

## Video Game Self-efficacy and its Effect on Training Performance

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### Abstract

*This study examined the effects of using serious games for training on task performance and declarative knowledge outcomes. The purpose was to determine if serious games are more effective training tools than traditional methods. Self-efficacy, expectations for training, and engagement were considered as moderators of the relationship between type of training and task performance as well as type of training and declarative knowledge. Results of the study offered support for the potential of serious games to be more effective than traditional methods of training when it comes to task performance.*

**Keywords:** *Serious Games, Training, Self-efficacy;*

### 1. Introduction

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Since the days of Pong (manufactured by Atari Incorporated, 1972), the video game industry has continued to grow, and video games have become an ever-increasing part of everyday culture for many people. In 2011, the industry had nearly \$25 billion in revenue [1]. However, this increased popularity has not only been among young males. In fact, 68% of those playing video games are 18 or older and 47% are female [1]. These percentages help show just how prevalent the use of video games has become across a variety of demographics.

The impressive growth of the video game industry has, at least in part, been due to the reasons children give for enjoying video games: they are fun, exciting, and challenging [2]. This point was further illustrated in an article by Przybylksi, Rigby, and Ryan [3] who states that "the appeal of video games lies in the inherent properties of the experiences they provide." Games allow us to experience and practice things that may be dangerous in the real world because the cost of making critical mistakes is too high. This could have potentially large implications for the area of employee training where games could allow employees to learn skills in a hands-on way without putting themselves, the company, or customers at risk. If the fun and excitement inherent in video games were to lead to increased motivation of trainees to perform the task trained, it could mean increased performance on that task; an outcome to be desired by any organization.

The purpose of this study was to examine the effects that video game training has on trainees' task performance and declarative knowledge compared to the more traditional forms of training. To do this, a review of the current literature on video game training and its effects on learning outcomes will be presented. Along with the literature review, hypotheses will be proposed. Next will be the discussion of the methods used to test the effects of video game training compared to traditional methods followed by the results found in the study. Finally, this paper will end with a discussion of the potential implications that this study could have in both the research and applied areas of training.

### 2. Literature review

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#### 2.1 Serious games

At this point, it is best to take a moment and define exactly what is meant when the term "video game training" is used. The term "Serious game" was initially coined in 1970 by Apt in his book entitled *Serious Games* [4]. However, it did not become widely used until 2002 with the start of the



Serious Game Initiative and has since been defined a number of times. One such definition provided by Michael and Chen [5] states, "A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment." Another definition by Zyda [6] puts forth the notion of a serious game as, "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives." Both definitions make it apparent that the major difference between traditional video games and serious games is the overall objective of the game. Video games are for entertainment and serious games are for education and training. Throughout this paper, when the term "video game training" is used, it is referring to the use of serious games.

This distinction between traditional video games and serious games is necessary due to the number of articles in the literature dealing with video games in general. Much of this literature is centered around the effects of violent video games on behavior and violent tendencies in children [7]. Other studies deal with the effects that playing commercial video games can have on a student's grades and motivation to perform in school [7]. While these are no doubt important research questions with significant implications, they do not fall within the scope of this study. The current effort was interested in looking at the effects that a specific genre of video games (Serious Games) has on training outcomes. As such, the following review of the literature will focus on serious games and their cognitive outcomes.

## 2.2 Video games and learning

Even though the idea of using video games to teach and train has been around for a long time [4], there has been a surge in the research and use of video games for learning and training since the Serious Game Initiative in 2002. In recent years, researchers have been examining the use of video games in a number of different areas and hundreds of games have been developed spanning across most major industries [8]. One example of video games being used both successfully and extensively for learning by an industry is the use of video game training in the military.

According to Prensky [9], the US military uses more than 50 different video games for a number of different teaching and training purposes and Beidel [10] stated that, "the influence of video games on military training has been substantial." An example of one of the most used and well known video games used by the military is the Army's *America's Army*, created in 2002, which consist of virtual basic training as well as team-based missions. The game can either be used to familiarize new recruits with what they can expect in basic training, or as a training tool for those soldiers once past basic training [11]. Another example is the Marine Corps' *Close Combat: First to Fight*, created in 2005, which uses a team of four Marines placed in the Middle East to help Marines practice their combat skills [11]. Both of these military training games are still extensively used by their respective branches and help illustrate the recent surge of serious games being used to teach and train.

Along with the surge in the use of serious games, the important research questions of whether or not video games have positive effects on learning, and if they are effective teaching and/or training tools, still loom. Those who do not believe in the usefulness of video game training argue that the effectiveness of video games as teaching tools is still unclear [12]. This argument against video games may at first seem accurate when considering that some early, but major, reviews found mixed results for games being effective teaching tools with no clear relationship between game use and improved performance [13][14].

In their review, Randel et al. [14] looked at 67 studies and concluded that 38 found no differences between games and traditional teaching methods, 27 favored games, and only 3 favored traditional methods. While this review did not discredit games as effective teaching tools, it does not offer complete support for them either. Instead, the mixed results seem to support the idea that, at the very least, games are no less effective than the more traditional methods.

