Testing the effectiveness of digital game-based learning in a corporate context: comparison to a passive e-learning approach

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Abstract

The investment in human resources by means of training programs is a key factor in creating competitive advantage for a commercial enterprise. For cost-efficiency reasons, e-learning programs are increasingly being implemented. These programs, however, are not always being used by employees. The present study aims to test whether digital-games based learning can offer a solution for the non-engagement and drop-out of employees in e-learning programs. More specifically, the present study investigated whether the interactivity of a game results in higher motivation to learn using the method, higher levels of enjoyment and better learning outcomes compared to a passive, instructional video. For this purpose, an experimental study was conducted among 64 employees working at a large bank, testing an e-learning training program (game or instructional video) aimed at teaching the bank's basic client-oriented principles in order to improve their loyalty to the bank. No differences regarding motivation, enjoyment or learning outcomes were found between participants receiving the game training and the instructional video. This shows that it might not always be required to –in a corporate context- invest in interactive content, considering it was not able to overcome the motivational issues related to more traditional e-learning approaches.

Keywords: e-learning, interactivity, effectiveness, corporate training

1. Introduction

Human resources are a key factor in a corporation's performance. Consequently, the investment in these individuals by means of training programs contributes to the corporation's competitive advantage (Joo, Lim, & Park, 2011).Corporate managers are constantly looking for more effective and efficient ways to deliver trainings to their employees, which has led to an increasing interest in technology enhanced learning over the past decades (Short, 2014). Technology-delivered instruction does not require separate training facilities, travel costs for employees and employees/trainers being away from the job, resulting in a more cost-efficient training method for large companies (Joo, Lim, & Park, 2011). Moreover, technology-delivered instruction provides the advantage of convenience and self-paced learning. While benefits of technology delivered instruction have been widely recognized, enthusiasm among employees to use e-learning programs, however, is rather low (Pannese, Cassola, & Grassi, 2005). E-learning is often still related to the passive learning of facts and is not able to engage the learners, resulting in high drop-out (Joo et al., 2011; Pannese & Carlesi, 2007).Digital Game-Based Learning (DGBL), which refers to the usage of the entertaining power of games to serve an educational purpose could provide a solution to this motivation problem (Prensky, 2001). For this reason commercial enterprises are increasingly investing in the development of games to serve training purposes (Donovan & Lead, 2012; Michaud, Alvarez, Alvarez, & Djaouti, 2012).

While a large amount of studies can be found regarding the effectiveness of DGBL in a school and health context, literature regarding its effectiveness in a corporate context is scarce. These either focus on the usage of business games among student or survey research on perceived outcomes. Testing the effectiveness of DGBL in a corporate context is, however, important as it can stimulate adoption of DGBL in corporations (Azadegan et al., 2012). Another reason why

an indication on DGBL effectiveness in a corporate context is required, is that cost-efficiency is not a stand-alone desired outcome for implementing DGBL; it should still be related to a certain learning effect, preferably similar to more traditional methods of instruction (authors).

1.1.Interactivity, motivation and learning

DGBL can be motivating in two ways. Firstly, DGBL can be implemented to 'seduce' the learner by gameplay to allocate his/her attention to the learning content (Ritterfeld, Weber, Fernandes, & Vorderer, 2004). Interactivity is one of the main characteristics of game-based learning resulting in higher attention during the activity and consequently, deeper processing of the content (Ritterfeld, Weber, Fernandes, & Vorderer, 2004). Secondly, DGBL can stimulate intrinsic motivation to engage in the training due to the enjoying experience it provides (Garris, Ahlers, & Driskell, 2002). This means, for instan ce, that learners wish to finish the game training because it is fun or because they wish to achieve in-game goals rather than because they are obliged to finish the training. Intrinsic motivation is, in turn, related to higher levels of engagement, performance, higher quality of learning and lower levels of dropout (Ryan & Deci, 2000). Interactivity is, again an important feature of digital games that can stimulate intrinsic motivation (Hwa Hsu, Lee, & Wu, 2005)

While indeed these motivational aspects can be very promising and have been widely recognized in the DGBL field, these all imply that everyone wants to play games and that by the simple act of introducing them, success is automatically achieved. However, DGBL participation can be a result of external coercion, influencing enjoyment of the activity and consequently, learning outcomes (Boyle, Connolly, & Hainey, 2011; Mayer et al., 2014). Hence, in this study we assess whether the motivational mechanisms that underlie DGBL hold true in a corporate context where DGBL is part of a compulsory program. Based on the literature we propose the following hypothesis:

H1: Employees will find DGBL more motivating and enjoyable compared to a more passive form of technology-enhanced learning.

