

## EFFECT OF FEEDBACK ON SITUATION AWARENESS AND PERFORMANCE FOR PRACTICING REAL-TIME STRATEGIC GAME

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Received November 2017; accepted February 2018

**ABSTRACT.** *The objective of this study is testing the effectiveness of feedback session on the performance as a final outcome and situation awareness as a process outcome. Serious games are widely used for education and training for industry, government, and military. Mostly the learning model of serious game is a behavioral model that trains the situation monitoring and decision making. In this sense, military training tried to use real-time strategic war simulation games for unit leaders, but the effectiveness of such training is still in question. This study empirically tested the effect of feedback by testing the performance of 20 university students: one group with feedback session, and the other without feedback session. Paired group with similar level of skill played 3 games before and after the feedback training session each. Feedback group has received information on their performance and opponent's performance along with game status on the three games played before. After the feedback session, feedback group gained more wins over no-feedback group and exceeded in the quantitative game score. Situation awareness score showed that feedback group has better understanding of situations after the feedback session.*

**Keywords:** Serious game, Situation awareness, Feedback on training, Real-time strategic game

1. **Introduction.** As technology advances, video games have evolved to reflect the real world more precisely. High computation power enabled simulating very complex environment together with realistic graphics. Especially, simulation and strategic games formed a significant trend in the computer gaming for several decades, in which players control a large and complex system to win over the opponent by strategic management of production, offense and defense. Since these activities are very similar to the task of military leaders covering from a platoon or company to battalion, war-game simulation were widely used for training purpose. One of the main advantages of war-game simulation is its interactivity. As compared to traditional classroom learning, interactive and engaging mode of learning improves the effects of learning. Surprisingly, military training programs less burdened by learning theories, have gotten generally better educational result by involving student in actions that simulate actual problem-solving situations. This could be probably because that it is more output-oriented training focusing on obtaining specific capabilities at minimum cost. Additionally, the subject and skills to be obtained are concrete and physically demonstrable operations.

The effectiveness of serious games in training and learning is, however, still under debate. Freitas and Oliver [1] pointed out that there is still doubt on the potential of games to achieve educational objectives since empirical evidence obtained through rigorous methodological approach is still missing. While there are increasing interests in using games for serious purposes, learning effectiveness still requires further validation. Thus

this study investigated the usefulness of feedback to maximize the effectiveness of training in the context of real-time strategic simulation game. The organization of this paper is as follows. In the related work, the literature review on the effect of computer games in military training and important factors influencing the effectiveness of training was presented. Then method section covered the experimental design and detailed procedures followed by the result of experiment and discussions. In the last section, the implications of the experiment and limitations were presented.

## 2. Related Work.

**2.1. Serious game.** Serious games are defined as games that use the artistic medium to deliver a message, teach a lesson, or provide an experience [2]. Several studies have demonstrated that serious games are effective learning tool in various context, such as clinical practice, classroom learning and self-driven learning [3,4]. In clinical practice, serious games have been successful to provide cognitive-attention distraction in children undergoing chemotherapy [5], promoting and increasing motor skills [6] and developing attention skills for children [7]. It is also found to be effective in raising achievement level of both children and adults in math and language [7,8]. Information-processing education games helped poor readers make significant learning gain, with the greatest improvement shown by the poorest reader [9]. For motivating students and encouraging the participation in class, several games were developed and deployed in classical teaching environment [10]. Complex games have been useful to encourage attitude change, supporting the development of critical thinking, problem solving and decision-making skills. Serious games provided a means to foster learners' understanding of theoretical models and interaction effects. In addition, complex game supported the development of team, social, communication and resource sharing skills [4,11-14]. Games have a long history in complementing military training. The Air Defence Simulation developed by Army Operations Research Office at Johns Hopkins University was the first truly computerized war games although much of the playability of board game was lost [15]. After this, designers and computer programmers developed complex logics and algorithms for various purposes. US Army released *America's Army* as a PC based game for recruiting tool to attract teenagers to join the military, which was very welcomed by teenagers, potential recruits. Singapore Armed Forces has been using a mod design from a commercial game called *Operation Flashpoint* for exploration into using games as a tool for training [16]. If this game is played in a multi-player mode, its custom mission provides real-time scenarios to practice various drills and improve their situation awareness and team-fighting skills. Recent development of serious games in military includes the application of virtual-reality environment and commercially available games [17,18].

