Training Game Design Characteristics that Promote Instruction and Motivation

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ABSTRACT

PC-based games are currently used for training purposes throughout the military. Although increasingly popular, little research has been conducted on the design features that make these games effective training tools. This paper provides some research-based design principles that can be applied to the development of training games, with a focus on factors that influence both instructional characteristics and motivational features of PC-based games. A within-subject research design was used to identify the design characteristics that influenced the retention of information presented during the game. The aspects of the game that motivated users to continue playing were also assessed. The findings suggest that the manner in which information was presented to the user and the relevance of that information to the user's progression of the game impacted how well the information was later recalled. Graphic images and spoken text were recalled more accurately than printed text. Participants recalled procedures better than facts. Information relevant to the progression of the game was recalled better than information that was tangential to the game storyline. In addition, motivation to continue playing the game was influenced by perceived levels of challenge, realism, control, and exploration. The findings from the current research correlated with previous research in the fields of training methodology, multimedia instruction, and game development. Based on the current findings and previous research, principles for developing training games that are both instructional and motivational are presented.

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INTRODUCTION

PC-based games have been used for military training purposes since the 1970's (Herz & Macedonia, 2002; Knerr, Simutis, & Johnson, 1979; Prensky, 2001). Some of these games were developed initially for the commercial purpose of entertainment but were modified for instructional requirements of the military. An early example was in 1978, when Atari modified its game "Battlezone" for the Army to use for training tank tactics (Prensky, 2001). The rationale for using games has been that games motivate learners to engage in learning for longer periods of time compared to more traditional training methods. This prompts the question, is the user learning while playing the game or just wasting time?

Previous research indicates that PC-based games can provide effective training (Garris, Ahlers, & Driskell, 2002; Gopher, Weil, & Bareket, 1994; Green & Bavelier, 2003; Knerr et al., 1979; Prensky, 2001; Ricci, Salas, & Cannon-Bowers, 1996; Rieber, 1996; Sims & Mayer, 2002). In particular, research has demonstrated that specific skills can be trained with PC-based games (Prensky, 2001; Rieber, 1996; Sims & Mayer, 2002). Research has also shown that training games can teach generalized skills like troubleshooting (Knerr et al., 1979) and visual attention (Gopher et al., 1994; Green & Bavelier, 2003). In addition, Ricci et al. (1996) found that by converting text-based instruction to a PC-based game format both skill retention and learning satisfaction could be increased.

While research has indicated that PC-based games can be effective for instruction, it has not been clear which specific features of games promote learning or motivation to continue using the game. In a recent experiment, Garris et al. (2002) used a PC-based simulation to compare the inclusion of a set of game features, including a high rate of interactivity, scoring, and audio/visual effects, against the simulation without such features. They found that the inclusion of the set of game features improved training outcomes (i.e., fewer errors). While Garris et al. identified a set of game features that influenced training effectiveness, they did not distinguish between the individual contributions of these features. The goal of the current research was to identify training game design features (instructional and motivational) that may influence training effectiveness.

METHOD

Participants

Twenty-one individuals participated in the experiment. All of the participants had made a commitment to the U.S. Army (enlisted or reserves), but none had yet gone through basic training.

PC-based Game

The game used for this research was the America's Army game, a first person perspective action/shooting game with advanced graphics and sound effects, which produces an immersive player experience. In this game, players go through virtual "basic training" and then are eligible to complete on-line military missions as part of a team.

The America's Army game was developed as a recruiting tool to inform the "recruiting age" public about the U.S. Army. The game has been popular, with over 2 million registered players completing a few hundred million missions during the first year and a half since its release (http://www.americasarmy.com). This volume of play indicates that the game motivates users; therefore it seemed that the game would be a good platform to identify motivating features of a first-person-perspective game. Additionally, since the game was developed to provide information about the U.S. Army, the characteristics that influenced learning could also be assessed.

Procedure

Pre-game Data Collection
Participants completed a nine-item multiple-choice questionnaire to measure prior knowledge about the game and the U.S. Army. The mean scores for the pre-game questionnaire was 19.6% (range 0-56%), indicating that the participants were not familiar with much of the information presented during the game.

Play the Game
Participants completed the "basic training" sections of the game: a) marksmanship training, b) an obstacle course, c) weapons familiarization, and d) a MOUT (military operations in urban terrain) training mission. Each section began with a printed text description of the basic training environment, a general overview of the task to be completed during the section, and some Army background information. Next, a computer-generated drill instructor verbally explained the specifics of what was required in the section and guided the player through different components of the task.