The added value of DGBL is, however, not only related to its motivational power, but its learning mechanisms also fit well within modern theories of effective learning proposed by educationalists and psychologists (Boyle et al., 2011). Digital games allow for the implementation of constructivist theories of learning (Boyle et al., 2011; Rooney, 2012). Constructivism relies on the assumption that learning is a process in which learners' knowledge and skills are constructed by making sense of their experiences. In constructivist learning theory, the learner is an active learner as opposed to a passive one receiving and processing information provided by an instructor (Hein, 1991). Main constructivist learning mechanisms that underpin the instructional potential of digital game-based learning are situated learning, experiential learning and problem-based learning (Boyle et al., 2011; Rooney, 2012). Games can enable situated learning, according to which learning is context-dependent and needs to occur in the context of the authentic learning environment to which the learning applies (environment, actions, situations and actors) (Ladley, 2010). An authentic learning environment is one that replicates what the learner would experience in a real-world situation. Learning is thus a result of the interaction of mental processes with the physical and social environment (Clancey, 1991). In certain cases such as emergency situations, a simulation of that authentic environment is the best alternative solution for providing this situated learning experience (Ladley, 2010). Digital games have the ability to provide this authentic environment, both regarding the simulation of the actual physical environment, events and consequences of actions made in this simulated world.

Digital games also enable an experiential learning experience, according to which experiences are a source of learning and one learns by doing (Kolb, 1984). According to Kolb, an experiential learning experience is a cyclical process which consists of four phases. The first

phase is the concrete experience, followed by the second phase, reflective observations, where the learner observes and reflects on this experience. Based on these observations and reflections, the learner draws conclusions and makes hypotheses and generalizations on how this acquired knowledge can be used in other situations, which is called abstract conceptualization. The final phase in this cyclical process is active experimentation, where the learner tests these hypotheses by experimenting and applying the acquired knowledge. This process also occurs while playing video games, requiring "…a constant cycle of hypothesis formulation, testing, and revision. This process happens rapidly while the game is played, with immediate feedback" (Van Eck, 2006, p. 5).

Digital games also offer the potential to provide a problem-based learning experience (Van Eck, 2015), where a particular problem is presented to the learners and knowledge and skills are acquired during the process of solving this problem (Savery & Duffy, 1995). Problem solving is a mechanism that often occurs in digital games, by means of goals or missions a player has to accomplish (Kiili, 2005). Hence, we propose the following second hypothesis:

> *H2: Employees instructed by DGBL will score better on a knowledge test compared to employees instructed by a more passive form of technology-enhanced learning.*

1.2. Emperical evidence on DGBL

Although single case studies and meta-analyses have proven the effectiveness of DGBL (Backlund & Hendrix, 2013; 2015; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012), results are still mixed and the current state of the art does not allow us to conclude that educational games and simulations have a positive effect on learning and motivation (Erhel & Jamet, 2013; Giessen, 2015). Certain authors have pointed out elements that jeopardize reliability and validity of some findings (Clark, 2007; Clark, Tanner-Smith, & Killingsworth, 2015). This includes comparisons with control groups that did not receive an educational

intervention (Hays, 2005), time-on-task differences between experimental and control groups, and validity of research instruments (Randel, Morris, Wetzel, & Whitehill, 1992). Moreover, some studies do not provide enough information about the implementation of the intervention (Clark et al., 2015; Sitzmann, 2011). This makes it hard for readers to know if the reported results are a consequence of the different methods, and not a cause of circumstantial factors that differed between conditions (Randel et al., 1992). Rigorous assessment is required to improve the quality of DGBL, to support resource allocation, and to gain insight in the most effective way to use games to support learning (De Freitas, 2006; Kirriemuir & McFarlane, 2004).

Moreover, there is a large heterogeneity in study designs used to assess the effectiveness of DGBL. For example, different research designs are applied, different measures are used for assessing effectiveness and different statistical techniques are used to quantify learning outcomes (Kharrazi, Lu, Gharghabi, & Coleman, 2012). An underlying reason for this is that DGBL is an emerging field, which combines different disciplines with specific research traditions (Kirriemuir & McFarlane, 2004; Van Eck, 2015). Hence, there is a need for an overarching methodology to research and evaluate DGBL, which should provide procedures, frameworks, and methods that can be validated (Mayer et al., 2014). While several suggestions have been made to improve the design of DGBL effectiveness studies (Brom et al., 2012; Serrano-Laguna et al., 2013), these do not cover all aspects of the experimental research design (e.g., aspects for which similarity between subjects should be attained, instructor role).

