Videogame-Based Training

Virtualized training provides high fidelity environments to practice skills and gain knowledge, potentially mitigating harmful consequences from real life mistakes. Videogames are believed to have characteristics that improve learning. There is conflicting evidence on the benefits of using videogame-based training to improve learning.

1. Introduction

Organizations have used virtualized trainings for decades [1][2][3] to allow employees to practice complex, work-related skills in a high-fidelity environment before performing those skills on the job [4]. Although virtualized training can come at a high monetary cost [5][6], it remains popular, particularly in high stakes learning environments such as the medical industry. One reason for the continued use of virtualized training is the potential mitigation of harmful or costly consequences of real-life mistakes [7][8][9][10]. Recent research in this area has focused the different elements of videogames [11][12][13][14][15][16][17][18]. Videogame-based trainings, sometimes called *serious games* [19] attract organizations because they are perceived to increase motivation and attention [20] which is believed to improve learning outcomes [21]. Despite this belief, there is mixed research evidence for the usefulness and application of videogame-based training as a tool for workplace training [22][23]. Despite the growing trend of using videogames as a form of training within organizations [24], the conditions under which videogames impact learning outcomes are still largely unknown [25]. Expanding this research area will provide guidance to organizations currently investing in videogame-based training.

Some researchers have proposed exploring videogame characteristics to better understand the use and effectiveness of videogames as training tools [27]. Some have predicted that certain videogame characteristics will improve performance during the training and learning outcomes after a training has been completed. However, it is still largely unknown how videogame characteristics influence learning [25]. Luckily there has been ore recent theoretical interest in videogame characteristics [19], and a growing number of empirical studies are being published [28][29]. While several researchers have shifted towards micro examinations of the connection between videogame characteristics and improved training outcomes [30][31][32], few have isolated and manipulated specific videogame characteristics to observe changes in learning outcomes [33][34].

Many definitions for videogame characteristics have been proposed [35][36][37][38][39][40][41][42]. The Game Attributes taxonomy [30] which is widely cited by videogame researchers [43][44][45] defines nine game characteristics (i.e., action language, assessment, conflict/challenge, control, environment, fiction, human interaction, immersion, and rules/goals). The two videogame characteristics rules/goals clarity and human interaction can often be changed without needing to alter a videogame's programming [30].

2. Videogame Characteristic: Rules/Goals Clarity

The rules/goals videogame characteristic is defined as the parameters a player must abide by when playing the game. This includes rules the player must follow (i.e., a player cannot return to a level once they have exited that level) and goals the player must strive to meet in order to win the game (i.e., a player must fix a device using the correct tool before the two-minute timer expires [30]). Videogames inherently have rules/goals, but the clarity of that information often varies. Researchers have previously claimed that providing clear rules/goals for a videogame is required when games are intended to teach players, since it is believed that the clarity of the rules/goals can positively impact performance in the game and learning outcomes [47][48]. It is valuable to establish empirical evidence for the relationship between clear rules/goals and how much a player learns in the game, beyond these theorized benefits [30][48].

Garris argued [48] that the concepts of goal-setting theory (i.e., clear, specific, and difficult goals improve job performance [49]) can be applied to the rules/goals of games that are intended for learning. The theorized benefits of clarifying the

rules/goals of a game include adding structure, increasing motivation for the players, and stimulating the gaming process [39][48][50][51][52][53][54][55], all of which may aid performance in the game and learning.

3. Videogame Characteristic: Human Interaction

The videogame characteristic human interaction is defined as the amount of contact an individual has with others while playing a videogame [30]. This broadly includes any form of communication between players in the game. Greater human interaction in a videogame-based training when conducted in a cooperative setting, may generate the context of a team-based training experience. Team training is defined as a scenario that includes collaborative involvement with others for the purpose of developing knowledge or skills [56][57]. Few studies have directly compared individual training to team training using the same training scenario [58].