It is important to note some aspects of the Randel et al. [14] review may have had significant impacts on their findings and conclusions. For example, the review was done prior to the Serious Game Initiative in 2002. It is possible that the review may have included video games that were not specifically made for educational purposes, and as such, may not be more effective than traditional teaching methods. Even with this possibility, it is interesting to note that only 3 of the articles reviewed favored traditional methods of instruction.

In fact, a majority of the studies that found no difference were in the area of social science and did not use a computer game [15]. On the other hand, Wolfe [16] reviewed only those studies that examined general management games using computers and found that learners in the game



conditions showed significantly more knowledge gain than those in the more traditional conditions. These conflicting findings suggest that some caution should be used when drawing conclusions about the effectiveness of video games as a training tool based on the results of the early Randel et al. [14] review. Since that major review, there have been a number of individual empirical studies that have found support for the effectiveness of video games in training and teaching [17][18].

More recent meta-analyses and reviews that focus on serious games have shown increased support for the use of video games as effective teaching tools [19-21]. Vogel et al. [20] performed a meta-analysis of 32 studies that included cognitive gains as one of its main hypotheses in order to determine whether games and interactive simulations, or traditional methods, would result in the highest cognitive gain for learners. The results of this meta-analysis found that, "across people and situations, games and interactive simulation are more dominant for cognitive gain outcomes."

Wouters et al. [21] provided more support for serious games as effective teaching tools in their review of 28 studies with empirical data. The authors found that three out of four studies showed that serious games increased cognitive gains compared to traditional methods. They concluded that this provides some support for "the new generation" of serious games supporting the acquisition of knowledge. Wouters et al. [21] pointed out that game features varied between studies, and this may partially explain the 25% of studies reviewed that did not support serious games increasing cognitive gains. When combined with the previous meta-analysis and review, the literature seems to suggest that serious games can be effective teaching tools for increasing cognitive gains.

### 2.3 Cognitive theories

While the above review of the literature shows support of video games as effective learning tools in regards to learning, it does not discuss why they might increase cognitive gains at all. There are many theories that attempt to explain the different ways in which individuals learn and acquire knowledge when being taught. Many of them support the idea of serious games being used to increase cognitive gains in training. Although an overly in depth review of every learning theory is beyond the scope of this study, some of the more relevant theories in regards to video game training will now be discussed.

### 2.4 Experiential/active learning

Experiential learning is defined as, "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" [22]. At its core, experiential learning is simply the idea that an individual learns through the experiences that they have. In other words, an individual who gets to experience performing a task under different conditions, or performing the task in different ways, will learn to better perform that task through those experiences. In his review of the literature, Cantor [23] found experiential learning to be a necessary component of higher education that helped learners apply the theory learned in traditional classes to practical context.

Another concept extremely similar to experiential learning is active learning. Active learning takes place when individuals do more than act as passive listeners [24]. In other words, active learning entails learners being engaged and taking part in the learning process. It has been shown that students who engage in active learning comprehend more of what they are being taught and also engage in more critical thinking [25]. Due to the emphasis that both theories place on the trainee taking part in training and performing different tasks, it would seem as if they happen simultaneously. This would appear to be an even more reasonable conclusion in the case of video game training where a participant is actively controlling the game, their actions in it, and the experiences they have as a result.

The literature contains theoretical support for both experiential and active learning in the context of video game training. Experiential learning has been a focus of game developers for a long time [26]. In fact, Gredler [27] developed a categorization system for simulations and learning games that are based in experiential training. The four categories are data management simulations, diagnostic simulations, crisis management simulations, and social-process simulations. For example, business games are generally developed to maximize experiential learning, and for the most part, would fall under the first category [26][28-31]. These games allow managers to freely experiment with things like policies and strategies without having to worry about causing harm to the company or any employees [30].

Video games, by their very nature, promote active learning since the trainee has to play the game in order to go through training. This type of required participation is one of the big distinctions



between video game training and more traditional methods of instruction. McKeachie [32] said as much in his statement that, "the chief advantage of games and simulations is that students are active participants rather than passive observers". Several other theoretical articles support the idea of video games promoting active learning more than traditional methods [33-36]. Garris et al. [34] theorized that the study of learning was moving away from more traditional models and towards a learner-centered approach. They also believed that this change in approach would encourage more active participation by the learner. This is especially the case for serious games since games for education or training directly promote active learner participation in order for the trainee to complete the training, and this greater participation leads to increased learning [33][34].

Hands-on training relies heavily on both experiential and active learning, and may be an area where serious games could have a big effect. For instance, some jobs may have little to no risk associated with allowing a trainee to learn while doing the job and learning hands-on. However, for other jobs, such as those in the medical field, the risk associated with hands-on training may be substantially high. It is in these high-risk training situations that the use of serious games to train may be most beneficial.

