7 Serious gaming @ work

Learning job-related competencies using serious gaming

Hans Korteling, Anne Helsdingen and Nicolet C. M. Theunissen

In our rapidly changing society, formal training alone cannot meet the need for development of working individuals. For this reason, serious games increasingly are gaining interest as a potentially valuable, efficient, and effective alternative for conventional training at work. Serious gaming for application in labor organizations can capture many characteristics and processes of the job. It can be used to train many relevant competencies of workers in a realistic, attractive and challenging manner. Serious gaming fits with recent theories of learning and instruction that promote a form of learning through experience, by doing, such as discovery learning (i.e. Gerven, 2003), action learning (i.e. Smith & O'Neil, 2003), and experiential learning (i.e. Jiusto & DiBiasio, 2006). Such theories advocate an active, central role for the learner and use authentic (realistic, practical, job-related) learning environments that require educators to adopt more supportive rather than directive roles (Johnston & McCormick, 1996; Salter, 2003). Although game-based learning builds on the 'learning through experience' tradition, in itself it is a relatively new learning technology. In this chapter, our discussion on the value of serious games for the workplace will borrow from three intersecting knowledge domains: Learning, Modeling & Simulation (M&S), and Play. Figure 7.1 shows that serious gaming can be positioned at the heart of these domains. From each domain, we will present those issues that are most relevant for serious gaming. On the basis of this presentation, we will show the possibilities and limitations of serious gaming for professional learning and training objectives and how gaming can play a *serious* role in training and development at the workplace.

Learning

The potential of games for education and job-related training can be partly ascribed to the opportunities that games offer for providing different and, from a didactical perspective, better ways of learning, education, and training. Therefore this paragraph discusses the potential benefits and limitations of using serious games, from the perspective of learning and didactics. In addition, it will present the basic principles of a training approach that capitalizes on the didactic possibilities provided by games.

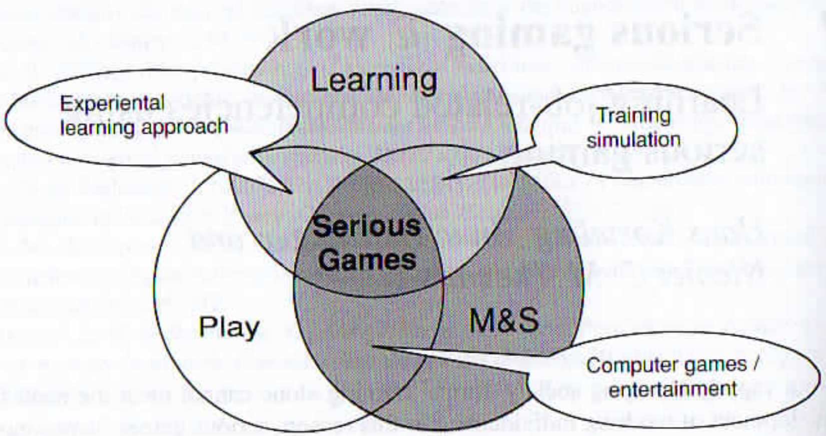

Figure 7.1 Three knowledge domains defining learning, modeling and simulation (M&S), and play

A flexible and innovative economy requires permanent adaptations of knowledge, skills and attitudes, also called 'competencies.' Competencies are indivisible clusters of skills, knowledge, conduct, attributes and notions (e.g. 'Able to cooperate with people from other organizations' or 'Uses ICT systems to collect information and knowledge quickly.')

They are context dependent, connected to activities and tasks, but also flexible in time (Van Merriënboer, Van der Klink & Hendriks, 2002). Another characteristic of competencies is that they can be acquired through training and experience. Competencies can be valuable to match individual performance and career planning with organizational job needs (Whan, Marko & Savickas, 1998).

Games may create dynamic, and interactive learning environments that offer the opportunity to practice job-related competencies, for instance, by introducing functionally relevant professional tasks. However, not all serious games that have been designed or used for educational purposes seem to live up to their potential. Hays (2005) has reviewed 48 empirical research articles on the effectiveness of 'instructional' games. Hayes' report also includes summaries of 26 other review articles and 31 theoretical articles on instructional gaming. For the present purposes, we will suffice ourselves with the major conclusions and recommendations of their report in Table 7.1.

