning, the motivation of isolated students will become a concern. The widespread perception is that computer-based training is frustrating, tedious, and unengaging. Documented student dropout rates, which are higher for distance learning (e.g., 30%-60%) than for classroom instruction, suggest that innovative approaches to training design must address the challenges of solo students (Phipps and Merisotic, 1999).

The game industry has reliably pushed the limits of imagination to create compelling experiences that motivate players (which includes 60% of all Americans over age six; Intihar, 2000) to return time and again. It appears that what motivates people to play is highly related to what motivates them to learn (Garris, Ahlers, and Driskell, 2001). Games teach knowledge and skills within game-based environments, rules, and goals. Players persist weeks, or months, to achieve fantasy objectives which result in mastery of platforms, weapons, tactical and strategic planning, and hand-eye coordination, for example. It appears that game strategies can also be applied to reality-based environments, rules, and goals. To ensure the effectiveness of game strategies in meeting mission critical training objectives, research is being conducted to clarify the relationships among training (game) characteristics, learner motivation, and training effectiveness.

The May 1997 N911 Science & Technology Round Table I prioritized Training R&D requirements (Department of the Navy, 1997). Requirement 10.1.a. includes, "Innovate and optimize instructional approaches (e.g., on-demand and just-in-time training) for initial, replacement, refresher and joint training: … 3. Examine methodologies and technologies such as media options and gaming… 6. Make training fun and relevant." This requirement (10.1.a) was ranked as being of the highest importance. In addition, the Chief of Naval Operations indicated a strong interest in leveraging interface and functional characteristics of commercial computer games to improve technical instruction, a traditionally dry subject matter.

Research into the use of instructional games has yielded promising results. For example, Whitehall and McDonald (1993) and Ricci, Salas, and Cannon-Bowers (1996) found that instructional game characteristics resulted in improved learning. Whitehall and McDonald suggested that a variable payoff schedule included in the game led to greater risk-taking and persistence on the task resulting in improved performance. Ricci, et. al (1996) suggested that game features enhanced student motivation leading to greater training-directed attention and superior retention. Additionally, research has been conducted to identify the critical game features to be incorporated into training design (Garris, et. al, 2001).

The rapid technical advances supporting high fidelity simulations and commercial computer games offer great potential for improved military training. In fact, the military has funded the entertainment industry in an attempt to leverage their simulation, game and cinematic design and development expertise to enhance military training and recruitment.

INCREASED DEPENDENCE ON STUDENT INITIATIVE AND PERSISTENCE

Traditionally, the instructor's role has been not only to disseminate information but to motivate students. Expert tutors expend at least as much effort influencing affect and motivation as providing information and influencing cognition (Lepper, Woolverton, Mumme, and Gurtner, 1993). Undeniably, educational outcomes are dependent upon student motivation and the resulting effort that students expend to learn. With reduced instructor billeting and the increasing shift to electronic classrooms and web-based instruction, students will find themselves more isolated from instructors and other students than

ever before. The requirement to get, and keep, students motivated will fall less frequently on instructors and classmates and more frequently on the individual students themselves.

To compensate, engaging approaches must be incorporated into instructional design more so than in the past, when it was considered unnecessarily difficult and expensive. The expected benefit of applying game approaches to training is the increased degree to which they will encourage students to: engage in repetitive practice, learn through exploration, and strive for increasingly more difficult goals. At a minimum, simply increasing practice time tends to result in increased learning (Wexley & Latham, 1981).

GAME CHARACTERISTICS

To identify state-of-the-art training game characteristics, an extensive review of the educational and psychological literature was conducted. This review revealed a broad set of game and motivational training descriptors. Although there were overlapping descriptions, no real consensus of what defines, nor even how to define, a game emerged. For example, Westrom and Shaban (1992) made a good case that what makes games fun includes challenge, curiosity, control and fantasy (a blend of descriptors of characteristics of a game itself and player reactions to the experience of playing a game). Lepper (1985) approached the problem from a slightly different angle and suggested that the four types of activities (player behaviors) that humans find attractive in training situations are: problem solving, processing information, exercising control, and playing. In addition to these features, social characteristics such as competition, cooperation, and recognition can be important motivators (Malone and Lepper, 1987). While these approaches are highly related, and apparently close to the mark, they do not approach the problem from the training design perspective.