The few studies that have compared team-based training to individual training have generally found support that in team-based trainings, participants have had better recall on trained information, made fewer errors, and demonstrated better quality task performance than those trained individually [58][59][60]. Virtual team training research does not typically make direct comparisons between virtual teams and individuals [61][62], but has demonstrated several positive mechanisms through which virtual teams interact [63]. Based on these findings it is predicted that human interaction will promote mid-training performance in the videogame-based training.

4. Post-Training Performance

As previously mentioned, mid-training performance is the scoring of observable behaviors that occurred during the videogame-based training experience. In contrast to this, post-training performance can be observed and scored after the training has been completed, in other tasks given to trainees. This means the knowledge or skills from the training are being applied to another context, such as a post-training task or back on the job; this is referred to as *transfer of training* [64]. Evaluating post-training performance can be beneficial for organizations to ensure that the knowledge and skills developed in training are applied outside of training to benefit future work. According to a model of decision-based evaluations, post-training performance can impact valuable outcomes such as long-term changes in workplace performance or organizational payoffs [65].

5. The Impact of Videogame Characteristics

Some researchers have looked at how videogame characteristics uniquely contribute to different outcomes (e.g., game motivation leads to immersive game playing [47]). These studies have not typically examined the statistical interactions between these characteristics [55]. Bedwell and colleagues argued [30] that videogame characteristics are not orthogonal and cannot be easily parsed apart from one another. They further stated that studying videogame characteristics independently is nearly impossible because they are too interdependent (i.e., influencing one videogame characteristic will influence several other characteristics through unintentional manipulation). Thus, it is important to consider videogame characteristics in conjunction with one another and to further explore the extent to which they interact. The analyses of this study will further explore how clear rules/goals and human interaction impact one another.

Researchers who study teams have identified beneficial processes between team members, such as knowledge sharing and information elaboration, which aids performance [66]. Having clear rules/goals is expected to assist learning to a greater extent for team members because they will have the added benefits of engaging in teamwork processes. Team members who are uncertain about the training will have an additional resource of working together to figure out what is needed to complete the training. Participants training individually will not have team member support for clarification or assistance.

Human interaction is expected to have a positive effect on mid-training performance and is anticipated to enhance the positive effects of clear rules/goals on mid-training performance and post-training performance in both the familiar and novel tasks. Participants working with a team may have assisted one another on certain tasks and understanding components of the game. The theory of transactive memory states that teams depend on each other to fill knowledge gaps during times of team interaction [67]. It is likely that participants will employ transactive memory during the videogame-based training in which they interact with their team and will therefore demonstrate the benefits of this in the post-training activities. Thus, participants in the team training condition will demonstrate greater benefit from clear rules/goals than participants who trained individually.

References

1. Orlansky, J.; String, J. Cost-Effectiveness of Flight Simulators for Military Training; Document No. P-1275-VOL-1; Institute for Defense Analyses: Alexandria, VA, USA, 1977.

2. Rowland, K.M.; Gardner, D.M. The Uses of Business Gaming in Education and Laboratory Research. Decis. Sci. 1973, 4, 268–283.

3. Thompson, F.A. Gaming via Computer Simulation Techniques for Junior College Economics Education; ERIC Document Reproduction Service No. ED 021 549; Riverside City College: Riverside, CA, USA, 1968.

4. Agapiou, A. The use and evaluation of a simulation game to teach professional practice skills to undergraduate architecture students. J. Educ. Built Environ. 2006, 1, 3–14.

5. Bowers, C.A.; Jentsch, F. Use of commercial, off-the-shelf, simulations for team research. In Advances in Human Performance and Cognitive Engineering Research; Bowers, C.A., Salas, E., Eds.; Lawrence Erlbaum: Mahwah, NJ, USA, 2001; pp. 293–317.

6. Marlow, S.L.; Salas, E.; Landon, L.B.; Presnell, B. Eliciting teamwork with game attributes: A systematic review and research agenda. Comput. Hum. Behav. 2016, 55, 413–423.

7. Dalla Rosa, A.; Vianello, M. On the effectiveness of a simulated learning environment. Procedia-Soc. Behav. Sci. 2015, 171, 1065–1074.