**2.2. Feedback in training.** In order to maximize the effectiveness of serious games in education, researchers introduced several factors and tested their effectiveness although there was no single successful factors across different domains. Among them, feedback was suggested to be a key feature that differentiates training from practice [19]. Feedback can be categorized as outcome feedback, process feedback, and normative feedback. Outcome feedback is providing knowledge of results of one's action, whereas process feedback is delivering information about how one should perform the task, but not necessarily how well one should [20]. Normative feedback is providing the information about their relative standing compared to others, but may not be specific performance-related feedback [21]. Recent research outcome suggested that process feedback has significant impact on participant's performance [22].

On the other hand, feedback can be classified as intrinsic and extrinsic in another dimension [23]. Intrinsic feedback cues and guides unit behavior during task performance, whether the task is being performed in an operational or training context. For example,

a scout unit may call for artillery fire on a target and receive intrinsic feedback when it observes that simulated or actual rounds of impact too far from the intended target. Someone from the artillery unit might be assigned to observe the fires and provide feedback to the artillery to adjust their fires. For a unit to improve its performance, unit member needs more feedback about what happened during an exercise than that gained by participating in it and observing what happened. Extrinsic feedback is provided by an outside source, usually observer/controllers or trainers after an exercise ends. It is designed to help participants understand the difference between the grounds and perceive truth and investigate what caused the events to occur as they did. Extrinsic feedback consists of information that the exercise participants do not ordinarily have available to them. It can provide insights into how to improve or sustain performance in the future. The After Action Review (AAR) is a method to provide extrinsic feedback to the units after training or exercises. The purpose of AAR is a session where trainees review prior training performance. It focused on what was planned to occur during training, what actually occurred during training why certain events occurred and what should be modified during subsequent training. As an example, a recent research on the game UrbanSim is used to train leaders in the execution of the Art of Battle Command. The game has three components: a two-hour, self-paced, instruction module that provides the participants with basic knowledge of the principles behind operations, a game-based practice environment, and an instructor-led AAR. The result reported that 88% of participants of the Captains' Career Course and 95% of soldiers from operational units commented it as a useful training tool. Although there are several comments and testimony that feedback is a good training tool, the relationship between the performance and feedback does not show unanimous outcome [24].

In the past decade, many militaries have sought to use serious games as a training tool, allowing the simulation of battles which might be cost prohibitive or downright impossible to stage in field training. However, owing to its nascent nature, there is a lack of research into how serious games ought to be designed to meet its goal for training players. Along this line, this study tried to explore if the feedback, which has been named as an important factor in training, improves participant's performance in serious games.

**3. Methods.** The experiment is designed as paired-sample design since the participant should play a match against each other. In order to minimize the difference in gaming skills between participants, participants are matched each other according to their performance against computer player.

**3.1. Participants.** A total number of 20 university students participated in the experiment. Ages of participants range from 21 to 30 years old. All the participants had prior knowledge and experience of playing real-time strategy games before.

**3.2. Experimental settings.** Spring 1944 AI was adopted as a gaming platform, which is an open source real-time strategy game based on the World War II. The game has four fully functional sides: US, Germany, USSR, and Britain with period-accurate units and strength. Since it is an open-source game, customization of scenarios and difficulty levels depending upon the situations can be manipulated and modified easily.

**3.3. Variables.**

**3.3.1. Feedback.** Independent variable of the experiment is feedback. During the game, participants are asked questions every 5 minutes shown in Figure 1. The questions are (1) Where do you think is your enemy current location? (2) How many units do you think your enemy has left? (3) What is your enemy intention?

At the end of the match, participants in the feedback group will be directed to a feedback task program shown in Figure 2. The participants review the match and the

comments made by oneself and the opponent together. The participants are required to answer the question, ‘What they could have done differently?’ This allows the participant to conduct one’s own personal AAR and think through possible ways to deal with similar situation in the future.

3.3.2. *Performance.* Three performance measures were used as dependent variables: win/lose, game time and units killed. As an overall performance indicator those three components were combined with weights preassigned. GameScore calculation is by the following