These conclusions and recommendations of Hays (2005) especially emphasize the significance of a sound didactical plan for implementation of serious games. Sitzmann (2011) draws similar conclusions concerning the role of instructional support. She also deduces that trainees learn more, relative to comparison groups, when instructional games convey content actively, rather than passively and when trainees could access the game as many times as desired.

Table 7.1 Major conclusions and recommendations of Hays (2005)

Conclusions	
1	The empirical research on the instructional effectiveness of games is fragmented, filled with ill-defined terms, and plagued with methodological flaws.
2	Some games provide effective instruction for some tasks some of the time, but these results may not be generalizable to other games or instructional programs.
3	No evidence exists that games are the preferred instructional method in all situations
4	Instructional games are more effective if they are embedded in instructional programs that include debriefing and feedback.
5	Instructional support during play increases the effectiveness of instructional games.
Recommendations	
1	The decision to use a game for instruction should be based on a detailed analysis of learning requirements and tradeoffs among alternative instructional approaches.
2	Games should be used as adjuncts and aids, not as stand-alone instruction, therefore instructor-less approaches (e.g. web-based applications) must include all 'instructor functions.'

Serious gaming didactics

Games *par excellence* provide the opportunity to model realistic environments and tasks that reflect the relevant functional aspects of the to-be-performed job. This helps learners to practice job-related competencies; stimulates them to learn to coordinate constituent skills; and facilitates transfer of what is learned to new realistic problem situations (Korteling & Sluimer, 1999; Merrill, 2002; Van Merriënboer & Kirschner, 2007). Furthermore, the rich learning environments of many serious games represent those features that help to encode new information or serve as retrieval cues for subsequent remembering of this information (Smith & Vela, 2001).

A didactical approach that specifically capitalizes on gaming and *authentic learning* is the Job Oriented Training (JOT) approach (Stehouwer *et al.*, 2005, 2006; Van der Hulst *et al.*, 2008). Authentic learning tasks create a challenging and integrated task training that is motivating for learners, but sometimes real-life tasks are too difficult for learners. Ideally, the sequencing of learning tasks and feedback should create a level of 'desirable difficulty' for the learner (Bjork, 1994) or practice in the zone of 'proximal development' (Vygotsky, 1978) to enhance learning and transfer. Instead of part task training to practice all constituent skills separately, different modeling approaches can be used to adapt task difficulty to the competence level of the learner. This can, for instance, be done by using worked-out examples (Renkl, 1997; Renkl & Atkinson, 2007) or software models (artificial intelligence, virtual agents) to scaffold the whole learning tasks. In many games, the difficulty level is usually selected by the players themselves, and if the game does not allow for scripted sequencing of levels, learners should be instructed as to what constitutes the right level for them. In the

JOT-approach, the focus on teaching such self-regulating skills to learners makes learners active managers of their own learning process and progress. This also enables them to select an adequate difficulty level.

Apart from sequence of game levels, the sequencing of learning tasks can also greatly contribute to learning and transfer. First, practice variability – that is, practice involving many parameter variations of a task – is supposed to lead to better post-training performance and transfer, compared to practice following only one or a limited number of parameter variations. This counts even for performance on criterion tasks that only involve that one, or a limited set of parameters. The benefit of practice variability has been found in motor tasks (Donovan & Radosevich, 1999) and similar results have been found with cognitive tasks as well (Goode, Geraci & Roediger III, 2008; Taylor & Rohrer, 2010). Second, random sequencing of different task variations, as opposed to blocked presentations of one variation per block, leads to better transfer (Helsdingen, Van Gog & Van Merriënboer, 2011; Magill & Hall, 1990; Van Merriënboer, De Croock & Jelsma, 1997). Game-based JOT, with its authentic learning tasks offers such practice variability in random sequence and thus provides an adequate learning experience.