Costikyan, (1994) a game designer, did just that. He first declared what games are not: puzzles (no opposition, roleplaying, nor resources to manage), toys (no objective), nor stories (too linear, limits player freedom and decision making). He calls games a "democratic artform" requiring active participation in which the game provides the rules but the player creates the consequences. In his attempt to identify what makes games interesting he suggested the following: decision making, goals, opposition (not as limiting as competition), managing resources, game tokens (i.e., your character), and information. He further suggests diplomacy (i.e., cooperation to achieve a goal), color, simulation, variety of encounters, position identification (i.e., rooting for your team), role-playing, socializing, and narrative tension make for a better game. His attempt to operationally define a game was an important contribution. However, he omitted characteristics suggested by others that appear to have merit, such as: progressive difficulty, performance feedback, informational complexity, sound effects, dynamic graphics, simulated danger, and high response rates.

The broad collection of game-related descriptors may be organized into three primary categories (Garris, et. al, 2001): *characteristics* that appear in the games themselves; emotional or cognitive *reactions* players have to them; and *behaviors* they evoke in the players. (See figure 1.) This schema is useful in guiding the design and evaluation of games because it suggests a linear relationship between the categories. If players behave in expected ways, it would be reasonable to assume that they first experienced desirable subjective reactions. It may further be assumed that these reactions resulted from an optimum mix of the characteristics of the games themselves. (It must also be acknowledged that different players may be more attracted to one game genre than to others, which distinguish themselves by differences in the relative emphasis placed on the different characteristics.)

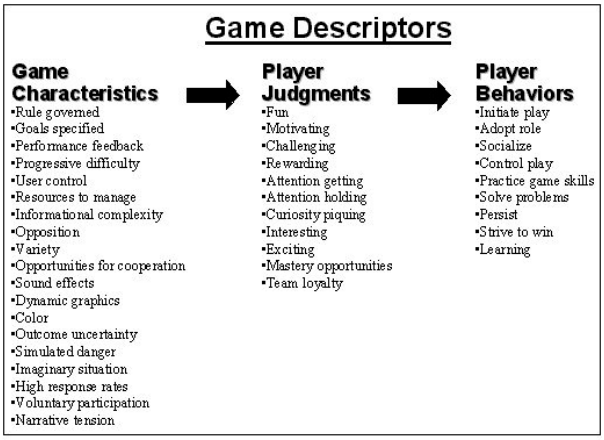

Figure 1. Game descriptors derived from the literature.

EFFECTS OF MOTIVATION ON PERFORMANCE AND TRAINING

Underlying the desire to develop intrinsically motivating instruction is the common belief that it not only makes learning more enjoyable, but that students learn best when they are intrinsically motivated to do so (Parker & Lepper, 1992). As a result, a large body of research has focused on identifying motivational factors that are related to learning and performance. Given that games can be highly motivating, it is important to determine the relationship between the multidimensional nature of motivation and training game characteristics in order to

increase the likelihood of designing training which truly captures the attention and effort of the learner. Four such factors were included in the focus of this research and are described in the following sections.

Expectancy Theory

Early theoretical development focused on understanding mediators of work behavior. These insights were later applied to educational issues. Expectancy theory, a formal model of work motivation developed by Victor Vroom (1964), was influential in understanding how people make decisions to behave in the ways they do. Also referred to as "instrumentality" theory, or "VIE" (Valence-Instrumentality-Expectancy) theory, it assumes that individuals ask themselves whether or not: (1) an outcome is valued (valence); (2) an outcome will yield other outcomes (instrumentality), and; (3) an action has a high probability of leading to an outcome (expectancy). Evidence that Vroom's model can predict educational outcomes follows.

Valence. Valence, having much the same meaning as the valence of an element in chemistry, has been found to play a major role in effort expenditure (Vroom, 1964). Likewise, Hamner, Ross, and Staw (1975), reported that level of effort was more accurately predicted than level of performance. Although it is somewhat disappointing that the relationship of valence to educational outcomes is not a direct one, it makes sense. We don't always attain what we strive for (because performance may be limited by other factors), but we try harder to get what we value than what we do not value.