In the marksmanship section, the practice and qualification rounds were repeated until the participant qualified (at least 23 out of 40 targets). For the obstacle course, the players ran the entire course against a clock until they bettered the time requirement of 90 seconds. The weapons familiarization section provided players an opportunity to try a variety of weapons. During the MOUT section the players used movement skills developed in the obstacle course and their shooting skills developed in marksmanship and weapons familiarization. This section also introduced "rules of engagement," which dictated that players were to only shoot "hostile" targets, while not shooting "noncombatant" targets.

Post-game Data Collection
Upon completion of the basic training sections, each participant completed a 26-item multiple-choice test on information presented during the game. The questions used for the post-game data analysis were different from the questions used in the pre-game data collection. The multiple-choice questions in the post-game test were classified along three different instructional characteristics: *information type*, *relevance of information to game play*, and *mode of presentation*. Items were classified as belonging to different subsets of *information type* using the following definitions: a) procedural – cognitive or motor skills and activities; b) episodic – experiential memories of sensation, perception, and past events; or c) factual - facts and concepts represented by text and symbols. For *relevance of information to game play*, items were classified as belonging to the subsets defined as: a) relevant – information that is required or helpful to progress in the game or b) irrelevant – information that does not impact progress in the game. Finally items were also classified by their *mode of presentation* using the following subset definitions: a) spoken text – narrated information, b) printed text – printed information, or c) graphic images. Five of the questions on the post-game test assessed information that was presented through more than one modality, so these questions were not used in the assessment of the effect of mode of presentation.

To address motivational aspects of the game, participants also answered four open-ended questions after playing the game. Two of the questions asked about the features that would promote continued play. The other two questions asked about features that would deter them from continuing to play. The responses from these questions were grouped into four categories: realism, challenge, exploration and control. These terms were selected because the participants frequently used them while answering the questions. Challenge was defined as responses that mentioned accomplishing the tasks required to continue on to the next section in the game (e.g., goal achievement, such as "it was fun trying to complete the obstacle course in only 90 seconds"). Control was defined as responses regarding the interaction of the player with the game environment (e.g., "I enjoyed seeing the targets fall when I shot at them"). Realism was defined as responses about elements that made the game experience representative of a real-life experience. This category included comments about the games high visual and audio fidelity as well as responses about realistic weapons and procedures. Exploration was defined as responses that referred to the process of discovery and novel sensory stimulation (e.g., seeing a new weapon or participating in a new activity like MOUT).

RESULTS AND DISCUSSION

For clarity of presentation, in the following sections specific results are discussed along with related research. Based on the results from the current experiment and previous research, design principles for the development of training games are proposed.

Information Type

Three different types of information were assessed through the post-game test: procedural, episodic, and factual. For procedural, episodic, and factual information the mean percentage for questions answered correctly was 77.9%, 70.5%, and 62.9%,

respectively. A Tukey pairwise comparison found a significant difference between the means for procedural and factual questions ($p < .05$).

This finding relates to Dale's (1946) continuum of instruction methodology of doing, observing, and symbolizing. The current research supports Dale's guidelines that what is done (procedural) is learned best, followed by what is observed (episodic), and what is presented as symbolic information (factual) is least likely to be learned.

Design Principle 1
Turn training objectives into procedures that the learner must perform in order to successfully complete the game.

Relevance to Game Play

Questions from the post-game test were also categorized as either relevant to player progress through the game or irrelevant to game play. For relevant and irrelevant information the mean percentage of questions answered correctly was 72.3% and 58.7%, respectively. Relevant information was recalled at a statistically significant higher level than irrelevant information (paired sample t-test, $t=2.29$, $p>.01$).

This finding suggests that training game developers should incorporate learning objectives into the storyline of the game. If the training objectives are not part of the game play, the player may remember how to play the game instead of learning the training objectives. If irrelevant information is included, it should be kept to a minimum, because previous research with multimedia instruction has shown that including extraneous details can be distracting and have detrimental effects on retention and learning transfer (Harp & Mayer, 1997; Harp & Mayer, 1998; Mayer, Heiser, & Lonn, 2001).

Design Principle 2
Integrate the training objectives into the storyline of the game.

Presentation Modality

Questions from the post-game test were also categorized based on the presentation modality (printed text, spoken text, and graphic images). For graphic images, spoken text, and printed text, the mean percentage of questions answered correctly was 79.1%, 73.8%, and 57.1%, respectively. A Tukey's pairwise comparison identified a significant difference between graphic images and printed text ($p<.01$) and between spoken text and printed text ($p<.05$).

These results extend the findings of Mayer and Moreno (1998), where they found that students retained text from multimedia instructional presentations better through spoken text than through printed text. Other research, however, has found that when audio and visual information were complementary to one another (instead of repetitive), then the information was retained better than through either modality alone (Leahy, Chandler, & Sweller, 2003; Tindall-Ford, Chandler, & Sweller, 1997). Therefore, the combination of text and graphic images, whereby one complements (i.e., clarifies or describes) the other, may be an effective way to provide instruction in a PC-based game environment.