The authors of this paper have been involved in a project which aims to develop a procedure for assessing the effectiveness of DGBL. In a first phase, study design characteristics of published DGBL effectiveness studies aimed towards cognitive learning outcomes were mapped by means of a systematic literature review. Secondly, DGB effectiveness was

conceptualized and operationalized by means of a user requirements analysis among relevant stakeholder groups. Thirdly, we defined best practices for assessing the effectiveness of DGBL by means of expert interviews in order to finalize the first version of the procedure. In a second phase, we tested the feasibility of the procedure by means of experimental studies using this procedure as a guideline in order to further optimize it. The checklist of the first version of the procedure can be found in Appendix A. The authors can be contacted for the full procedure.

A second aim of this paper is thus to test the feasibility of the procedure that has been developed for assessing the effectiveness of DGBL (authors) as this procedure pursues to be applied flexibly across contexts. The procedure has already been tested in a school context (authors) and a health context (authors). The present paper represents the feasibility test of the procedure in a corporate context. Based on this validation study, a final version of the procedure will be developed.

2. Methodology

2.1.Stimulus materials

2.1.1. Game

The game that was tested has been developed for a large bank in order to teach new employees the bank's basic principles of customer-friendliness. The game was developed several years ago, because the bank's costumers' loyalty to the bank had decreased. Hence, they decided to develop some client-friendly principles to be applied at the office in order to improve this loyalty. They had chosen for a game-based format for cost-efficiency reasons. A cost-benefit analysis where the game was compared with hypothetical oral classes of 15 people, the game proved to be more cost-effeciënt after 50 sessions.

The game consists of 5 minigames. Considering the bank would like to remain anonymous, screenshots of the game cannot be provided. Table 1, however, gives a description of the

minigames. At the end of every minigame the player also gets an a) an overview of his score and b) an overview of lessons learned, referring to the client-oriented principles that where applicable to the minigame just played. The game is available to all employees via the online learning platform of the bank, accessible only via the intranet of the bank. The minigames can therefore only be played in the workplace. It takes between 40 and 55 minutes to complete all minigames, depending on the game skills of the player.

Table 1: Overview of minigiames

Mini-game	Goal	Playtime	Gameplay
1	Client-oriented principles to be applied before clients are received (e.g., clean office, briefing)	+/- 5 min	The player gets 5 minutes to get everything that needs to be done before opening the office in order. At the end of the simulation he gets an overview of what he has done and what he has forgotten, linked to a score.
2	Client-oriented principles that should be applied at the reception (e.g., make eye contact with entering customers)	+/- 10-15 min	Minigame with 9 levels where one has to drag and drop images in the right order in a grid below (e.g., picture of a broken ATM should come before a picture of an entering costumer). Some activities also need to occur within a certain time (e.g., 3 seconds to make eye contact with an entering costumer). Every level contains more images to be sorted.
3	Client-oriented principles to be applied when dealing with a client (e.g., empathize with the environment of the customer)	+/- 10-15 min	Minigame based on the format of the TV show *Who wants to be a millionaire?*, which is a quiz where the player can choose from 4 answers to a question and can get several helpline options.
4	Client-oriented goodbye (e.g., accompany the client to the exit)	+/- 5 min	A graphic novel which the player has to complete by choosing from several options to fill in the blanks in the story.
5	Client-oriented organization during a day at the office; This final game consists of all client-oriented principles learned in the previous minigames.	+/- 10-15 min	This minigame consists of a certain dashboard consisting of all activities that occur at a day at the office. At the top of the dashboard there is a customer satisfaction meter that can turn red. To know what to do to when the customer satisfaction meter reaches the red zone, the player can look at several meters that correspond to tasks that need to happen during the day. These can also turn red, so the player needs to know where actions should be taken. The player can also assign tasks to two (fictional) colleagues during this game.

2.1.2. Instructional video

For the purpose of this study, an instructional video was developed, using the game and game play as a basis. For this purpose, the screen of the game was captured while being played by the researcher. To make it look more like an instructional video and less like a game, in game-actions were accompanied by texts boxes, explaining why a certain decision is taken or why a certain action is being carried out. For instance, in minigame 2, one has to attribute priorities to certain in game events; if a person walks in and at the same time the phone is ringing, one should answer the phone before the third ringtone, one should make eye contact with the customer coming in. When the phone call is finished, the employee should ask the customer how he/she could be of service. When playing the game, one has to drag and drop events based on their priority within a certain timespan. In the instructional video, one sees the events being dragged and dropped based on priority, but a small text box is added next to every event that is being dropped: 'when the phone rings, one should answer within the time of three ringtones', 'While answering the phone, make eye contact with the customer' and 'one you have finished your call, ask the customer how you could help him/her'. Hence, the content treated in the game and the instruction video is exactly the same. The only difference between the two instructional materials is interactivity.