Locus of Control. The Locus of Control (LOC) construct (closely related to Vroom's "instrumentality") is based on Rotter's (1954) social learning theory. LOC is defined by Rotter (1966, 1992) as a person's generalized expectancy (on a continuum from external to internal control) based primarily on his reinforcement history. Internal control refers to the perception that reinforcements are the result of one's own actions or effort. External control refers to the perception that reinforcements are the result of chance, luck, or some other external forces.

The literature generally supports the notion that a student with an internal locus of control will tend to be a higher academic achiever than a student with an external locus of control. Bar-Tal & Bar-Zohar (1977) reviewed 36 studies on the relationship between perception of control and academic achievement. Thirty-one of the studies reported some support for the existence of a positive relationship between internal locus of control and achievement. Reimanis (1973) reported "that internal control is a necessary pre-condition to the development of achievement striving in a school situation." (p. 207). Likewise, Duchesne (1986) found "a substantial relationship between academic achievement and locus of control" (p.113) in a population of students attending a vocational skills training center. Others have also demonstrated a relationship between locus of control and educational issues (Nowicki, 1973; Kren, 1992; Spector; 1982).

Self-Efficacy. Self-efficacy, which is closely related to Vroom's "expectancy," is typically measured in reference to a specific set of circumstances. It can be simply defined as context specific self-confidence. Bandura (1986) states that, "Perceived self-efficacy is defined as people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses." (p. 391). Self-efficacy has been demonstrated to be a significant predictor of performance (Cannon, 1988; Sherer, Maddux, Mercandante, Prentice-Dunn, Jacobs, and Rogers, 1982; Lee, 1982; Barling and Able, 1983) as well as training outcomes (Bandura, 1977; Ames, 1984; Bandura, 1986; Nichols and Miller, 1993; Gist, 1988). Self-efficacy determines what activities people participate in, how much effort they will put forth and how long they will persist to overcome difficulties (Tipton and Worthington, 1984). These factors are clearly related to academic achievement (Rodin, 1990).

Goal Theory

Presumably, if a student desires to learn a new skill, believes the material or situation can be mastered, and that he personally possesses the skills or other required characteristics to do so, the more likely he is to try hard. Likewise, the more effort a student expends (given adequate ability), the more likely he is to master it assuming that he actually commits himself to do what is necessary.

The relationship between goal-setting and performance has been widely explored. It is generally accepted that specific, difficult goals result in superior performance to general "do your best" types of goals (Locke, 1991). However, only relatively recently has research been directed toward understanding the effects of goal commitment on performance (Kanfer, 1990).

Analyzing the value of a goal (valence), determining the possibility of attaining it (instrumentality), and evaluating the sufficiency of one's resources to get the job done (expectancy) are all part of a process to determine an effort-reward probability. However, the decision that something is worth the effort and is likely

to pay off does not necessarily result in the required work. Before initiating action, a sufficient level of commitment to the goal must first exist. This decision to commit to taking action to achieve a goal represents a critical missing link to Vroom's theory.

EFFECTS OF TRAINING ON MOTIVATION

The previous sections established that motivation has been found to influence academic achievement. It is perhaps of more interest and importance to note that the literature has also suggested the reverse to be true. Characteristics of a learning situation may increase motivation. These two findings, when taken together, indicate that a positive feedback loop may result from exposure to engaging training – motivation leading to learning, leading to increased motivation to learn, leading to more learning, and so on.

Bandura (1986) explained that one's self-efficacy, whether accurate or faulty, is based on four principal sources of information: performance attainments; vicarious experiences of observing the performances of others; verbal persuasion and related social influences; and physiological states.

Verbal persuasion, both oral and written, is perhaps the most commonly used approach to increase self-efficacy (e.g., screaming sports fans increase the self-efficacy of athletes). Verbal reinforcement by instructors for student effort expenditure, combined with student use of strategy goals, resulted in increased self-efficacy (Butler and Winne (1995). Additionally, self-help books that focus on attempting to help people understand and alter their self-efficacy in various contexts abound (e.g., Aleksiuk, 1996).

