

Videogame-Based Learning

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The game characteristic of human interaction has a large positive effect on affective states, and a small but significant effect on declarative knowledge. Additionally, perceived value and active learning were important mechanisms through which human interaction impacted affective states. These emerging areas of research show there are potential avenues for continued research in the application of game-based training and education.

videogame-based learning

human interaction

affective states

declarative knowledge

teams

1. Introduction

A videogame is a virtually constructed environment, with rules and goals that challenge the player while engaging their attention with a series of decisions ^{[1][2][3]}. Videogame environments are well-suited for teaching because they provide a high degree of control over the features and characteristics of the game. This flexibility is beneficial to organizations because game scenarios can be easily adapted to different needs ^{[4][5]}. Recent years have seen a rise in the application of videogames for purposes other than entertainment ^[6]. Sources have projected continued growth in the development and application of videogames for novel purposes, such as being used in the classroom to teach elementary school children, in interactive displays for museum exhibits, and within organizations to train and develop employees ^[7]. Despite the increasing use of videogames for training purposes, the research evidence used to justify the investment in and implementation of videogame-based learning is limited ^[4]. Research on videogame-based learning has found evidence that both supports and discredits the claim that videogames enhance learning outcomes ^{[8][9]}. This research presents and tests an alternative methodology for videogame-based learning that could help explain previous contradictory findings and clarify future research results. This proposed methodology is an extension of a model of videogame-based learning ^[10] that isolates game characteristics and identifies specific mechanisms through which different training outcomes are affected. In this current research, one game characteristic (i.e., human interaction) will be evaluated to determine the direct effects on two types of training criteria (i.e., affective states and declarative knowledge), and to test two indirect effects (i.e., perceived value and active learning).

2. Impact of Game Characteristics

The results of this research demonstrate that game characteristics can have an impact on training outcomes. Because only one game characteristic (i.e., human interaction) was explored in the current research, more

research is needed to clarify the effects of other game characteristics and their impacts on other training outcomes. However, it is still clear that game characteristics can impact training outcomes, and should be considered from a design perspective for future game-based learning tools. Examining other game characteristics could shed light on the complex relationships between game characteristics, mediating variables, and training outcomes, e.g., [11]. For example, the game characteristic assessment (characterized by the extent of feedback an individual receives during the training) could have a greater impact on mediating factors such as active learning and cognitive engagement, which could then lead to a greater effect on learning outcomes. By only examining one game characteristic (i.e., human interaction), the ability to find the relationships that were hypothesized may have been limited. Thus, another research opportunity is for other studies to systematically explore multiple game characteristics across studies, while tracking the characteristics and combinations of characteristics that produce the strongest effect. This would benefit researchers and practitioners by clarifying which characteristics they may choose to include in the design of a game, and what combinations would best match the unique goals of the training.

Since game characteristics can have an impact on training outcomes, it is concerning when researchers do not disclose sufficient information about a game for the game characteristics can be inferred. A primary benefit of disclosing detailed information about a game is that the effects of the game characteristics can be identified. Without considering the effects of the game characteristics, the findings from the research may be misattributed to other factors (e.g., condition assignment). Thus, future researchers should disclose information about the game in sufficient detail that the game characteristics can be identified.

Another beneficial practice would be describing the game characteristics using a common framework or taxonomy. Using a standardized framework to describe game characteristics would help future researchers understand and synthesize the results of game-based learning across studies. This would allow more accurate comparisons and interpretations to be made across studies, and would provide a clearer picture of the impact of game characteristics within the larger context of game-based learning. However, research synthesis and cumulative research (building on what others have found) is limited by poor descriptions or mischaracterizations of game characteristics by researchers or game manufacturers. Research would benefit from the disclosure of game characteristics using a standard framework, such as presenting a profile of game characteristics.

One primary benefit of expanding the literature on game characteristics is that research findings can lead to intentional game design decisions, such as using specific game characteristics or combinations of characteristics to meet training objectives. The goal of understanding game characteristics is that research findings can inform the future design and development of videogames used for learning. As scientific findings provide clear evidence about the game characteristics that lead to specific training outcomes, games can be customized by developers or chosen by clients specifically for the intended training outcomes. An example from the present research is that a game designed to include a multiplayer option would lend itself to a training intention of improved affective states. Previous research has demonstrated that specific training design can influence training outcomes [12], and it is advantageous to consider research findings during the development phase to inform the decisions made regarding a training program.

3. Human Interaction

In the current research, human interaction led to decreased levels of active learning. This is potentially due to the additional attention that team members paid to interacting with others when collaborating and coordinating their efforts. In this research, participants interacted only once for 20 min. It is possible that the initial interaction detracts from the attention paid to the learning process, but that later interactions may be different, once teams have had sufficient opportunity to develop collaborative relationships. This may indicate that teams need additional time in game-based training to interact and be effective, which is consistent with previous research that has shown that the benefits of teams may take time and multiple interactions to emerge [13]. Practitioners could design training with a multiplayer component to allow extra time for team interaction, to emphasize the importance of active learning, or to allow the team ample time to prepare before the game (e.g., preparing a strategy of working together).