The instructional video training was also subdivided into 5 separate video's corresponding the 5 topics in the minigames. This way, the same training format could be applied: the employees could spread the training over several days, to their own time convenience. Table 2 gives on overview of the timings of the instructional videos. It takes 35 minutes and 15 seconds to view all instructional videos. The time difference between the separate minigames and instructional videos is related to the elimination of information regarding gameplay at the beginning of each minigame.

Table 2: Overview of instructional videos

Instructional video	Goal	Time
1	Client-oriented principles to be applied before clients are received (e.g., clean office, briefing)	4:16 min
2	Client-oriented principles that should be applied at the reception (e.g., make eye contact with entering customers)	6:29 min
3	Client-oriented principles to be applied when dealing with a client (e.g., empathize with the environment of the customer)	11:12 min
4	Client-oriented goodbye (e.g., accompany the client to the exit)	2:06 min
5	Client-oriented organization during a day at the office; This final game consists of all client-oriented principles learned in the previous minigames.	11:22 min

2.2.Design

A pre-test post-test control group experimental design was implemented whereby one group had to finish the game training and another group the instructional video training. Considering that the game was developed for cost-efficiency reasons, no 'business as usual' was available as the only training available was the game-based one. Hence, we could not compare the game-based group to a group that received a more 'traditional' intervention as suggested by the procedure. Instead, one group that did not receive an intervention served as a control group. Blocked random assignment (i.e., 'matching') was used to assign participants to conditions. Blocks were created based on age, number of months working at the bank and gender. As prescribed by the procedure (authors), the game was played in the context in which it is meant to be played: during working hours at the employee's convenience.

2.3.Measures

2.3.1. Cognitive learning outcomes

Two parallel versions (i.e., same types of questions and difficulty level) of a knowledge tests were developed based on the content treated in the games, in cooperation with the training manager of the bank. We choose for administrating parallel versions pre- and post-intervention, to reduce pre-test influences (Crawford, Stewart, & Moore, 1989; Randel, Morris, Wetzel, & Whitehill, 1992). Test development consisted of 3 iterations: a first version of the test was piloted among a convenience sample of 18 participants (9 received version A, 9 received version B) who have no prior experience with working in a bank and are not currently working at a bank to test whether or not the test was too easy (e.g., too obvious what the correct answer would be) and whether the parallel versions of the tests could be considered equal regarding difficulty level. Results showed that participants receiving version A scored significantly higher than participants receiving version B, $F(1,16) = 5,36$, $p = .03$. Consequently, the tests could not be considered as parallel versions. Based on the average correct answers per question, a new version of the test was created. This new version was piloted among 14 employees at the bank who have been working there for several years, of which 6 received version A and 8 version B. Results showed no significant difference on the total score between the versions, $F(1,12) = .31$, $p = .59$. Results of the final pilot (N = 14) showed no significant differences between scores on both versions, $F(1,12) = .31$, $p = .59$. The final tests used for the study consisted of 15 questions: 3 ranking questions where different events at work need to be ranked according priority; 4 open ended questions and 9 multiple choice questions. The scoring occurred accordingly: correct ranking yields 3 points and a correct answer on the multiple choice yields one point. The open questions are good for 12 points. The maximum score possible on the test is 30.

2.3.2. Motivational outcomes

The IMMS -Instructional Materials Motivation Survey- (Keller, 1987) was used to assess motivation towards the instructional method. We based ourselves on Huang, Huang & Tschopp (2010) for the game version of the IMMS. The IMMS consists of 36 items, divided in 4 subscales: attention (i.e., gaining and keeping the learner's attention, $\alpha = .82$), relevance (i.e., activities must relate to current situation or to them personally, $\alpha = .76$), confidence/challenge (i.e., activities cannot be perceived as too hard or too easy, $\alpha = .78$) and satisfaction/success (i.e., learners must attain some type of satisfaction or reward from the learning experience, $\alpha = .81$. The interest/enjoyment scale developed by Ryan (1982) was also used in the post-test. The scale consists of 7 items that are rated on a 7 point Likert scale ($\alpha = .94$).

2.4.Participants and procedure

An e-mail was sent by the training manager with a link to the online pre-test on to all people who had started working at the bank between 1 and 12 months before the start of the study (n = 89). After filling out the pre-test, participants received 6 weeks to complete the training (game or instructional video) on the electronic learning platform. It was not necessary to play/watch all five games/video's consecutively, but they could choose to spread them over several days/weeks. The training manager could retrieve weekly reports on who participated in each mini game/video and provided them to the researcher. One week before the six-week intervention period had passed, the researcher sent a reminder to those who did not finish the game yet, asking them to complete the training considering they would receive a post-test a week later. If they still not had finished the training 6 weeks after the pre-test, the researcher contacted the employees by phone. Once the employees had finished the training, the researcher sent them an e-mail with the link to the post-test.