It is important that learners self-regulate their learning. In this context, the concept of self-directed learning is often mentioned and intensively discussed. Self-directed learning implicates that the learner has control over all educational decisions. In interaction with the environment, social and physical, the learner decides what he needs to learn and how he can achieve this (Percival, 1996). According to a review study of Stubbé and Theunissen (2008), a learning solution that supports self-directed learning needs to help the learner: (1) to get insight in his/her own development; (2) to manage and monitor his/her own learning process; (3) to collaborate in learning; (4) to relate the learning to 'real life' needs; and (5) to take control over educational decisions. This has profound implications for the way instructors interact with learners (Zimmerman, 1990). The JOT approach advocates this notion: rather than a very directive role, instructors have to act as expert coaches merely guiding the practice sessions, and stimulate reflection (Stehouwer *et al.*, 2005, 2006). This means that in the absence of a directive instructor providing feedback, JOT requires a *meaningful* learning environment that provides the learner with adequate feedback on the appropriateness of his/her actions. Games are very suitable to present such an environment. Paramount for learning and transfer, especially in such an unguided approach, is that learners are stimulated to reflect on their learning and self-explain their strategies afterwards (Aleven & Koedinger, 2002; Chi, 2000; Schworm & Renkl, 2007).

The JOT approach for game-based training has been implemented and evaluated in several military training courses. An example is the training of new platoon squad leaders of the Royal Netherlands Army: In this training program, the game Virtual Battle Space 1[1] is implemented and used according to JOT principles. Learners play several scenarios in multiple sessions over multiple days. Reactions of the learners and training staff were very positive and enthusiastic (Hulst *et al.*, 2008). Recently, a more quantitative validation study with positive results has been carried out in the training program of operators of submarine mine sweepers (Stubbé & Oprins, 2011). Students reported high scores for the quality of the courses and took more control over their own learning process during these courses. All students passed the courses with high scores on practical exam, initiative, pro-activity, independence, motivation, and working as a team.

The conception of the learner as an active agent managing his/her own learning process and progress, as described above, is also consistent with what we know about the basics of neuronal development and the functioning of the brain (e.g. Hebb, 1949; Korteling, 1994; McClelland, McNaughton & O'Reilly, 1995; Meltzoff, Kuhl, Movellan & Sejnowski, 2009). Contemporary cognitive neuroscience states that knowledge and skills are embodied in the way neurons in the brain are connected and interact with one another. Learning then, is the acquisition and development of memories, behavior and skills by the constant refinement and expansion of this neuronal (or cognitive) framework. These processes are similar to what Piaget (1950) called *assimilation* (fitting into cognitive framework) and *accommodation* (reframing). On micro-level, this existing neuronal (or cognitive) framework is very idiosyncratic and unique for each individual. Therefore, only when the learners are *actively* involved in the process of integrating new knowledge (Büchel, Coull & Fristel, 1999) they can adequately link new information to their own personal neuronal/cognitive framework, that is: build new or refined neuronal connections. This forms the neuroscientific basis for the constructivistic conception that individuals construct new knowledge from their experiences. Serious games provide those experiences from which new knowledge can be actively created.

Modeling and simulation

In the domain of Modeling and Simulation (M&S), an elaborate research agenda has been dominated by questions regarding those characteristics that determine the value of models and synthetic environments to be used for different purposes (Farmer *et al.*, 1999; Lathan *et al.*, 2002, Liu, Machiarella & Vicenzi, 2008). Therefore, in the current paragraph, we will focus on training value, or transfer of training, borrowing from the domain of M&S. We introduce the key concepts and present information about possibilities and limitations and potential advantages of game-like PC-based (or desktop) training simulations.

In the domain of M&S, the concepts of training effectiveness and efficiency are captured in the term transfer. Transfer denotes the ability to flexibly apply (parts of) what has been learned to new tasks and/or new situations, i.e. real world tasks (see e.g. Detterman & Sternberg, 1993; Mayer & Wittrock, 1996). In line with similar definitions provided by Baldwin and Ford (1988) and Gielen (1995) for Transfer of *Training*, we define Transfer of *Gaming* (ToG) to the workplace as:

> The degree to which knowledge, skills and attitudes that are acquired by playing a game can be used effectively in the real workplace.