Video games can be used to provide trainees with the same experiences and amount of active learning that they would get in hands-on training, while having the added benefit of no risk for the trainee, organization, or customers [37]. For instance, in the medical field serious games are used to improve the surgical skills of doctors [38]. The use of video games in this field gives doctors the opportunity to have hands-on practice that would be far too risky when using real patients. Another example is the use of video games, such as the previously discussed *America's Army*, by the military to train soldiers in combat tactics and operations [11]. These military games allow soldiers to understand how to react quickly and efficiently without putting themselves in real danger to do so.

## 2.5 Situated learning/anchored learning

Situated learning suggests that learning best takes place in specific contexts and environments in which the learned material will be used [39][40]. Bransford, Sherwood, Hasselbring, Kinzer, and Williams [41] first coined the term of a similar concept known as anchored instruction. According to Barab, Hay, and Duffy [42], anchored instruction, "refers to instruction in which the material to be learned is presented in the context of an authentic event that serves to anchor or situate the material and, further, allows it to be examined from multiple perspectives." In other words, both situated learning and anchored instruction are constructs based on the idea that effective learning best takes place in contexts that are meaningful to the learner [41] and authentic to the material being learned [43]. Similar to experiential and active learning, it seems safe to conclude that situated learning and anchored instruction both work together and take place simultaneously.

The theories of situated/anchored learning and instruction are supported in the literature as being important to learning in general and in video game training. As an example of this general importance, Savery & Duffy [44] created a list of seven principles of instructional design to be used as design guidelines for an overall learning environment. The first three of these principles are: 1. Anchor all learning activities to a larger problem, 2. Design an authentic task, and 3. Design the learning environment to reflect the complexity of the environment in which the learner should be able to function at the end of learning. These principles are directly aimed at insuring a situated/anchored learning context for effective teaching.

As with experiential/active learning, situated learning and anchored instruction focus on a more learner-oriented approach to training compared to traditional methods [45]. Once again, video game training is in a position to take advantage of this to increase learning outcomes since it has been shown that video games can provide authentic and realistic contexts and environments in which learners can practice meaningful and authentic responsibilities and tasks [46-48]. This ability of games to allow trainees to learn in, and control, environments similar to those where the learned actions will be performed, enables learners to better understand the impact of specific actions on outcomes in a safe manner, and may be video game training's greatest strength [49].

Video game training is already being used to promote situational learning and anchored instruction in order to increase learning and the practice of skills when it would be too dangerous for trainees to practice on the actual job. To go back to previously used examples, two of the more apparent areas where video games could help trainees acquire crucial skills safely are the medical field and the military [11][38]. Using video games in the medical field allows surgeons to practice actual surgical skills in a relevant context that simulates actual surgical setting [38]. Similarly, military games such as *America's Army* allow soldiers to practice tactical skills and learn field procedures



in a safe environment that simulates the combat zones where they could end up actually using the learned skills [11]. These two examples help illustrate how video games can be used to provide trainees with essential skills, and practice, in authentic situations that they would normally not have access to for practice.

## 2.6 Summary

As shown in the review of the literature, there is both theoretical and empirical support to suggest that serious games have the potential to be more effective training methods than more traditional methods. Due to this support, the first hypothesis of this study is that participants trained using a serious game will show higher levels of performance on an immediate test of task performance and on a later measure of declarative knowledge than those participants trained using the more traditional methods of text-based training.

## 3. Moderators

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### 3.1 Self-efficacy

It is possible that the relationship between type of training and performance is moderated by other variables. One such variable may be self-efficacy. In a broad sense, self-efficacy is typically thought of as a belief that one has in their own ability to meet situational demands or perform tasks [50]. More specifically, self-efficacy is believed to be domain specific and is thus variable across different tasks, behaviors, and contexts [51]. In other words, self-efficacy is thought to be task-specific and should be thought of and evaluated in terms of specific constructs. The construct of self-efficacy has been studied extensively in the training literature, and it has been consistently found that those trainees high in general and/or task-specific self-efficacy learn more and perform better than those with lower levels of self-efficacy [52][53].

In fact, Colquitt, Lepine, and Noe [54] found in their 20-year review of the literature that trainee self-efficacy had one of the largest impacts on motivation to learn. Other research has both supported the findings of self-efficacy being linked to motivation [55] as well as linking self-efficacy to important motivational variables such as goal setting and self-regulation [56]. Chiaburu and Marinova [57] also found that when trainees reported higher levels of self-efficacy, they were more motivated to train than other trainees. This impact that self-efficacy has on motivation to learn, and other motivational variables, implies that self-efficacy could play a large role in the effectiveness of training.

According to Saks [58], the idea that task-specific and general self-efficacy affects the overall effectiveness of training is supported by several studies that varied in training tasks and contexts, with some including computer-based training [59-64]. Research has also consistently shown that self-efficacy has a significant effect on training performance [55][61][62][65-71]. One meta-analysis by Sitzmann, Casper, Brown, Ely, and Zimmerman [72] found that self-efficacy accounted for 14% of the variance in post-training procedural knowledge and 24% of the variance in delayed procedural knowledge. Their meta-analysis helped to demonstrate how powerful a predictor self-efficacy is of performance [72].