3. Results

In total, 64 employees participated in the study, of which 20 employees trained themselves with the game, 21 with the instructional video and 23 served as a control group. Table 1 shows that

no pre-existing differences exist between the groups regarding age, gender, previous work experience at a bank, game experience (games at least a couple of times a year) or scores on the pre-test, showing successful randomization. Moreover, no differences were found between the two versions of the knowledge test on the pre-test, showing that both tests can be considered equal, $F(1,62) = 1.59$, $p = .21$

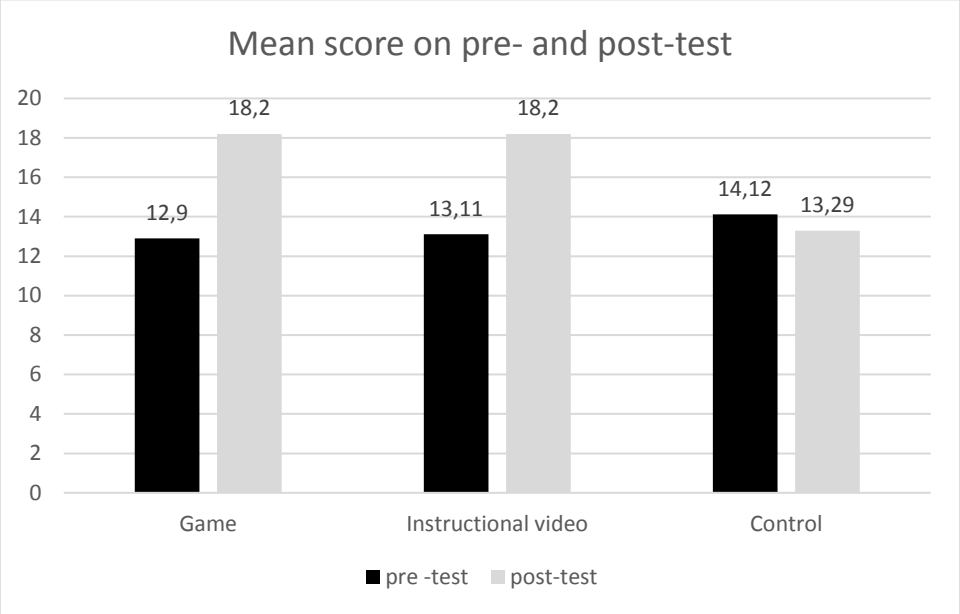
Table 3: Control for balanced groups as a result of randomization (N=64)

	Game (n = 20)	**Instructional video (n = 21)**	**Control (M/SD) (n = 23)**	**F/ Chi²**	**p**
Age (M/SD)	29.95/5.34	29.62/7.40	28.70/5.79	.24	.79
Female gender (n)	13	15	16	.21	.90
Previous professional bank experience (n)	2	4	5	1.11	.57
Gamer (n)	15	13	14	1.85	.40
Pre-test (M)	13.3	13.5	14.54	1.37	.26

Four participants from the instructional video group did not complete all four video's and three participants from the game group did not complete all mini games when filling out the post-test. Hence, we have conducted the analyses twice: once on the complete dataset (n = 64) and once only including the participants that have fully completed the training (n = 57) .

Results show a significant gain from pre- to post-test ($p < .01$) with a large effect size for both the game and instructional video group ($r = .57$ for the complete game group, $r = .51$ for the complete instructional video group, $r = .54$ for those who fully completed the game training and $r = 0.57$ for those who fully completed the instructional video training). The control group shows no significant difference between pre and post-test ($p = .14$). For the complete dataset, the biggest gain from pre- to post-test can be found in the game group ($M = 5.5$, $SD = 4.93$), followed by the instructional video group ($M = 4.86$, $SD = 4.84$). The control group slightly declined ($M = -.1.07$, $SD = 3.38$).

Figure 1: pre- and post-test scores for all groups



An ANOVA on the gain scores shows a main effect of treatment with a large effect size $F(2,61) = 14.90$, $p < .001$, $r = 0.57$. Post hoc Scheffé tests show that the gain of the game and video group is significantly larger than the control group ($p < .001$). No significant differences can be found regarding progress on the knowledge test between the game and instructional video group ($p = .90$).