Other social mechanisms could contribute to the differences observed between individuals and teams, such as diffusion of responsibility [14]. That is, participants playing with a team may not feel that they are responsible for learning all the components of the game if they have others who they can depend on to help them be successful during the game. Although participants were warned they would complete a test at the end of the research, they may still have experienced this diffusion when working with other team members. It would be valuable for future researchers to more closely observe the social interactions and experiences that teams are having in the game, and to explore how these interactions impact learning outcomes. Increasing awareness of the processes that occur during the game cycle and building in new features to the game may change the training process and improve training outcomes.

4. Mechanisms in the Game Cycle

Based on the game-based learning model [10], inputs are believed to impact training outcomes via various training processes in the game cycle. In previous research, these game cycle mechanisms have been considered a black box of training processes [15]. Other researchers have identified the need to examine variables that may exist in this black box of game cycle processes and that mediate or moderate the relationships between game characteristics and training outcomes [16]. However, there is little empirical research examining these mechanisms. Therefore, several mechanisms that were expected to exist in this game cycle were explored.

It was found that perceived value mediated the relationship between human interaction and affective states. This is consistent with previous research, which has shown that understanding the value of a training program has an important association with participants' experience and the outcomes of the training [17]. In one previous study, researchers found that perceived value of the learning process led to increased levels of participant enjoyment [18]. It was also found that active learning is a mechanism through which human interaction impedes both affective states and declarative knowledge. Thus, this research was one of the first to identify specific game processes that are influenced by game characteristics.

Despite the complications in studying the game cycle, it is important to evaluate the user experience so as to understand the role it plays in affecting training outcomes [1]. The cycle of game elements leading to a unique user experience, which influences training outcomes, has been described as a feedback loop that can be designed to lead to beneficial states such as happiness, engagement, flow, and satisfaction [1][19][20]. Thus, it is important to understand the processes from a design perspective, in order to help optimize the user experience and the effectiveness of the training towards the intended outcomes. It would be valuable for game designers to intentionally build in opportunities to enhance the game cycle according to the intended goals of the training.

One critical next step for future research on game-based learning for workplace outcomes is for researchers to study the actual games that organizations are using to develop employee knowledge and skills. Empirical studies of games used in business environments rarely examine the games used by training practitioners. There may be a number of reasons for this. Understandably, concerns about sharing proprietary information or programs may limit a company's willingness to share their training products for scientific exploration. However, it would benefit both practitioners and researchers to generate evidence on the effectiveness of game-based learning using the actual games used in organizations. At present, many researchers use games that are readily available (e.g., commercial games, entertainment-based games) as proxy measures for the training games used by organizations. There is a dearth of research studying the game-based tools that organizations are using today. The generalizability of the results is limited by the tools being used in the research. The present research used a game focused on building teams of individuals to coordinate their efforts on a ship in order to meet specific mission objectives. An immediate concern of this game is that participants will rarely see any real-world value in developing their skills in this game. Not only does the game lack face validity for real world application, but the skills the participants are developing (e.g., communication and knowledge sharing) are secondary skills, and not the primary focus of the game. Future studies could address this concern by studying games currently being used within workplace settings. This would allow more clear connections to be made between the research and the application of the results.

5. Links to Job Performance

Finally, future research should establish a clear link between game-based training and job performance. This research demonstrates that human interaction impacts affective states and declarative knowledge, but stops short of showing impacts on job performance. Prior research has demonstrated a positive correlation between declarative knowledge and transfer of training, but not as clearly between affective reactions and transfer of training [21]. There is some theoretical support for the statement that some positive affective states experienced in the training (e.g., motivation) can benefit the acquisition of declarative knowledge, which may increase the likelihood that transfer of training will occur [22]. However, there are many factors that affect transfer, such as workplace support, and opportunity to practice and apply the skill [22]. Considering the number of factors that can influence this outcome, it is important to gather direct transfer measures rather than relying on the relationship between transfer of training and other available measures. Thus, there is little that can be said regarding the generalizability of the current results to direct work-related outcomes, such as job performance. However, future researchers could design their studies to demonstrate these connections. Using a real-world sample of workers

would strengthen this area of research and provide stronger evidence about the effectiveness of game-based learning for transfer of training and job performance. There are several benefits that would come with using a real-world sample. For example, student participants may be less motivated to pay attention and do their best in a lab experiment because there is little incentive for them to put forth effort in the research. In addition to this, workers have previous skills and experiences that could be applicable to the experiment, and could influence the results of the research in a meaningful way. Thus, these differences between a subject pool of students and a sample of workers could impact the results, and it is important to recognize that future studies using real-world samples may benefit from these differences and provide a more accurate indication of game-based learning in an organizational setting.

In a design that coordinated with an organization to use a game-based training with employees and then gathered job performance data for the employees, the impact that the training had on relevant work-related outcomes such as job performance could be clearly seen. Providing evidence about the implications of game-based training for job performance can help an organization better understand the return on investment for game-based learning. A major limitation of existing research in this area, and of the current research, is that implications for transfer of training and job performance are being inferred using proxy measures of learning (e.g., declarative knowledge). Being able to draw these connections directly could aid organizations in making decisions about investing in and developing future game-based learning programs. Thus, the current platform of using a lab-based experiment limits the generalizability of these results, as the measures and methodologies did not resemble the real-world context.

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