8. Denby, B.; Schofield, D. Role of virtual reality in safety training of mine personnel. Min. Eng. 1999, 51, 59–64. Available online: https://www.osti.gov/etdeweb/biblio/20007172 (accessed on 27 January 2022).

9. Wood, A.; McPhee, C. Establishing a virtual learning environment: A nursing experience. J. Contin. Educ. Nurs. 2011, 42, 510–515.

10. Zajtchuk, R.; Satava, R.M. Medical applications of virtual reality. Commun. ACM 1997, 40, 63–64.

11. Anderson, G.S.; Hilton, S. Increase team cohesion by playing cooperative video games. CrossTalk 2015, 1, 33–37.

12. Caroux, L.; Isbister, K.; Le Bigot, L.; Vibert, N. Player-video game interaction: A systematic review of current concepts. Comput. Hum. Behav. 2015, 48, 366–381.

13. Dempsey, J.; Lucassen, B.; Gilley, W.; Rasmussen, K. Since Malone's theory of intrinsically motivating instruction: What's the score in the gaming literature? J. Educ. Technol. Syst. 1993, 22, 1973–1983.

14. Griffiths, M. The educational benefits of videogames. Educ. Health 2002, 20, 47–51.

15. Jacobs, J.W.; Dempsey, J.V. Simulation and gaming: Fidelity, feedback, and motivation. In Interactive Instruction and Feedback; Dempsey, J.V., Sales, G.C., Eds.; Educational Technology Publications: Englewood Hills, NJ, USA, 1993; pp. 197–228.

16. Pierfy, D.A. Comparative simulation game research: Stumbling blocks and stepping stones. Simul. Games 1977, 8, 255–268.

17. Ricci, K.E.; Salas, E.; Cannon-Bowers, J. Do computer-based games facilitate knowledge acquisition and retention? Mil. Psychol. 1996, 8, 295–307.

18. Seok, S.; DaCosta, B. Predicting video game behavior: An investigation of the relationship between personality and mobile game play. Games Cult. 2015, 10, 481–501.

19. Landers, R.N.; Sanchez, D.R. Game-based, gamified, and gamefully designed assessments for employee selection: Definitions, distinctions, design, and validation. Int. J. Sel. Assess. 2022, 11, 12376.

20. Kirschner, D.; Williams, J.P. Measuring video game engagement through gameplay reviews. Simul. Gaming 2014, 45, 593–610.

21. Blair, L. The Use of Video Game Achievements to Enhance Player Performance, Self-Efficacy, and Motivation. Ph.D. Thesis, University of Central Florida, Orlando, FL, USA, 2011.

22. Bell, B.S.; Kanar, A.M.; Kozlowski, S.W. Current issues and future directions in simulation-based training in North America. Int. J. Hum. Resour. Manag. 2008, 19, 1416–1434.

23. Girard, C.; Ecalle, J.; Magnan, A. Serious games as new educational tools: How effective are they? A meta-analysis of recent studies. J. Comput. Assist. Learn. 2013, 29, 207–219.

24. Fuchsberger, A. Improving decision making skills through business simulation gaming and expert systems. In Proceedings of the Hawaii International Conference on System Sciences, Koloa, HI, USA, 5–8 January 2016; pp. 827–836.

25. Landers, R.N.; Bauer, K.N.; Callan, R.C.; Armstrong, M.B. Psychological theory and the gamification of learning. In Gamification in Education and Business; Reiners, T., Wood, L., Eds.; Springer: New York, NY, USA, 2015; pp. 165–186.

26. Adcock, A. Making digital game-based learning working: An instructional designer's perspective. Libr. Media Connect. 2008, 26, 56–57.

27. Backlund, P.; Engström, H.; Johannesson, M.; Lebram, M.; Sjödén, B. Designing for self-efficacy in a game-based simulator: An experimental study and its implications for serious games design. In Proceedings of the Visualisation International Conference, London, UK, 9–11 July 2008; pp. 106–113.