While information provided through graphic images and spoken text was most likely to be recalled, this does not necessarily mean that printed text should not be used. Print was recalled, but in a lesser amount. Casual observation indicated that some of the participants skimmed or did not read full pages of text. They merely clicked on "next" to proceed with the next page without enough time lapsing for them to have read the text. This suggests that large blocks of written text may be ignored, and a method that ensures that the learner has read the material may help to overcome this problem.

Design Principle 3
When possible, present information graphically.

Design Principle 4
When using text, favor spoken text rather than printed text. When printed text is used, ensure that the information is viewed by the user and is complementary to other information presented (graphically or auditory).

Motivation

Motivation was measured using the four open-ended questions regarding participant's intentions to continue playing the game and the comments they made regarding what features of the game would promote continued playing or keep them from playing again. The data showed that perceived levels of challenge, realism, control, and exploration influenced player motivation. These four categories are similar to those in the framework of computer game playing motivation developed by Malone (1981) and Malone and Leeper (1987), which were: challenge, fantasy, control, and curiosity.

Of the responses to the open-ended questions in the post-game test assessing what motivated players to continue playing, 45% mentioned realism, 30% mentioned challenge, 15% mentioned exploration, and 10% mentioned control over the game environment. Of the responses to the open-ended questions assessing features of the game that did not motivate players to continue playing, 41% mentioned a lack of control, 29% mentioned challenge in terms of being too easy, 18% mentioned challenge in terms of being too difficult, and 12 % mentioned a lack of realism.

Design Principle 5
Challenge, realism, control, and opportunities of exploration should be incorporated into the game design.

Optimal levels
Three of the four motivational features were mentioned as reasons for both continuing to play the game and not continuing to play the game. For example, with regards to challenge, some individuals identified sections of the game as too difficult, while others identified sections as too easy. An attempt to identify a single optimal level of any one of these features would be difficult because of individual differences among players. Because of individual differences, having a system that allows for the variation of these levels may be beneficial to learner motivation.

Many variable systems have been used in commercial games to modify the game to best meet individual differences across players (Bowman, 1982). For a training game, a combination of mechanisms that vary particular levels of these motivational features may be appropriate. For example, the game designer/instructor might select the level of realism based on the training objectives, the player might select the level of exploration and control, while the game automatically regulates the level of challenge based on the player's performance.

Design Principle 6
Develop training with the capability for optimal levels of the mechanisms that influence motivation to be set by the instructor or the user prior to the start of the game, or by the performance of the user during the game.

CONCLUSIONS

In the current research, features of a PC-based training game were assessed in an attempt to identify aspects of a first-person-perspective game that would influence both the learning of content and player motivation to continue using the game. For the current research, the findings related to the instructional characteristics (information type, relevance of information, and presentation modality) may be limited to the PC-based first-person-perspective game used. However, the findings mirrored previous research on interactive multimedia instruction, suggesting that the findings might generalize to other applications. Likewise, the findings regarding motivation in this game confirmed previous research on motivational aspects of other types of games.

The assessment of instructional features suggest that PC-based training games would be more effective for learning procedures than for learning facts. Additional research would be needed to determine if the type of skill or procedure influences the effectiveness of using games for training or if the type of game influences the effectiveness of the training.

The findings also suggest that instructional objectives should be integrated into the game's storyline so that the training material is relevant to the progression of the game. If the training objectives are part of the storyline of the game, the training effectiveness of the game may be increased. If the training objectives are not part of the storyline, then players/students may only learn how to play the game while disregarding the training objectives. The relevance of the training objectives also overlaps with the motivational feature of realism, which should increase the likelihood of skill transfer from the game to the application of the skill trained.

Spoken text and visual images were found to be more effective presentation modalities than printed text, suggesting that course developers should focus on these modes of presentation. It does not mean that printed text should be abandoned completely, only that it should be limited during game play. Casual observation of the participants in this research showed that players might skip large portions of text.

The assessment of motivational features suggest that PC-based training games should be designed with attention to challenge, realism, control, and opportunities for exploration, which may make the learner's experience more positive and motivate them to continue using the game. While the inclusion of all of these features does not guarantee that users will play the game for hours on end, they are features that should be considered while developing a training game.

For a training game to be effective, it should be both instructional and motivational. Additionally, some of the instructional features identified may influence motivation, while some of the motivational features

identified may influence instruction. More research is needed to develop a better understanding of the interaction of instructional and motivational influence on the training effectiveness of first-person-perspective games.

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