Although other approaches have been successful, Bandura (1986) asserted that one's own performance attainment would provide the most influential source of efficacy information because it is based on authentic mastery experiences. Successes will raise efficacy appraisals while repeated failures will lower them. He further stated that the degree to which self-efficacy will change depends upon task difficulty, effort expended, amount of external help received, the particular performance circumstances, and the temporal pattern of success and failure experiences.

Likewise, Lepper and Gilovich (1982) suggested that by using motivational approaches found in games, a generalized positive attitude toward learning may be established in previously unsuccessful individuals. By designing training that engages students and leads them to increasing levels of competence, educators can: 1) make students perceive the control they can exert to learn, 2) increase their learning-related self-efficacy, 3) enable them to experience the personal reward of success, and 4) illustrate that committing to a goal makes that goal more likely to be attained. Thus, a positive cycle may be established.

Current well-designed commercial entertainment games also provide graduated learning environments that encourage the student-player to master increasingly difficult situations. Student-players do not typically stop playing just because they have won the current game. They actively seek out new, more difficult games (e.g., expansion packs). How do we get student-players to actively seek out new, challenging training experiences? This is the question we propose to address.

It is hoped that via appropriate design, (using the right combination of characteristics such as those listed in Figure 1) a training game will inspire student-players to determine that within the scope of the training game:

1. Victory is possible
2. I have what it takes
3. I want to win
4. I am going to play now

Accepting that desirable levels of motivational variables are related to student performance two questions emerge: 1. Is it conceivable that we can help students change these variables in desirable ways by providing them with specific experiences during their training? (Refer to the center column of Figure 1.) and 2. If students do change these variables in desirable ways, do they become more effective students in that and other training situations? This paper represents an initial attempt to synthesize and apply the motivation-learning-motivation spiral within the context of military training research.

GAME-BASED TRAINING MODEL PROPOSED

There is an implicit model of learning inherent in the use of games for instruction. The first phase of the model is to incorporate certain game characteristics into the design and implementation of an instructional game. In the second phase, these game characteristics trigger player judgments that result in positive player behaviors, such as persistence, striving to win, or learning. These behaviors tend to lead to improved mastery of the instructional game. In the final phase of the model, the instructional game provides feedback that results in positive player reactions that expedite a repeat of the cycle.

To the extent that instructional content is successfully paired with appropriate game characteristics (ensuring

contingent reinforcement of training objectives), this cycle results in repeated and self-motivated game play. As a result of this maintained engagement in game play, training objectives may be achieved. This instructional model is illustrated in Figure 2.