Task-specific self-efficacy has also been shown to be related to both transfer performance and transfer motivation [73-79]. Again, the above literature included multiple training contexts including computer-based training. For example, in his longitudinal study of 126 employees participating in a training program to introduce computer software operation and design, Tai [79] found that computer self-efficacy had a significant effect on participants transfer motivation. In their 10 year review of the literature to create an integrated model of training evaluation and effectiveness, Alvarez et al. [73] found that the one individual characteristic shown to relate to transfer performance was pre-training self-efficacy. These findings were especially important to the current study since the participants were asked to perform the trained job task after training.

For the purposes of this study, video game self-efficacy is the task-specific efficacy of most interest. Video game self-efficacy is a belief that one holds in their ability to successfully play video games or to complete task in a video game context [80][81]. While there has been significantly less research looking directly at video game self-efficacy than is the case for general self-efficacy, there are studies in the literature that support video game self-efficacy having a similar impact on the effectiveness of training in a video game context as general self-efficacy does on training, overall [76][80][80][82]. For instance, Orvis et al. [80] found that when training



participants using *America's Army*, a first-person-shooter, video game self-efficacy had a positive impact on trainee motivation, satisfaction, and performance. Similarly, Brusso, Orvis, Bauer, and Tekleab [76] found that video game self-efficacy can help offset the effects of early negative performance by a trainee and is important for ensuring trainee success in video game-based training.

Along with the research directly studying video game self-efficacy, the literature also contains indirect support for video game self-efficacy increasing trainee motivation and performance. This indirect support is present in research that examined task-specific self-efficacy in contexts that are similar to video game training [68][79][83-86]. As an example, Brown [83] examined how learner choices in a computer-based (or electronic-learning (e-learning)) training context would affect training outcomes, and found that computer (or technology) self-efficacy was related to motivation, time on task, and performance. Johnson, Hornik, and Salas [85] supported these findings in their study where they found technology self-efficacy to be related to course performance and course satisfaction in an e-learning context. When one considers that serious games can be thought of as a type of e-learning, it would seem logical that video game self-efficacy would have the same type of impact on training in a game based learning context [87].

Due to the consistent and strong support shown in the literature, the second hypothesis of the current research is that those participants with higher levels of video game self-efficacy will score higher than those with lower levels of video game self-efficacy on measures of performance and declarative knowledge for the game-based condition.

### 3.2 Expectations

Another possible moderator is an individual's expectations for training. Before a trainee participates in training they form their own expectations regarding numerous aspects of the training including its effectiveness, its relevance, and even how much training will help them accomplish their work goals [88]. Noe and Schmitt [88] put forth the idea that trainees' expectations, along with their attitudes, interests, and values, might decrease or increase a training program's effectiveness. The authors proposed that expectations, along with the other variables, had this effect on training effectiveness mainly due to their influence on trainees' motivation to learn.

Similarly, other authors have also promoted the idea that expectations can influence the level of trainee participation [89-92]. As discussed previously in the review of the literature, these effects on motivation and participation could have a potentially large impact on the effectiveness of training. For example, if a trainee has negative expectations going into the training, they could have lower motivation to train and not participate fully. In turn, they would learn less and the effectiveness of the training will be lower for that individual than for others.

Some research has found little [93] to no evidence [94] to support the idea of expectations having a significant effect on the outcomes of training. However, there is more research to suggest that expectations toward training are effective predictors of subsequent training outcomes [95-100]. For example, two studies by Martocchio [67][86] found evidence of participants' expectations having a significant positive relationship with both learning on computer-based work tasks and post-training computer efficacy.

Another study involving 93 managers going through leadership training by Switzer, Nagy, and Mullins [101] found support for the managers' expectations influencing motivation to learn. These findings were supported in a study by Sitzmann, Brown, Ely, Kraiger, and Wisher [102] in which they found a, "dynamic interplay between course expectations, motivation to learn, and trainee reactions". There has also been research to suggest that expectations can moderate the training experience [103].

Expectations affecting training outcomes may be particularly important in the case of using serious games for training. Some individuals may have strong biases against the use of video games for anything other than entertainment which could have a significant impact on the effectiveness of serious game training [53]. While there has been virtually no research pertaining to this specific theory according to Cannon-Bowers and Bowers [104], the authors point out that, "it is clear that some students are at least dubious about being educated in computer-based environments" [105][106]. There has also been research to suggest that expectations affect outcomes in computer-mediated instruction [107]. When taking into account the extensive literature showing that expectations have an effect on training outcomes, and the literature showing some hesitancy to use technology for learning, it seems logical to conclude that an individual's attitude towards video game training could significantly affect their outcomes. This study could help contribute to the



literature by shedding some light on how a trainee's expectations regarding the use of video games as a training tool can affect their subsequent performance and motivation.

Based on the above research and theory, the third hypothesis is that participants with higher pre-test scores on their expectations for training in the game-based condition will score higher on measures of performance and declarative knowledge than those with lower expectations.