For the participants that have fully completed the training, we consist of data on when they finished the training. Hence, for those participants, we can conduct an ANCOVA with the time between start and finish of the training and time between completion of the training and post-test as a covariate, allowing us to control for these potential confounding variables. As time between start and finish of the training violates the assumption of independence and the treatment effect, this was omitted from the ANCOVA analysis. More specifically, the instructional video group finished the training in less days ($M = 1.18$, $SD = 3.11$) compared to the game group ($M = 30.65$, $SD = 38.35$), $F(1,32) = 9.97$, $p = .003$. After controlling for time between completion of the training and the post-test, the game group shows an average gain of 5.40 ($SD = 1.19$) and the instructional video group of 5.56 ($SD = 1.19$). Still, no significant

differences can be found between the game and instructional video group, F(1,31) = .001, p = .97. Hence, we need to reject H2.

For the analysis of the IMMS (N = 64), one case was excluded due to non-response on all IMMS items. Here, also no significant differences can be found between the game and instructional video group on the total IMMS score, $F(1,38) = .27$, $p = .61$. When conducting a MANOVA on the subscales, also no differences can be found, F(4,35) = 1.45, p = .24. The scores on the IMMS and its subscales and can be found in table 2. While interpretation is rather difficult considering that the IMMS has not yet been implemented in a study in a corporate context and we have no scores to compare it to, we have found one study stating that instructional material can be considered successful if the average score on the IMMS and its subscales is 3.5 or more (Pittenger & Doering, 2010). If we apply this threshold, the game nor the instructional video can be considered successful. Also, the total score on the IMMS is below the midpoint of 108 for both groups.

Table 2: Mean and standard deviation on Instructional Materials Motivation Survey (N=34)

	Attention		**Relevance**		**Confidence**		**Satisfaction**		**Total score on IMMS**	
	M	SD	M	SD	M	SD	M	SD	M	SD
Game	3.15	0.40	3.27	0.35	3.58	0.53	2.93	0.51	117.05	9.99
Instructional video	3.16	0.52	3.49	0.43	3.69	0.43	3.04	0.51	120.73	13.72
p	0.98		0.08		0.42		0.46		0.32	

For the interest/enjoyment scale also one case was excluded due to non-response on all items. The game group scores on average 3.86 (SD = 1.24) on enjoyment and the video group scores on average 3.86 (SD = 1.13) on the 7-point scale. Again, no differences can be found between both instructional groups for enjoyment, F(1,38) = .34, p = .98. Hence, we have to reject H1.

4. Conclusion & discussion

Both the game and the instructional video proved to be effective in terms of learning outcomes, as they increased knowledge compared to only on-the job experience. The interactivity of the game, however, did not add value to learning or motivational outcomes. Thus, the idea that games are automatically a more motivational alternative for 'passive' technology delivered instruction, does not hold true in a corporate context -in this case. Consequently, the instructional video could in this case be considered as more effective, as the development of an instructional video is typically cheaper. Moreover, it takes less time to finish the instructional video training. This means that corporations need not always invest in DGBL as similar results can be achieved using (cheaper) more traditional ways of technology-delivered instruction. This is in line with a study comparing the effectiveness of several technology delivered instructions in a military context (Parchman, Ellis, Christinaz, & Vogel, 2000).

A second goal of this study was to test the feasibility of a standardized procedure to assess the effectiveness of DGBL in a corporate context. A main issue we encountered is the impossibility to compare the game with traditional instruction that is currently implemented, as there is none. Not adding a control group to where another educational activity is being implemented in a DGBL effectiveness study, has been criticized by several as non-rigorous research (Clark, 2007; Hays, 2005). While for the present study, we have developed the instructional video, to answer a research question relevant for the e-learning field, this was not at the request of the company. For the company, there is no added value in developing a 'control instruction condition' just for the sake of research. Hence, we would like to refute the necessity of a control group where another educational activity is implemented if there is no other current method to compare it to. We would however, suggest, to make meaningful comparisons. In the present study, the question the training manager had was simply 'does the game help new staff gain insight in client friendly principles?' In this case, comparing to a group that does not receive extra instruction is not meaningless, as it looks at the added value the game provides compared to on

the job experience. In this case, ‘business as usual’ could thus simply be no extra instruction. This shows that a distinction needs to be made between absolute effectiveness and relative effectiveness. What type of effectiveness will be required, will ultimately depend on the research question. Absolute effectiveness refers to the simple question: does DGBL succeed in achieving its predefined goals? This thus primarily refers to learning outcomes and refers to the investigation of progress regarding those learning outcomes as a result of the game. Hence, this requires an analysis from pre- to post-test. It is still recommended to also have a control group, to investigate whether differences between pre- and post are a result of the mere lapse of time (Campbell, Stanley, & Gage, 1963). Interpretation of motivational outcomes is more difficult as this is a post-intervention measure. Here, only descriptive analysis of the scores is possible. Relative effectiveness refers to the question: is DGBL similar or even better compared to the other instructional media? Here, preferably, the media that are currently implemented to teach a certain subject matter are used. With relative effectiveness, comparison of motivational, learning and efficiency outcomes are considered relevant (authors). Note that when using the relative effectiveness approach all parameters concern a judgment of relative worth, comparing the outcomes to the current instructional medium used for teaching a particular content matter, implying the need for a control group where another educational activity is implemented.