Empirical transfer studies are complex and sometimes even impossible because it is often difficult to determine what exactly is learned with respect to the (real) task or job for which the training is intended. In addition, job situations do not always easily allow for the objective measurement of performance of former learners. And even when these real world measures can be collected, it remains questionable to what respect the (confounding) training has contributed to that performance level, and to what respect performance effects can be attributed to other factors. However, it is possible to get a reasonable insight in the ToG, or training value of games, by means of smart experimental studies. Numerous studies over the past years have already documented that PC-based or desktop simulation environments can offer effective training for certain types of tasks (e.g. Jentsch & Bowers, 1998, Fisher *et al.*, 2002). For example, in a study of cockpit crew training, an experimental group trained on a PC-based simulator was compared to a control group. Detailed crew resource management (CRM) proficiency data as well as self-reports showed that the experimental group performed better on many skills, such as task management, communication, and crew coordination (Nullmeyer *et al.*, 2006). The evidence in favor of games, however, is less strong although positive results have been reported for example in academic achievement (Blunt, 2007) in aviation training (Proctor, *et al.*, 2004), and education of small unit tactics (Proctor, *et al.*, 2002). Rosser *et al.* (2007) showed that completion time in laparoscopic surgery was faster for surgeons when they had game experience in a learning environment that was specifically designed for this kind of surgery, than for non-gaming surgeons. These gaming surgeons also made fewer errors. In the previously discussed literature review of Hays (2005) on instructional games, he concluded that empirical research thus far on the effectiveness of games is rather fragmented. Besides, in her meta-examination of the instructional effectiveness of computer-based games, Sitzmann (2011) provides evidence of publication bias in this research area. In this respect, it is interesting to focus on what constitutes a game's potential training value and what factors are involved in determining transfer to task performance in the real world.

Key concepts

It is generally conjectured that *similarity* between a simulated world used for training and the real world results in transfer; that is: higher degrees of similarity lead to more transfer (Korteling & Sluimer, 1999). The degree of *physical* similarity between a synthetic environment and reality is called *physical fidelity* (Baum *et al.*, 1982). Fidelity denotes to what extent a simulation mimics the real equipment and environment in terms of physical measurable characteristics i.e. does a game steering set mimic the real world vehicle in such a way that the forces experienced during game play are the same as in the real vehicle? For most simple PC-based simulations and games, the physical environment in which a person has to work does not match that of the real world. It is therefore said that the fidelity of games is relatively low compared to simulators on which, for instance, realistic mock-ups are used to mimic real world operator environments. However, it is not easily defined to what extent the fidelity of the elements of a simulation contribute to the experience of realism (Roza, 2005). The graphics and animations of a simulation, for example, may be very realistic; however, if the behavior of the entities is not realistic, the game may not 'convince' or attract the player. This points at two other major constructs determining transfer. First, *functional fidelity* defined as the degree to which the simulation acts like the operational equipment in reacting to the operations that are performed by the trainee (Allen *et al.*,1986). While expensive simulators can recreate visual cues and precise instrument operation (i.e. physical fidelity), comparatively inexpensive gaming technologies may be very effective in recreating interactivity (i.e. functional fidelity) across a range of applications (Lewis & Jacobson, 2002). Second, *psychological fidelity* is the degree to which the simulation replicates the relevant psychological phenomena, such as stress or mental load, which are also experienced in the real-world environment. This will affect and engage the trainee in the same manner as the actual job environment and tasks would in the real world (Kaiser & Schroeder, 2003). Taking into account all these aspects of fidelity, the issue of the relationship between realism, or similarity and transfer remains complicated. Ultimately, the issue concerns the degree to which a simulation or game fulfills its intended use, which is termed *validity*. Next to learning and training, this use may include a variety of purposes, such as entertainment, research and development, health care, providing information, etc. When placed in a training program the intended purpose of a simulation is the obtainment of specific training objectives. As long as those training objectives are obtained that are *intended* to be trained, a simulation is valid. Hence, in a training context, validity is always coupled to the training objectives to be acquired. These training objectives are usually described as knowledge, skills, or competencies. Validity, in a game-training context, can therefore be defined in terms of transfer, i.e. the degree to which competencies learned by gaming are similar to those needed for real-task performance. This 'transfer of gaming' can be objectively and quantitatively measured by various types of experimental studies (Roscoe & Williges, 1980; Korteling & Sluimer, 1999; Korteling *et al.*, 2011).