### 3.3 Engagement

Engagement occurs during learning that is both active and collaborative [108]. It can be thought of as the, "degree to which the learner is motivated by tasks, and interacts and takes part socially in the task environment" [53]. Engagement is thought to be, "an essential element of the player experience" [109]. Indeed, the most successful games are engaging by their very nature and have a powerful ability to draw people to the game and keep them playing for long periods of time [109-112]. This means that video games have the potential to cause trainees to spend more time on a task than more traditional methods of training. This is important because time on task has long been shown to increase learning outcomes and thought to be crucial to student performance [113]. This could help video game training to be more effective than traditional training.

A student's level of engagement is typically thought of as one of the better predictors of both learning and personal development [114]. This would suggest that when trainees are more engaged they will learn more, and training will be more effective. Video games engage the player by being fun and enjoyable to use, and according to learning theory, individuals can be motivated to learn with learning tools that are fun [115]. Since games are inherently fun, it is no surprise that the literature shows game-based training to have a positive impact on both trainee enjoyment and training effectiveness [116]. A concept similar to engagement is that of flow. Flow is a state that occurs when there is high challenge in an activity that is matched by the high skill of the player [117]. Flow can cause individuals to become so engaged in an activity that they lose track of time, forget their self-consciousness, and lose sight of external rewards [118]. The flow state instead causes individuals to engage in the activity because it is inherently motivating.

According to Prensky [9], flow occurs in gamers when there is an optimal match between the difficulty of the problems presented and the player's ability to solve those problems. The result of this optimal match is that the player becomes so engrossed and motivated to play that they will forget about all other concerns, such as being tired or hungry. This idea that flow in video games will take place when the flow conditions are met, and the optimal balance between skill and difficulty is met, means that the player can experience flow at any time regardless of how long they have been playing the game [119]. This is one of the core aspects of the appeal of games [120] and means that as long as a serious game meets all the conditions of flow, any content could become intrinsically rewarding and engaging [121].

This suggests that serious games can engage trainees to such an extent that they begin to develop intrinsic motivation and interest towards the training and content being trained, due to trainees experiencing a state of flow. According to Bizzocchi and Paras [122], a serious game meeting the conditions for flow is vital because it directly influences the amount of intrinsic motivation developed in the learner. This ability of video games to create a state of flow and develop intrinsic motivation should lead to increased performance gains, when compared to traditional methods of training, according to Self Determination Theory (SDT) [123][124].

SDT argues that activities that foster an individual's feelings of autonomy, competence, and relatedness produce intrinsic motivation and lead to enhanced performance, and creativity [123][124]. When someone playing a video game experiences a flow state, they feel extremely autonomous, competent, and have a large sense of relatedness to the virtual environment they are playing in. This suggests that SDT and Flow work in a reciprocal capacity, which means that increased flow will increase intrinsic motivation, which will in turn help to increase flow, etc. As such, serious games would seem to be able to substantially increase intrinsic motivation, and in turn performance, of trainees. To support this, Ryan, Rigby, and Przybylski [125] found that perceived autonomy and competence enhanced participants' motivation to play games.

With the support found in the literature for engagement, the fourth hypothesis is that participants in the game-based condition will spend more time interacting with the training material than those in the text-based condition and that increased time on task would lead to higher scores on task performance measures across both conditions. The fifth hypothesis is that those with higher levels of engagement in the game-based condition will score higher on measures of task performance and declarative knowledge.



## 4. Methodology

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### 4.1 Participants

A total of 40 participants were recruited and randomly assigned to either the game-based or text-based condition during the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC). Any potential participants with experience in Explosive Ordnance Disposal (EOD) or with Improvised Explosive Devices (IEDs) were excluded from the study. This exclusion was done to ensure that any performance and/or knowledge differences observed between participants in the video game training and text training conditions (IV) were actually due to the difference in training condition, and not any previous experience with the trained material. Those under the age of 18 were also excluded.

### 4.2 Materials

A serious game developed by Cubic Corporation in 2013, was used for the video game training condition. The game was designed to utilize both a television and iPad in order to teach participants the steps to disabling an IED. In the game, participants have been assigned to provide EOD support for two Navy vessels prepared to enter port in Jakarta. During the game, participants were taught the essential and supplementary steps to disabling an IED.

Participants first watched a cutscene explaining the different parts of an IED and their purpose. This cutscene also taught participants the order of steps needed to disable the IED. After the cutscene's, participants were given three different levels with various levels of scaffolding that they could work through. The participants performed actions in the game by touching their finger to the iPad screen to select an object. The selected object would then give them a context menu to select from in order to take an action.

The first level involved the participant being told what action to take and then shown, via highlight, what action to take on the screen. They could not move on to the next step until they completed the shown step correctly. The second level involved the participant being told, but not shown, what action to take on screen. They could still not move on to the next step until what was shown was completed correctly. The final level involved the student going through the steps on their own with no directions. They could do the steps in any order they wanted but the level did not end until all steps were completed.

For the text-based condition, a written manuscript was used in order to teach participants the same concepts taught in the game developed by Cubic. Special care was taken to ensure that the text material covered all steps and components covered in the video game. Subject Matter Experts (SMEs) were used to ensure that the material being taught in the two conditions was indeed equivalent.