28. Lepper, M.R.; Chabay, R.W. Intrinsic motivation and instruction: Conflicting views on the role of motivational processes in computer-based education. Educ. Psychol. 1985, 20, 217–230.

29. Parry, S.B. The name of the game is simulation. Train. Dev. J. 1971, 25, 28–32.

30. Bedwell, W.L.; Pavlas, D.; Heyne, K.; Lazzara, E.H.; Salas, E. Toward a taxonomy linking game attributes to learning an empirical study. Simul. Gaming 2012, 43, 729–760.

31. Erhel, S.; Jamet, E. Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. Comput. Educ. 2013, 67, 156–167.

32. Kampf, R. Are two better than one? Playing singly, playing in dyads in a computerized simulation of the Israeli–Palestinian conflict. Comput. Hum. Behav. 2014, 32, 9–14.

33. Cameron, B.; Dwyer, F. The effect of online gaming, cognition and feedback type in facilitating delayed achievement of different learning objectives. J. Interact. Learn. Res. 2005, 16, 243–258. Available online: https://www.learntechlib.org/primary/p/5896/ (accessed on 28 January 2022).

34. Moreno, R.; Mayer, R.E. Role of guidance, reflection, and interactivity in an agent-based multimedia game. J. Educ. Psychol. 2005, 97, 117–128.

35. Egenfeldt-Nielsen, S. Overview of research on the educational use of video games. Digit. Kompet. 2006, 1, 184–213.

36. Kickmeier-Rust, M.D.; Peirce, N.; Conlan, O.; Schwarz, D.; Verpoorten, D.; Albert, D. Immersive digital games: The interfaces for next-generation e-learning? In Universal Access in Human-Computer Interaction. Applications and Services; Stephanidis, C., Ed.; Springer: Berlin, Germany, 2007; pp. 647–656.

37. Kickmeier-Rust, M.D. Talking digital educational games. In Proceedings of the International Open Workshop on Intelligent Personalization and Adaptation in Digital Educational Games, Graz, Austria, 14 October 2009; Kickmeier-Rust, M.D., Ed.; pp. 55–66.

38. Kirriemuir, J.; McFarlane, A. Literature Review in Games and Learning; NESTA Futurelab Series: Report 8; NESTA Futurelab: Bristol, UK, 2004; pp. 1–35.

39. Michael, D.R.; Chen, S.L. Serious Games: Games That Educate, Train, and Inform; Thomson Course Technology, Muska & Lipman/Premier-Trade: Boston, MA, USA, 2005.

40. Riedel, J.C.K.H.; Hauge, J.B. State of the art of serious games for business and industry. In Proceedings of the Concurrent Enterprising, Aachen, Germany, 20–22 June 2011; pp. 1–8.

41. Sawyer, B.; Smith, P. Serious games taxonomy. In Proceedings of the Game Developers Conference, San Francisco, CA, USA, 18–22 February 2008.

42. Zyda, M. From visual simulation to virtual reality to games. Computer 2005, 38, 25–32.

43. Lamb, R.L.; Annetta, L.; Vallett, D.B.; Sadler, T.D. Cognitive diagnostic like approaches using neural-network analysis of serious educational videogames. Comput. Educ. 2014, 70, 92–104.

44. Landers, R.N.; Landers, A.K. An empirical test of the theory of gamified learning: The effect of leaderboards on time-on-task and academic performance. Simul. Gaming 2015, 45, 769–785.

45. Oksanen, K. Subjective experience and sociability in a collaborative serious game. Simul. Gaming 2013, 44, 767–793.

46. Sedano, C.I.; Leendertz, V.; Vinni, M.; Sutinen, E.; Ellis, S. Hypercontextualized learning games fantasy, motivation, and engagement in reality. Simul. Gaming 2013, 44, 821–845.

47. Blunt, R. Does game-based learning work? Results from three recent studies. In Proceedings of the Interservice/Industry Training, Simulation, & Education Conference, Orlando, FL, USA, 26–29 November 2007; pp. 945–955.