Transfer of gaming

As will be clear now, not all tasks, competencies or types of jobs, can be effectively or efficiently trained using simple desktop simulations or games. When designing simulation-based training, job and training analyses should identify the types of (sub)tasks and related competencies that have to be trained as well as instructional support. These analyses specify the necessary input, task-features (visual, auditory, procedural, cognitive, motor), and instructional support (instructions, performance monitoring, and feedback), that are critical for the training goals, i.e. the competencies that have to be learned. These critical features need to be present in the game scenarios to realize an adequate training environment. Whether or not a simulation or game may be adequate for a specific job training program thus depends on whether or not the critical task features *can be represented adequately* in a game environment. This can be decided on the basis of general knowledge on human performance (e.g. Fleishman, 1972; Proctor *et al.*, 2002, 2004) and learning processes (Van Merriënboer, 1997; Van Merriënboer, Jelsma & Paas, 1992). Based on this knowledge, it is possible to identify classes or types of tasks that are better suited to train using a typical desktop simulation or training game, and types of tasks that seem unfit for this kind of training. A typical game, in this respect, constitutes a PC game configuration with standard commercial software, a flat screen and simple manual controls. In collaboration with four training and simulation experts we have developed a *Competence Taxonomy* (see Table 7.2) for this purpose and estimated the degree of transfer for each type of skill, expressed in +++, ++, +, –, – –, – – – meaning excellent, good, reasonable, little, very little and no transfer, respectively). Estimated degrees of transfer thus are global and do not count for each specific game and/or for each skill to be trained. In addition, it should be noted that we considered as equal all other factors that may affect the effectiveness and efficiency of simulation and gaming, such as the instructional support, didactical approach, or factors that may influence the motivation of learners. In other words the Competence Taxonomy, represented below, shows potential transfer of training, assuming that the standard PC game has been well designed and developed to represent and practice the listed types of competences.

The estimated amount of transfer of training is then determined by the *physical*, *functional*, and *psychological fidelity* that may be obtained by typical PC gaming consoles. In combination, these three kinds of fidelity determine the degree to which activities, attitudes, emotions, knowledge, skills, and/or processing operations competences that are included in the game may call upon the same (type of) underlying competences that are required in the real world (validity).

On a physical, level (i.e. physical fidelity) the look and feel of the standard PC gaming environment may differ substantially from operational environments in which people process information and operate. However, for most kinds of tasks (except primarily for perceptual motor tasks) these differences do not necessarily affect or degrade realistic interactivity (functional fidelity), and/or the realism of social, emotional or cognitive behaviors to be trained (psychological fidelity). In other words: for the transfer of job-related competences, the degree of similarity between game and real task – such as exact forms, sounds, motion or colors – often is relatively less important (e.g. Woodman, 2006).

As can be seen above, we expect TOG to be generally limited with respect to *perceptual-motor* task components (Woodman, 2006). This is not the case when the game (and especially its user-interface) is specially developed to train a specific perceptual motor task (e.g. laparoscopic surgery games). The reason for this is that perceptual-motor training requires that the specific characteristics of the physical task environment (e.g. control devices, visual cues) are represented with high physical and functional fidelity. Since most games are typically played on a PC or game console with a small flat screen, a keyboard and/or simplified game controllers, such a high level of fidelity is usually lacking. The differences

Table 7.2 Competence taxonomy with potential transfer of training estimations for typical PC games (PC, standard commercial software, flat screen, simple manual controls)

	Transfer
Attitudes	
Initiative	+++
Motivation	++
Integrity	+
Honesty	+
Courage	–
Knowledge	
Rules (regulations, guiding principles)	+++
Procedures (if…, then…, fixed action sequences)	+++
Job-specific facts (background, context, goals, conditions)	++
Mental models, schemata (e.g. functionality of interfaces)	+/–
Social skills	
Communication (primarily verbal)	+++
Collaboration, cooperation	+++
Leadership	+++
Emotional skills	
Stress coping, resilience	+++
Self-efficacy	++
Empathy	++
Non-verbal communication	+/–
Cognitive skills	
(Contingency) planning	+++
Calculation, problem solving, (strategic) decision making	+++
Interpretation	++
Self reflection	++
Perceptual-motor and physical skills	
Physical fitness	++
Perception (different modalities)	+/–
Operation	+/–
Searching	–
Detection	–
Motor performance	– –

between typical game displays/controls and the real equipment have a large impact on sensory input and motor output and thus make perceptual-motor transfer impossible.