### 4.3 Measures

In order to measure video game self-efficacy, the General Self-Efficacy Scale (GSE) [126] was slightly adapted to fit the specific construct of interest [87]. For example, an item on the GSE is "I can always manage to solve difficult problems if I try hard enough." In order to measure video game self-efficacy, this item was altered to state "I can always manage to solve difficult problems within a video game if I try hard enough." The GSE was developed in order to measure the construct of Perceived Self-Efficacy, and was originally developed in German before being adapted into 26 other languages. Support for the validity and reliability of the GSE has been found across a number of cultures and specific context [127] which provides further support for adapting the GSE to measure video game self-efficacy. The adapted GSE is a 10 item self-report measure which ask participants to endorse each item on a scale from 1 (strongly disagree) to 6 (strongly agree). Participant's scores were totaled and higher total scores indicated higher levels of video game self-efficacy.

Expectations of game training were measured using a pre-training scale developed in 2013. One item stating "I expect that the game will be useful for preparing for the psychological challenges faced during deployment" was removed from the questionnaire because it could not be easily adapted to fit the context of the study. A separate item was slightly adapted to fit the study context of disabling an IED. The expectations of game training scale is composed of 9 items, and asks participants to indicate the extent to which they agree with each item on a 5-point Likert scale,





ranging from 1 (strongly disagree) to 5 (strongly agree). One example of an item used on this scale is; "I expect that I will be able to apply what I learn throughout the game in the real world." Similar to the video game self-efficacy scale, a participant's score is totaled, and a higher total score indicates more positive expectations.

The Game Engagement Questionnaire (GEQ) [128] was used to measure levels of engagement after training. The GEQ is a self-report measure consisting of 19 items. The GEQ was developed using both classical and Rasch analyses, and contains 4 factors. These factors are psychological absorption, flow, presence, and immersion. The GEQ treats these 4 factors as various levels of Game Engagement. An example item on the GEQ states; "I played longer than I meant to." Participants are asked to indicate on a 5-point Likert scale the extent to which they agree with each item, with 1 being strongly disagree and 5 being strongly agree. As with the previous measures, participant scores were totaled and a higher total score indicated a higher level of game engagement.

To measure task performance (DV), participants were asked to actually perform the task of disabling an IED and all relevant steps on a training dummy with a dummy replica IED vest attached, immediately after training. Participants were asked to speak out loud each step they took so that the researcher could mark off that they performed the step on a checklist. Participants were instructed that the researcher would assume nothing and would grade them based on what they said out loud. Participants were scored based on time and accuracy. For this task, the maximum score was 100. This provided each participant the chance to demonstrate their learned skills in a high-fidelity task.

Declarative knowledge (DV) was measured using a follow-up quiz that was emailed to participants 48 hours after their participation in the study. They received the quiz in the form of a SurveyMonkey link. The quiz was in a multiple choice format and covered the basic concepts of disabling an IED, which were covered during training. For example, participants were asked to look at a list of the steps to disabling an IED and put them in correct order. The maximum score for the declarative knowledge measure was 15.

#### 4.4 Procedure

As participants arrived, they were randomly assigned to either the game-based or text-based condition and informed which they were assigned to. This was done in order to test participants' expectations for training. Pre-test measures of expectations for training and video game self-efficacy were administered before training took place. Along with these measures, minimal biographical data was collected in order to exclude individuals under the age of 18 and/or those with EOD/IED experience. At this point, participants were also asked if they would like to participate in the 48-hour follow-up quiz.

Next, participants completed their assigned training. Participants in each condition were instructed that they could interact with the training material, text or game, as long as they wanted. They were also instructed to let the researcher know when they felt ready to perform the trained task. The researcher recorded the amount of time that each participant spent interacting with the training material. Once participants completed reviewing the training material, they were asked to perform the trained task using the dummy IED, while a researcher observed and scored them. Finally, participants were given the post-test measure of game engagement. Those participants that agreed to the follow-up survey were emailed a SurveyMonkey link to the declarative knowledge quiz 48 hours after their participation in the main part of the study.

### 5. Results

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One participant in the game-based condition was disqualified due to previous EOD/IED experience and his data was not used for any data analysis. A total of 29 participants responded to the follow-up quiz. As such, the data of only those 29 participants was used when conducting analysis pertaining to the follow-up data. Multiple Shapiro-Wilk's tests were used to test the assumption of a normal distribution for all data across both the game-based and text-based conditions. All data was found to be normally distributed for both conditions ( $p > .05$ ), except for follow-up declarative knowledge scores which was not normally distributed in either condition ( $p < .05$ ). No transformation was conducted on the follow-up declarative knowledge scores because they satisfied the assumptions necessary to conduct nonparametric tests in every instance. For all t-test conducted, the assumption of homogeneity of variance was also satisfied.