48. Garris, R.; Ahlers, R.; Driskell, J.E. Games, motivation, and learning: A research and practice model. Simul. Gaming 2002, 33, 441–467.

49. Locke, E.A.; Latham, G.P. A Theory of Goal Setting and Task Performance; Prentice Hall: Englewood Cliffs, NJ, USA, 1990.

50. Akilli, G.K. Games and simulations: A new approach in education? In Games and Simulations in Online Learning: Research and Development Frameworks; Gibson, D.G., Aldrich, C.A., Prensky, M., Eds.; Information Science Publishing: Hershey, PA, USA, 2007; pp. 1–20.

51. Alessi, S.M.; Trollip, S.R. Multimedia for Learning. Methods and Development, 3rd ed.; Allyn and Bacon: Needham Heights, MA, USA, 2001.

52. Bergeron, B. Developing Serious Games; Charles River Media: Hingham, MA, USA, 2006.

53. Hays, R.T. The Effectiveness of Instructional Games: A Literature Review and Discussion; Document No. NAWCTSD-TR-2005-004; Naval Air Warfare Center Training Systems Division: Orlando, FL, USA, 2005.

54. Prensky, M. Digital Game-Based Learning; McGraw-Hill: New York, NY, USA, 2001.

55. Vandercruysse, S.; Vandewaetere, M.; Clarebout, G. Game based learning: A review on the effectiveness of educational games. In Handbook of Research on Serious Games as Educational, Business, and Research Tools; Cruz-Cunha, M.M., Ed.; IGI Global: Hershey, PA, USA, 2012; pp. 628–647.

56. Carayon, P. Handbook of Human Factors and Ergonomics in Health Care and Patient Safety; CRC Press: Boca Raton, FL, USA, 2016.

57. Weaver, S.J.; Salas, E.; King, H.B. Twelve best practices for team training evaluation in health care. Jt. Comm. J. Qual. Patient Saf. 2011, 37, 341–349.

58. Liang, D.W.; Moreland, R.; Argote, L. Group versus individual training and group performance: The mediating role of transactive memory. Personal. Soc. Psychol. Bull. 1995, 21, 384–393.

59. Brodbeck, F.C.; Greitemeyer, T. Effects of individual versus mixed individual and group experience in rule induction on group member learning and group performance. J. Exp. Soc. Psychol. 2000, 36, 621–648.

60. Laughlin, P.R.; Zander, M.L.; Knievel, E.M.; Tan, T.K. Groups perform better than the best individuals on letters-to-numbers problems: Informative equations and effective strategies. J. Personal. Soc. Psychol. 2003, 85, 684–694.

61. Dennis, K.A.; Harris, D. Computer-based simulation as an adjunct to a flight training. Int. J. Aviat. Psychol. 1998, 8, 261–276.

62. Proctor, M.D.; Panko, M.; Donovan, S.J. Considerations for training team situation awareness and task performance through PC-gamer simulated multi-ship helicopter operations. Int. J. Aviat. Psychol. 2004, 14, 191–205.

63. Papargyris, A.; Poulymenakou, A. The constitution of collective memory in virtual game worlds. J. Virtual Worlds Res. 2009, 1, 3–23.

64. Baldwin, T.T.; Ford, J.K. Transfer of training: A review and directions for future research. Pers. Psychol. 1988, 41, 63–105.

65. Kraiger, K. (Ed.) Decision-based evaluation. In Creating, Implementing, and Maintaining Effective Training and Development: State-of-the-Art Lessons for Practice; Jossey-Bass: San Francisco, CA, USA, 2002; pp. 331–376.

66. van Knippenberg, D.; De Dreu, C.K.W.; Homan, A.C. Work group diversity and group performance: An integrative model and research agenda. J. Appl. Psychol. 2004, 89, 1008–1022.

67. Lewis, K. Measuring transactive memory systems in the field: Scale development and validation. J. Appl. Psychol. 2003, 88, 587–604.