FIGURE 1. Situation awareness measurement

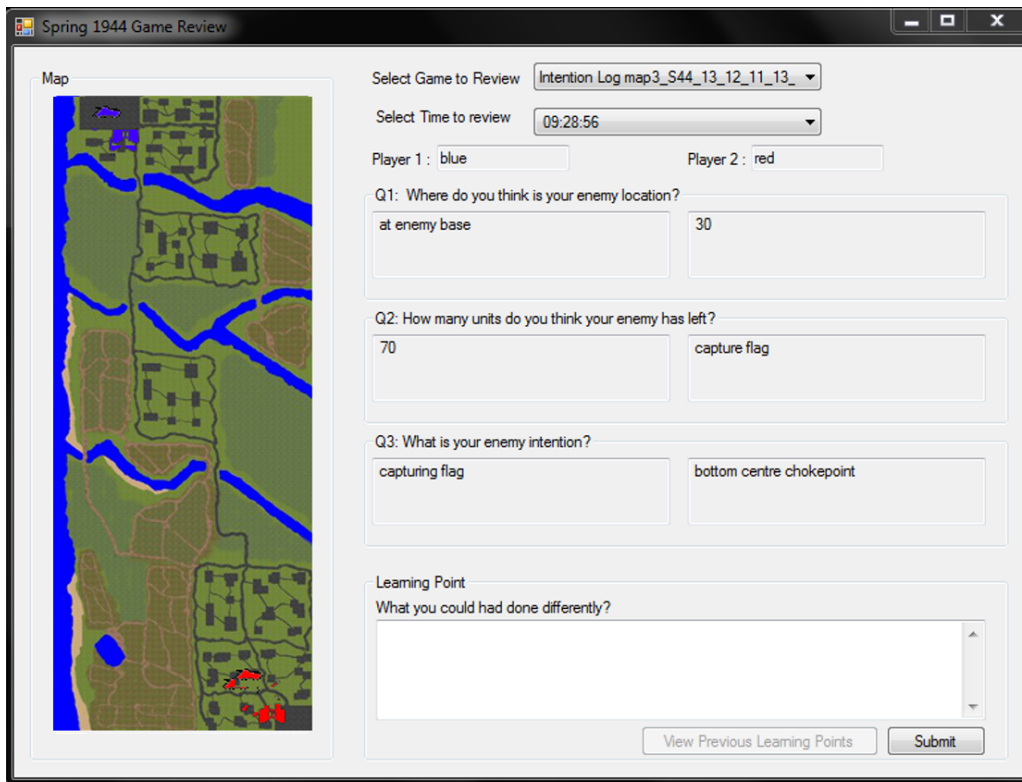


FIGURE 2. Feedback session screenshot

formula.

$$\begin{aligned} \text{GameScore} = & 0.4 \times \text{Win} - 0.2 \times \frac{\text{OwnUnitLost}}{\text{TotalUnits}} \\ & + 0.2 \times \frac{\text{EnemyUnitDestroyed}}{\text{TotalUnits}} - 0.2 \times \text{GameTime} \end{aligned}$$

Here, Win is set to 1 for winner and 0 for loser. GameTime refers to the time taken to secure both flags successfully. If player wins, GameTime = 1 - actualtime/30 and if player loses, GameTime = actualtime/30. OwnUnitLost is the number of own units killed during the game and EnemyUnitDestroyed is the number of enemy units destroyed in the game.

3.3.3. *Situation awareness.* The three questions asked above for providing feedback were also for measuring situation awareness. Three raters who have experience of the game play assisted in rating the participants self-perceived situation awareness by reviewing the accuracy of their answers through game logs, game replays and answers to the above three questions. The raters were asked to rank the participants self-perceived situation awareness from 0% to 100% at the intervals based on the following questions:

- 1) To what extent is the participant aware of the enemy current location?
- 2) To what extent is the participant aware of the enemy units remaining?
- 3) To what extent is the participant accurate in predicting the enemy intention?

3.4. **Procedure.** After completing the informed consent form, participants are requested to fill up a pre-experiment survey asking demographic information. In the demographic survey, personal game experiment was collected such as the type and frequency of real-time strategic games. In order for the participants to get accustomed to Spring 1944, each participant played the game around 30 minutes with a short guide explaining interface, controls, available units and their characteristics. Then, participants proceeded to play three practice matches with a computer player. The purpose of this match is to allow participants to familiarize themselves with the game scenario. Based on the performance of each player participants will be ranked and paired up. After 10 minutes of break, they engaged in three matches against their paired opponents. Then, participants in each pair are randomly assigned to either feedback or no-feedback group, and only the feedback group was provided the feedback on their play. Once all the training matches and feedback session are over the participants played another three matches against their paired opponents.

4. **Results.** The result of training match (before feedback session) and final match (after feedback session) is shown in Table 1.

Chi-Square Analysis showed that  $\chi^2 = 4.00$ ,  $df = 1$ ,  $p < 0.05$  and thus null hypothesis is rejected. No-feedback group lost more in after-training match, whereas the feedback group wins more after the feedback session.

GameScore calculated for the feedback and no-feedback group showed similar result. Before the training, no-feedback group performed better even though the difference is not significant. After the feedback session, however, feedback group showed better performance compared to the no-feedback group ( $t = -3.594$ ,  $p < 0.05$ ).