An independent-samples t-test was conducted to compare task performance scores in the game-based and text-based conditions. It was found that those in the game-based condition ( $M = 68.83$ ,  $SD = 21.42$ ) performed the trained task significantly better ( $t(37) = 4.25$ ,  $p < .001$ ) than those in the text-based condition ( $M = 40.76$ ,  $SD = 19.82$ ). Due to follow-up declarative knowledge scores not being normally distributed, a Mann-Whitney U test was run to compare scores in the game-based and text-based conditions. Distributions of the follow-up scores in both conditions were similar, as assessed by visual inspection. No significant difference ( $U = 158.50$ ,  $z = -.873$ ,  $p = .38$ ) was found between the scores for the game-based ( $Mdn = 7.50$ ) and text-based ( $Mdn = 7.00$ ) conditions.

Typically, to test for moderation, linear regressions are run that incorporate the interaction between the IV and the Moderator [129]. Due to the IV being dichotomous in the current study, this method turns the test for moderation into a simple correlation between the DV and the Moderator, while using only the scores in the game-based condition. A Pearson's correlation coefficient was computed to assess the relationship between video game self-efficacy and task performance scores in the game-based condition. The results showed a moderately strong correlation between the two variables ( $r(16) = .61$ ,  $p = .01$ ). As a control, a Pearson's correlation coefficient was computed to assess the relationship between video game self-efficacy and task performance scores in the text-based condition. No significant correlation was found between the two variables ( $r(19) = .17$ ,  $p = .47$ ). A separate Spearman's rank-order correlation was run to assess the relationship between video game self-efficacy and follow-up declarative knowledge scores in the game-based condition. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatter plot. No significant correlation between the two variables was found ( $r_s(16) = .11$ ,  $p = .66$ ). Another Pearson's correlation coefficient was computed in order to assess the relationship between expectations for training and task performance scores in the game-based condition. No significant correlation was found between the two variables ( $r(16) = .44$ ,  $p = .07$ ). A Spearman's rank-order correlation was computed to assess the relationship between expectations for training and follow-up declarative knowledge scores in the game-based condition. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatter plot. No significant correlation was found between the two variables ( $r_s(16) = .09$ ,  $p = .74$ ).

A second independent-samples t-test was conducted to compare the recorded time spent interacting with the training material in the game-based and text-based conditions. It was found that those in the game-based condition ( $M = 0:09:46$ ,  $SD = 0:02:51$ ) spent a significantly greater amount of time interacting with the training material ( $t(37) = 4.39$ ,  $p < .001$ ) than those in the text-based condition ( $M = 0:06:13$ ,  $SD = 0:02:12$ ). A Pearson's correlation coefficient was computed to assess the relationship between time on task and task performance scores across both conditions. The results showed a moderately strong correlation between the two variables ( $r(37) = .56$ ,  $p < .001$ ).

One last Pearson's correlation coefficient was computed in order to assess the relationship between engagement and task performance scores in the game-based condition. No significant correlation was found between the two variables ( $r(16) = -.02$ ,  $p = .93$ ). A Spearman's rank-order correlation was computed to assess the relationship between engagement and follow-up declarative knowledge scores. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatter plot. No significant correlation was found between the two variables ( $r_s(16) = -.35$ ,  $p = .15$ ).

## 6. Discussion

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Partial support was found for the first hypothesis that participants trained using a serious game will show higher levels of performance on an immediate test of task performance and on a later measure of declarative knowledge than those participants trained using the more traditional method of text-based training. The finding that participants in the game-based condition scored significantly higher on a measure of task performance shows support for the first part of the hypothesis. However, no support was found for participants in the game-based condition scoring higher on the later measure of declarative knowledge. The implications of the supported part of the hypothesis are substantial. Serious game training leading to better task performance than traditional text-based training could lead to more efficient and cost effective ways of training tasks to the work force and/or military.

It's possible that this support for the first half of the hypothesis is partially due to participants in the game-based condition having the opportunity to engage in experiential/active learning through the game. An opportunity that the text based condition did not have. Another possible contributing factor could be the design of the game itself. The levels in the game are naturally scaffolded and



scaffolding has been shown to have an important impact on instruction and learning [44]. In this study, specific elements of game design could not be controlled, but future research should carefully design game based training to test which game design elements help video game training be most effective. Also, the high-fidelity of the task performance measure described in the methodology section of this study set it apart from much of the other research in this area. The finding that video game training directly transfers to a task has the potential to cause a surge in the research and application of game-based training.

Partial support was again found for the second hypothesis that those participants with higher levels of video game self-efficacy will score higher than those with lower levels of video game self-efficacy on measures of task performance and declarative knowledge for the game-based condition. Once more, support was found for the first part of the hypothesis that individuals scoring higher in video game self-efficacy would perform better on a measure of task performance, but no support was found for them scoring better on a measure of declarative knowledge. This support for video game self-efficacy moderating the relationship between training and task performance implies that care should be taken when designing training programs in order to take advantage of this effect. At the very least, training programs should take care not to allow video game self-efficacy to lower the effectiveness of training. However, if designed correctly, training programs may be able to increase video game self-efficacy in order to allow trainees to get the most out of training. Future research should attempt to look at video game self-efficacy in closer detail and attempt to find the ways in which video game self-efficacy could be increased during training.