A second issue we have encountered with the procedure, is the suggestion to implement the game in a context for which it has been developed to improve external validity. This quasi-experimental design was, however, far from ideal. While almost everyone filled out the pre-test, a major issue in the present study was motivating the employees to start playing the game, even though it was compulsory. The researcher had to track activity of every individual participant, following up on whether or not they had already started playing the minigames/watching the instructional videos. Subsequent e-mailing and calling participants

several times to finish the training reduced external validity as this is not common practice in the corporation.

Related to this, if we would take the cost of *monitoring* whether or not the employees followed the training into account and following up on those who did not, we can put the efficiency rationale behind technology delivered instruction and game-based learning -in this case- in doubt. The lack of motivation to start the training is also detected on a broader scale within the company, as only 200 of 8000 employees have already played the game. This lack of motivation to start playing is unlikely to be related to individual underlying reasons such as technology skills, game skills or attitudes towards games considering it was as difficult to motivate the participants in the instructional video group, which did not require any of these skills. Hence, a more plausible explanation might be related to the format of the training. Making the training only accessible at the office and consequently, during working hours may have impeded employees to play the game. Time management has indeed previously proven to be an issue for employees to actually use e-learning programs (Joo et al., 2011). Other impeding factors are the lack of social interaction on the platform (Short, 2014), the lack of supervisory support and, related to this, lack of incentive to engage in e-learning programs (Joo et al., 2011). The non-engagement to start the training might thus be related to the lack of a meaningful learning context (De Freitas, 2006). While DGBL was not successful in solving engagement issues that are encountered in more passive e-learning approaches, it has the potential to tackle these issues in a way passive e-learning initiatives cannot, that is, by using game mechanics. For instance, a simple score board in the game, creating competition between colleagues could provide a solution for the lack of social interaction and incentive. Hence, the reason why the game did not add value to the instructional video, is that the motivational game features may not have been used to their full potential.

To conclude, the success of games as instructional medium in a distance self-paced learning context is not only related to the question 'If learners play it, does it improve motivation, learning outcomes and/or cost-efficiency?' but also 'does it succeed in getting learners to actually start playing?'. Further research should thus not only focus on whether DGBL is effective and which in-game elements make DGBL effective, but also on which implementation methods or context variables motivate employees to actually start the game-based training.

5. Limitations

Due to practical limitations –we could only include new employees that had started working at the bank- we had a small sample size. A second limitation is that intervention period possibly confounds our results, as it was significantly different between the instructional video and game group. Thirdly, we could not add instructional time as a measure in this study, as the online learning environment of the bank does not track time spent on the minigames. This would have provided us more insight in instructional time as a potential confound.

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Procedure for the assessment of digital game-based learning effectiveness: checklist

1. Operationalization of DGBL effectiveness

Learning outcomes	Motivational outcomes	Efficiency outcome
Level 1: Situational interest This level of learning outcomes effectiveness refers to stimulating interest in the content matter discussed in the game. Relevant in all sectors.	***Level 1: Enjoyment*** This level of motivational outcomes effectiveness is not related the game as an instructional tool, but as en entertainment medium and whether or not this creates an enjoying game experience. Relevant in all sectors.	***Cost-effectiveness*** Effectiveness with regard to efficiency outcomes refers to the cost of implementing a DGBL intervention with respect to a) the number of learners that can be reached and b) the time required to teach the target group certain content using the digital game-based method. This is a judgment of relative worth, compared to other instructional methods. Especially relevant in a corporate context.
Level 2: Performance This level of learning outcomes effectiveness refers to the attainment of learning goals as defined by the game developer or the client who ordered the development of the game. Relevant in all sectors.	***Level 2: Motivation towards DGBL*** This level of effectiveness refers to the motivation to learn through the digital game-based instructional method. This is a judgment of relative worth, compared to other instructional methods. Relevant in all sectors.	
Level 3: Transfer This level of learning outcomes effectiveness refers to the application of learned content matter in the game to real world situations. Especially relevant in a corporate and health context.		

2. Procedure for the assessment of DGBL effectiveness

The checklist is subdivided in two columns. The first column defines a design with minimal requirements for the assessment of the effectiveness of DGBL. The second column defines an optimal design. Note, however, that a elements from the optimal design can still be added to the minimal requirements design.