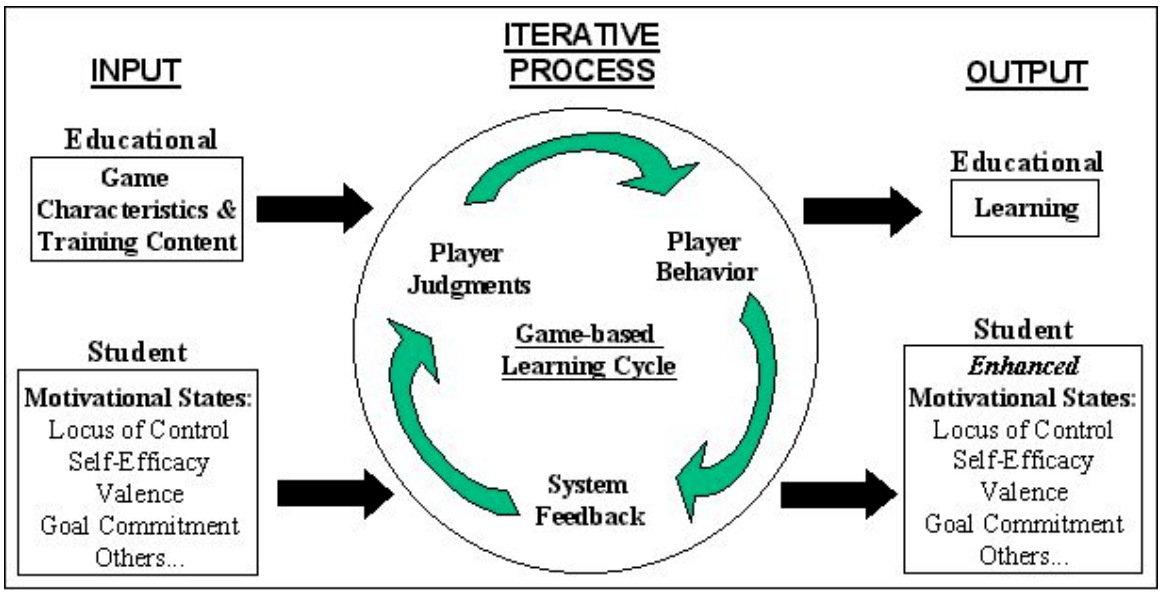

Figure 2. Game-based training model incorporates training and student characteristics.

Although the current model adopts the input-process-output framework, the key component is the game-based learning cycle that is triggered by specific game features. A central hallmark of game play is that users are drawn into playing a game over and over. In fact, a game player may often have to be told to put it down or to stop playing. We view the game cycle as iterative, such that game play involves repeated judgment-behavior-feedback loops: Game play can lead to certain user judgments or reactions such as increased interest, enjoyment, involvement, or confidence; these reactions lead to behaviors such as greater persistence or intensity of effort; and these behaviors result in system feedback on performance in the game context. Thus, the game cycle is a defining characteristic of computer game play, wherein users are engaged in repetitive play and continually return to the game activity over time. It is this feature of computer game play that training professionals hope to capture and incorporate in instructional applications.

In addition to the learning that results from iterative play, a cumulative effect accrues, resulting from repeated success designed into the game. It is this success which inspires confidence and continued effort in the face of difficulty. This tendency to continue to play is the result of a composite of the repeated demonstration of the situation's controllability, the player's employment of his skills, the joy of winning, and the satisfaction of meeting a goal. It represents a fundamental change that takes place in the student-player by demonstrating his control over the game world. This student-player has learned both the intended content and something invaluable about himself. The degree to which this lesson generalizes to other situations highlights the potential value of developing game-like training.

"BOTTOM GUN" A PERISCOPE TRAINING GAME

Based on the documented game descriptors (see the left column of Figure 1), a training game was designed which incorporated many of the salient characteristics. (See Figure 3.)

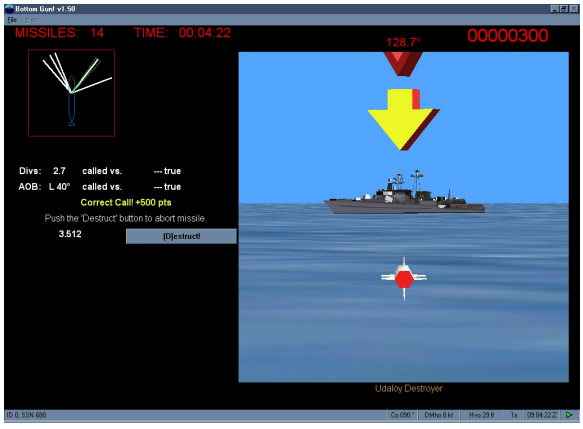

Figure 3. Bottom Gun.

The first and most important design task was to identify a training objective that could be met by a training game. Our criteria for the task to be selected for the current experiment included that it had to be: difficult to perform accurately, tedious to learn, perishable, and relevant to submarine fleet training requirements. The resulting training game, called "Bottom Gun," is a fantasy game. It was designed to provide an entertaining way to practice making estimates of critical visual variables, including angle-on-the-bow, or AOB, (i.e., angle at which the observed ship is visually presenting or sometimes called target aspect angle), and divisions (the number of tick marks on the periscope reticle representing the height of the targeted ship from its waterline to its highest visible point).