No support was found for the third hypothesis that participants with higher pre-test scores for their expectations for training in the game-based condition will score higher on measures of task performance and declarative knowledge, than those with lower expectations. However, it is interesting and important to note that the relationship between expectation for training in the game-based condition and task performance scores were close to having a moderate and significant correlation. When taking into account the limitation of sample size in this study ( $n = 18$ ), it is reasonable to believe that an increased sample size would lead to this relationship becoming significant. Future research should look into expectations for training in more detail, with a larger sample size, in order to better understand its effect on training outcomes. This information could be extremely helpful to practitioners because it could mean that doing small things, such as making sure to frame training in a positive view, could help to increase the effectiveness of training programs.

Support was found for the fourth hypothesis that participants in the game-based condition would spend more time interacting with the training material than those in the text-based condition and that increased time on task would lead to higher scores on task performance measures across both conditions. This means that game-based training could have the potential to get trainees to spend more time willingly learning the training material than those taking part in text-based training. In fact, this increased time spent with the training materials in the game-based condition could be another possible contributing factor to the positive training outcomes seen in this study. This could have major implications in the business world or the military, especially in situations when it is important to keep critical, but infrequently used, skills refreshed on a regular basis. Trainees may be more willing to spend time refreshing these critical skills when interacting with a game instead of text material. Future research should look at the difference in time spent interacting with training material between game-based training and other forms of training as well. Also, it could be beneficial to look at the differences in time spent with training material when the material is either more complex, or when participants have more time set aside to interact with the training material. No support was found for the fifth, and final, hypothesis that those with higher levels of engagement in the game-based condition will score higher on measures of task performance and declarative knowledge. There are some potential limitations to this study that may have contributed to this lack of support. These limitations are covered in the following section.

## 7. Limitations

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The first potential limitation is that the study took place in an environment that may not have been very conducive to participants becoming engaged in the game. Participants were interacting with the game in the middle of the I/ITSEC conference with a lot of noise and movement happening in the background. This may have affected participants in varying ways and made it hard for some to become truly engaged. Also, many I/ITSEC attendees try to see everything they can in one day and



move quickly through many of the exhibits. This feeling of being pressed for time may have prevented some participants from becoming engaged in the game. Another potential limitation is the GEQ that was used to measure the level of game engagement in participants. The GEQ measures different levels of engagement progression including immersion, presence, flow, and psychological absorption [128]. It is possible that not all of these levels were relevant to the relatively simple training game used in this study, and that a different engagement measure may have produced different results.

One of the most impactful potential limitations to this study was the amount of time available to participate in the training task. Participants were only given one opportunity to interact with the training material and this may help account for the lack of any significant findings involving the follow-up declarative knowledge measure, especially when it comes to finding no significant difference between the type of trainings and declarative knowledge scores. It is possible that one short training session was not enough time to show any significant effects that may be present. Future research should look at the effects of game-based training as it pertains to long term declarative knowledge over longer periods of training.

Another potential limitation of the current study is the use of a sample population consisting entirely of I/ITSEC attendees. Due to I/ITSEC being a technology conference, attendees may be more interested in technology and gaming than would be the case in the general population. It is possible that the results would be different if a sample population consisting of active members of the work force with no technology or gaming interest was used, and that serious games may affect the learning outcomes of the two groups differently. This implies that the results of this study may not be entirely generalizable to applied settings. However, the game itself may help the results be generalizable across a genre of serious games in the military since that was the focus of the game. In this scenario, the limitation of the population would still hold true. Future research should attempt to conduct field studies or use samples consisting of more diverse populations in order to try and determine the generalizability of these results. These field studies could also look closer at transferability of serious game training. The lack of being able to look at long term transfer is a separate limitation of the study.

Yet another potential limitation of this study is that confounding variables could be accounting for some of the variance seen between types of training. For example, while the content of the training was held as consistent as possible across both conditions, it is possible that minor differences in content actually account for the differences in training outcomes observed as opposed to the different types of training being the cause. This could drastically change the results of the study and should be examined in future research as well. Another potential confounding variable is the video game used as training material itself. Factors such as how engaging or playable the game was could have greatly affected learning outcomes or even scores on the GEQ. Also, the participants knowing the various training conditions they could be in may have affected the results of the study. Knowing if they were going to play a game, or read text instead of playing a game, could affect a participant's motivation to train, which could in turn affect the training outcomes. Future researchers should look for other ways to control the content of the training material and the ways to test the outcomes of that training to best control for confounding variables, as well as the affect of keeping the various training conditions a secret from the participants. They should also look closely at the games used in their studies and how they may affect the results.

## 8. Conclusion

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While the results of this study in no way offer a definitive answer as to whether or not serious games are more effective training tools than traditional text-based training, they do offer some support for their potential to be more effective. The results of this study have important theoretical and applied implications. Future research should be conducted in order to replicate the results showing support for the hypotheses, but in different conditions in order to further support the effectiveness of serious games and allow for more generalizability of the results. Also, future research should take care to further restrict the limitations seen in this study in order to better understand the effects that moderating variables can have on the relationship between training and outcomes, especially as they relate to delayed declarative knowledge. In the applied setting, the results of this study as they relate to task performance could lead to significant economic gains for organizations by making task-based training more effective.



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