Procedure for the assessment of DGBL effectiveness	Minimal requirements design	Optimal design
A_ DESIGN		
1. Pre-test	X	X

(Only for learning outcomes level 1 and level 2[1] and control variables)		
2. Experimental group 1 (Pre-test is attributed)	X	X
3. Experimental group 2 (No-pretest is attributed, Solomon 4-group design)		X
4. Control group 1 (Pre-test is atributed)	X	X
5. Control group 2 (No-pretest is attributed, Solomon 4-group design)		X
6. Similarity of groups (experimental and control) is assured by one of the three following options: 6.1.Randomization of subjects 6.2.Randomization of clusters **6.3.**Blocked randomized design (i.e., 'matching')	X	X
7. Similarity between interventions is assured by the following aspects		
7.1.Time exposed	X	X
7.2.Content (including difficulty level and types of exercises)	X	X
7.3.Support received	X	X
7.4.Environment	X	X
7.5.Awareness of testing moment	X	X
7.6.Reward for participation	X	X
7.7.Day of the week		X
7.8.Interaction with other people		X
7.9.Instructor		X
8. Follow-up study		
8.1.Minimum: after 2 weeks	X	
8.2.Minimum: after 3 months		X
B_PARTICIPANTS		
9. Recruitment		
9.1.Minimum: Recruitment on voluntary basis under terms on p. 8-9	X	X
9.2.Minimum: Random selection of participants/clusters		
10. Sample size:		
10.1. Minimum 20 participants per condition	X	
10.2. Minimum 30 participants per condition		X
11. Incentives aloud	X	
C_INTERVENTION		
12. DGBL is implemented as stand-alone intervention (See p. 9 for an overview of what is not allowed during the intervention)	X	X

[1] Note that we do not give recommendations with regard to what level of effectiveness with regard to the different categories of outcomes one needs to assess, because this depends on the topic of the game and the interest of the institution requesting the study.

13. Instructor role reduced [2]		
13.1. Procedural help aloud (see p. 10-11 for description)	X	X
13.2. Role reduced to supervision (no procedural help aloud)		X
14. Instructor type		
14.1. Researcher	X	
14.2. Familiar person (i.e., the person who is normally in charge, such as a teacher)		X
15. Procedure provided for instructor in case the instructor is not a researcher	X	X
16. Observation by researcher in case the instructor is not a researcher		X
17. Context of play representative for real world context of play	X	X
18. Implementation period representative for implementation in real world	X	X
19. Reporting on playing time		
19.1. Frequency	X	X
19.2. Total number of sessions	X	X
19.3. Average time spent for session	X	X
19.4. Breaks	X	X
19.5. Total playtime	X	X
D_MEASURES		
20. Learning outcomes: Level 1: increased interest Level 2: Objective performance	At least one level of learning outcomes needs to be assessed	 X X
21. Learning outcomes: validated tests or test developed by researchers (Test developed by researchers under certain conditions, see 21)	X	X
22. Pilot study for test developed by researchers		
21.1. Cognition interviews	X	X
21.2. Experiment with min. 14 participants in order to	X	X
a) Check for normality of data	X	X
b) Similarity of tests in case of parallel tests	X	X
23. Assessment of transfer		X
24. Motivational outcomes: Level 1: enjoyment Level 2: Motivation towards instructional method	At least one level of motivational outcomes	 X X

[2] Note that an instructor is not always required. For instance, when the game is played at home. Although, in this case, intermediaries, such as parents are considered as instructors. Consequently, there role should also be reduced by providing them with a procedure to follow during the intervention.

	needs to be assessed	
25. Motivational outcomes: validated questionnaires	X	X
26. Efficiency outcome		X
27. Control variables		
27.1 Gaming frequency	X	X
27.2. Game skills (see appendix G)	X	X
27.3. Gender	X	X
E_DATA-ANALYSIS		
28. Report on psychometric properties of measures	X	X
29. Check and report on assumptions for conducting analysis of variance or regression 29.1. Normality of data 29.2. Equality of variances	X	X
30. Check and report on pre-existing differences	X	X
31. In case of pre-existing differences, add pre-test scores as covariate	X	X
32. Covariance adjustment		
32.1. Gender	X	X
32.2. Gaming skills	X	X
32.3. Gaming frequency	X	X
32.4. Ability (by subdividing subjects in low, medium and high achievers)		X
33. Adding any elements which are observed that can lead to extra variance on top of the experimental variance as random effects (e.g., classroom level, teacher influences, testing moment)	X	X
34. Effect size calculation	X	X