Bottom Gun runs on a Pentium PC and simulates the visual appearance of a large selection of moving ship models through a Type-18 periscope. Scripted scenarios provide players with the opportunity to visually track moving contacts. The Bottom Gun display is represented in Figure 3. The player scans the area around own ship in order to determine another ship's AOB and divisions, and then uses those estimates to determine whether the other ship will come too close for safety. If a ship is determined to be a safety threat, the player can then eliminate the threat of possible collision with the other ship by destroying it with a missile. The missile firing solution is determined from a combination of the estimates of AOB and divisions. After selecting the number of weapons to be fired, the student fires at the contact and receives a variety of visual and sound effects based upon the outcome. For example, if the firing solution is accurate, the target ship explodes with flames and a bang! If the solution is inaccurate, the missile flies to the location indicated by the student inputs, makes a sound indicating failure, and the target is likely to fire back. Additional precise performance feedback is presented, and the game score is appropriately incremented or decremented.

CONTROL CONDITION

The control condition was presented on the same computer, using the same graphics engine, visual ship models, and presentation conditions (See Figure 4). As with Bottom Gun, students typed in their estimates of AOB and divisions. They received the same factual feedback on their accuracy as was presented by Bottom Gun. There was no attempt to make the control condition appear to be a game.

GAME VERSUS CONVENTIONAL TRAINING

An experimental comparison was conducted to determine the degree to which support could be revealed for training game effectiveness. We hypothesized that:

1. Participants in the Bottom Gun condition would rate their training as more game-like than would the participants in the control condition.
2. Both Bottom Gun and the control condition would result in improved periscope observation performance.
3. Participants in the Bottom Gun condition would be more accurate in estimating AOB than participants in the control condition.
4. Assuming that the training experience was successful in improving participant visual skills, components of motivation would shift in a positive direction.
5. Participants in the Bottom Gun condition would experience a greater increase in motivation than would the participants in the control condition.

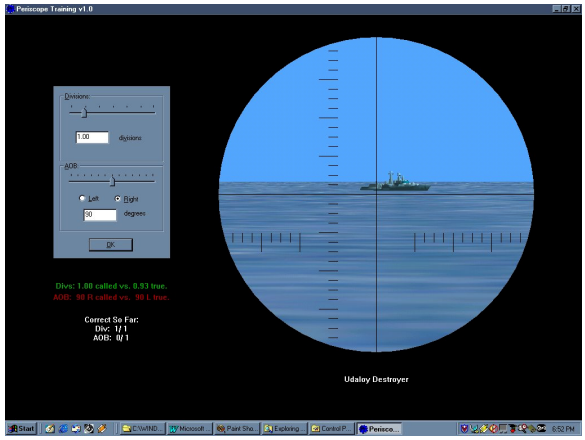

Figure 4. Control condition.

Assessment of Training "Gaminess"

The first goal for this research was to determine if we could identify legitimate game characteristics and then create two training systems (one a game and one a non-game) to meet the same training objectives. In order to determine our success in this first goal (creating a distinguishable game) a questionnaire was administered which asked subjects to assess the degree to which they believed that the game characteristics found in Figure 1 were included in the training they received (suggesting a new meaning for the word "gamey"). A brief review of Figure 1 reveals that many of the characteristics associated with games are also associated with activities other than game playing, making the task somewhat difficult (hence the common claim that creating a good game is more art than science).

All but four of the twenty-seven items on the questionnaire revealed higher means (indicating a greater degree of presence of the variable) for Bottom Gun than for the control condition.

Of the characteristics rated higher for Bottom Gun, the following twelve items resulted in significant differences ($p < .05$).

1. The training included elements of *danger*.
2. The *outcome* frequently seemed *uncertain*.
3. Characteristics of the training piqued my *curiosity*.
4. The training encouraged *competitiveness*.
5. The training *got harder* as it progressed.
6. The training incorporated *fantasy*.
7. *Sound effects* related to training events were included.
8. *Visual effects* related to training events were included.
9. The training permitted me to exercise adequate *control*.
10. The training provided *scores* that indicated how I was doing *relative to other* trainees.
11. The training gave me opportunities to *solve problems*.
12. Whenever I made an error I would *try again*.