TABLE 1. Wins & loss counts

	No feedback		Feedback	
	Wins	Loss	Wins	Loss
Before training	5	3	3	5
After training	2	6	6	2

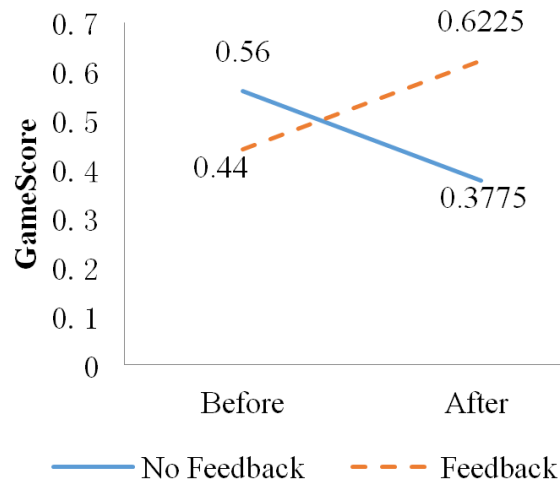


FIGURE 3. GameScore comparison

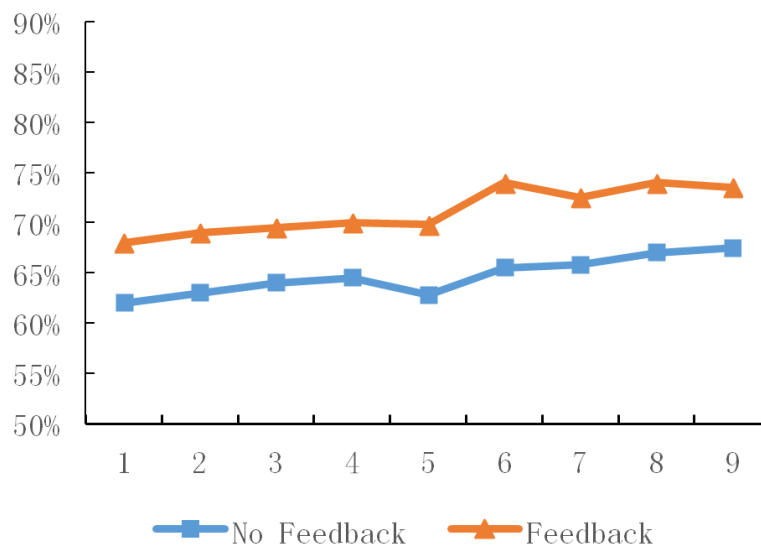


FIGURE 4. Situation awareness per group

Participants' situation awareness level was by three reviewers as explained in the previous section. From the results, the inter-rater reliability was calculated (Fleiss' Kappa = 0.56), which showed fairly good level of agreement among three different reviewers. As Figure 4 shows, the situation awareness score increases as the round progresses. A repeated measure ANOVA showed that there is significant difference in the situation awareness score between feedback and no-feedback groups ( $F = 95.064$ ,  $p < 0.05$ ).

**5. Discussion.** This study investigated the effects of feedback session on the performance and situation awareness. By providing feedback on the performance of the training session, participants have shown a better situation awareness of the games, which can lead to understand the enemy's intent more precisely. The feedback provided in the experiment is a combination of outcome feedback and process feedback, which comments on the win/loss and performance at that time. Participants in the feedback group can update their mental model according to the situations. Thus making a better understanding of adversary behavior model was possible. Situation awareness in general refers to knowing what is going on around you and predicting what is going to happen in the near future. The term situation awareness was originally used in commercial and military aviation. Till date there have been extensive researches in other areas where situation is needed

for various reasons. Many studies demonstrated the importance of situation awareness for decision making, action execution and performance. By providing intuitive means to specify possible adversary objectives, the relationships between these objectives and the tasks and actions, feedback group participants can better understand the opponent's strategy and finally play better at the matches after the feedback session [25].

**6. Conclusion.** Serious games are frequently used in various areas, but it is not quite clear yet what strategy maximizes the effect of training. This study showed that proper process feedback can improve the performance of trainees when playing real-time strategic game. It also improves the situation awareness of the players and possibly better situation awareness may have led to a success when playing after-training matches. The findings of this experiment have limitations for generalizations. Practical limitations on the sample size, participant group, scenario varieties exist because of the experimental setting. Thus the result should be further validated depending upon the situations to be applied. Invasive measurement of situation awareness may have influenced the normal play of the participants, which could change the performance either. In spite of practical limitations, however, this study empirically showed the effectiveness of feedback on training for the task of strategic management within limited time. The result can be used for designing a training program for military unit leaders.

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