All of the significant mean differences were in the predicted direction (Bottom Gun more game-like). The fact that only about half of the listed game characteristics achieved significance indicates that Bottom Gun's design may need to include stronger game features. Additionally, the predicted differential effects of game features on motivation may be washed out due to the apparent similarity between the two training products on over half of the measures of game characteristics.

Periscope Performance

In addition to being able to specify what defines a game, we wanted to produce an effective training experience. Four training scenarios were run in each of the conditions with each succeeding scenario containing more contacts, appearing at increasingly shorter intervals, in order to make the training more difficult as it progressed.

A mixed factor repeated measures Analysis of Variance (ANOVA) was conducted with the four AOB scenarios as the within-subjects variable, the experimental training condition (Bottom Gun and control condition) as the between-subjects variable, and AOB estimate error scores as the dependent variable. (See Table 1 for means and standard deviations).

	Control			Bottom Gun		
Scenario	M	SD	n	M	SD	n
1	27.79	9.17	30	25.76	8.97	30
2	25.27	9.43	30	21.58	9.16	30
3	19.51	7.80	30	13.74	8.86	30
4	9.51	4.78	30	6.87	4.27	30

Table 1. Summary statistics (degrees) for AOB errors.

A significant main effect for AOB scenario (labeled "AOB" in Table 2) was revealed, $F (.05,1,58) = 91.7$, $p < .000$. Repeated contrast ANOVAs revealed significant differences between each succeeding scenario: between scenarios 1 and 2, $F (.05,1,58) = 6.936$, $p < .011$; between scenarios 2 and 3, $F (.05,1,58) = 29.256$, $p < .000$; and between scenarios 3 and 4, $F (.05,1,58) = 66.456$, $p < .000$, indicating that performance improved with each succeeding scenario in both training conditions in spite of the increasing difficulty.

Source	DF	Sum of Squares	Mean Square	F Value
AOB	3	12135.40	4045.14	91.70*
AOB*CONDIT	3	121.25	40.42	0.92
Error	174	7675.54	44.11	

*p<.000

Table 2. AOB X Training Condition ANOVA.

A significant main effect for training condition was also found, $F (.05, 1,58) = 5.898$, $p < .018$, indicating that the Bottom Gun condition resulted in significantly smaller AOB errors than did the control condition. See Figure 5 for the graphed means.

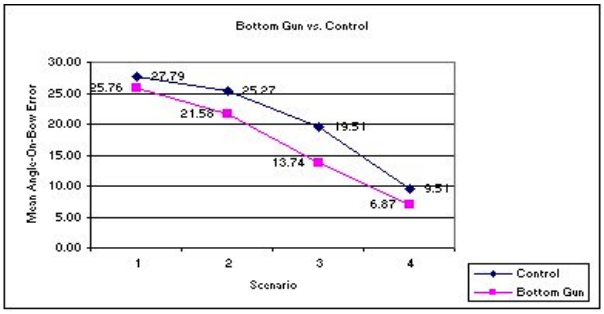

Figure 5. Bottom Gun vs. Control Condition.

Components of Motivation

Valence. A visual skills-specific Valence measure was administered prior, and subsequent, to the periscope training. A repeated measures ANOVA revealed that the means were significantly different ($F (1, 59) = 21.682$, $p < .000$) with visual skills valence being higher at the post-test (m=20.08) than at the pre-test (m=18.33). (See Table 3.)

Source	DF	Sum of Squares	Mean Square	F Value
VISVALEN	1	91.88	91.88	21.682*
Error	59	250.63	4.25	

*p<.000

Table 3. Repeated Measures Visual Skills Valence ANOVA.

Locus of Control. A visual skills-specific Locus of Control questionnaire was used to assess student-player perceptions about the degree to which the student-players felt they generally had control over their ability to perform well on the periscope visual estimation task. This questionnaire was also administered before and after the periscope skills training.

A repeated measures ANOVA was conducted to determine if pre-test LOC differed from post-test LOC. Refer to Table 4 to review the results of the ANOVA, which indicated that the means were significantly different, F (1, 59) = 29.982, p < .000, with the post-test (m=46.55) manifesting a more internal LOC than the pre-test (m=53.47).

Source	DF	Sum of Squares	Mean Square	F Value
VSLOC	1	1435.21	1435.21	29.982*
Error	59	2824.29	47.87	

*p<.000

Table 4. Repeated Measures Locus of Control ANOVA.

Self-Efficacy. A visual skills-specific Self-Efficacy measure was administered prior to, and subsequent to, the periscope training. A mixed factor repeated measures ANOVA was conducted with time of administration (pre- and post-test) as the within-subjects variable and experimental condition as the between-subjects variable. Refer to Table 5 to review the results of the ANOVA, which revealed a main effect for time of administration, F (1, 59) = 5.82, p < .019, with the post-test (m=80) manifesting a higher level of visual skills self-efficacy than the pre-test (m=73.93). Additionally, a significant difference was revealed between the Bottom Gun group (marginal mean=80.03) and the control group (marginal mean=73.9). F (1, 59) = 4.803, p < .032, indicating higher self-efficacy in the Bottom Gun group.

Source	DF	Sum of Squares	Mean Square	F Value
VSELFEFF	1	1104.13	1104.13	5.820*
CONDIT	1	1128.53	1128.53	4.803**
VSELFEFF*CONDIT	1	192.53	192.53	1.02
Error	58	11003.33	189.71	

*p<.02 **p<.04

Table 5. Mixed Factor Self-Efficacy ANOVA.

Goal Commitment. A measure of goal commitment (regarding the periscope training task) was also administered before and after periscope training. A repeated measures ANOVA revealed that goal commitment was higher subsequent to the training (m=34.13) than it was before the training (m=32.18), F (1,59) = 7.81, p < .007. (See Table 6.)

Source	DF	Sum of Squares	Mean Square	F Value
GOALCOM	1	114.08	114.08	7.933*
Error	59	848.43	14.38	

*p<.007

Table 6. Repeated Measures Goal Commitment ANOVA.

CONCLUSIONS AND IMPLICATIONS

We accomplished three major goals with this work. First, a training game model was established. This model yielded a list of game characteristics, which was used in designing a training game. The game (Bottom Gun) resulted in success based upon student-player ratings, which distinguished between very similar trainers, one a game and one a non-game. Student-players rated the training game, Bottom Gun, as significantly higher in terms of game characteristics. Attention in future training game design efforts will be focused on those characteristics that did not reach significance in "gaminess" ratings.

Second, using the list of game characteristics, a training game was designed that provided effective training and yielded significant improvements in student-player estimates of critical periscope observation variables (AOB) across the series of four training scenarios. Additionally, it resulted in superior performance to the control condition, which was also found to provide effective training.

Third, it has been previously reported that motivation can affect the outcome of instruction. This research provided support for the hypothesis that successful training experiences could influence student motivational states in a beneficial way. This was indicated by favorable shifts subsequent to the training, including: increased visual skills valence; more internal visual skills locus of control; higher visual skills self-efficacy, and greater commitment to the goal of learning visual skills.

As predicted, self-efficacy was higher for participants receiving training via Bottom Gun. However, the remaining three measures of motivational constructs registered no significant differences due to training condition. Although these findings were disappointing, they are not entirely surprising. The results of the ratings of the "gaminess" of the two training conditions, while promising, did not discriminate between the game and the non-game to the expected degree. It is possible that the two training conditions were too similar to yield the predicted differential effects on motivation.

Overall, these results are encouraging. Our primary expectations received support. However, additional research and development is needed to refine the training design guidance resulting from the current work and to further evaluate the relationship between training game design, motivation, and training effectiveness. However, a strong foundation has been laid for future work in the area of optimizing training game design and evaluation.

Although it should be common sense, the following bears repeating: It is essential that training objectives be identified *prior to* training game design. The challenge for the training game designer is to ensure that what is rewarded in the context of a game reinforces the specified training objectives. Gratuitous "gaminess" could become cost prohibitive and may result in negative training. It is also critical to recognize that existing lessons learned about computer-based training design should be included in the design of training games. Additionally, general training design approaches need to be broadened to incorporate the engaging and reinforcing characteristics of games. However, a structured and comprehensive approach to training game design must be followed.

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