Although game- – or PC – based simulation training may not be as effective or efficient as training in real, on-the-job, training settings, this does not necessarily mean that this training has little or no added value for training, or that it is of little use. Gaming- – or low – cost training simulation can still be efficient or valuable for various other reasons:

- It may be *very cheap* relative to training with real equipment and/or under real training conditions.
- It may provide an alternative training solution when training with real equipment under real task conditions is *dangerous* or restricted due to regulations.
- It may be preferred because of *environmental and sustainability* issues.
- It offers the possibility of training under certain relevant conditions that *rarely occur* at the working place, such as emergency situations.
- It can be done in *leisure* time, which may make it very cost-effective.
- It still may *save on the cost* of instruction personnel.
- It may awake or encourage people for new initiatives or *stimulate interest* for new tasks or knowledge areas.

In conclusion, we argue that, despite large superficial or physical differences between playing games and real tasks, serious gaming may allow people to learn many kinds of relevant skills. This, however, does not generally count for the training of most perceptual-motor skills, generic, and academic skills or for experienced learners (Korteling *et al.*, 2011).

Play

In the previous sections on Learning and M&S, aspects of learning motivation, flow, and engagement, and their relation to serious gaming have not yet been discussed. In this section it will be the main focus. Only when these aspects of *play* are purposefully combined with learning and M&S, *serious gaming* emerges. In the present paragraph we discuss why play should be included when one intends to enrich a training simulation program, what function may be ascribed to it, and what factors should be taken into consideration.

There has been a longstanding debate on the function of play, and more specifically, the role of play in learning (see e.g. Christie, 2001; Eifermann, 1971; Ortlieb , 2010; Pepler & Rubin, 1982; Singer, Golinkoff & Hirsh-Pasek, 2006), and the current debate surrounding 'serious gaming' shows a similar complexity. Some authors seem to suggest that games will provide the solution for all learning problems (e.g. Prensky, 2001; Rieben, 1996; Stapleton and Taylor, 2003), whereas others argue that gaming can never provide real learning experiences (e.g. 'I would not like to be a passenger in an airplane with a pilot that learned flying in Microsoft Flight Simulator,' Cannon-Bowers, 2005). Therefore, in this paragraph, we will analyze the potential value of play in serious games in learning for the work place. For this purpose, we will first ask ourselves the question why we play in the first place. This question may have two answers (Chick, 1998). The first is that people play because there are certain endogenous or environmental stimuli that trigger playful behavior. Play is fun, engaging, triggers 'flow' (Csikszentmihayli, 1999), and it can be competitive and inspiring, as will be argued in the next section. The second answer is related to development and evolution: play may exist because playful behavior has somehow evolutionary benefits to the species (e.g. Lewis, 1982; Poirier, 1982; Smith 1982).

The function of play

Play is often seen as an activity of minimally scripted, open-ended exploration in which the participant is absorbed in the spontaneity of the experience (Ortlieb, 2010). Evolutionary biologists have attributed numerous functions to play (Bekoff, 1997; Bekoff & Beyers, 1981; Fagen, 1981; Smith, 1982, 1995) and numerous studies indicate that these various forms of guided and unguided play give children the opportunity to practice motor skill (Pellegrini, 1987; Pellegrini & Smith, 1998), important social behaviors (e.g. Connolly & Doyle, 1984; Howes & Matheson, 1992), acquire academic (e.g. Kagan and Lowenstein, 2004; Ramani & Sigler, 2008) and cognitive skills (e.g. Elias & Berk, 2002; Lloyd & Howe, 2003). Play thus seems to aid educational, developmental and evolutionary goals. The evolutionary explanation for the function of play also offers an explanation for the *non-goal directed* behavior in play: i.e. a key process generating random variation in behavior (Gregory, 1987, p. 239). The non-goal directed aspects of play may be useful to explore and possibly extend the behavioral envelope (e.g. a monkey may not be able to think through the cracking effect of a stone thrown on a nut, but may stumble upon this effect when 'just playing around' with some stones). This newly discovered strategy may be refined and/or generalized by 'useless' repetitions. So, playing may be considered as an important aspect in the development of higher organisms. This is supported by the finding that play behavior peaks during periods of maximal cortical development (Chick, 1998; van Lawick-Goodall, 1968).

Nevertheless, there are also researchers who advocate a more prudent attitude towards the value of play for learning, especially when it concerns academic or cognitive skill. As Christie and Johnson (1983) state: 'why use play as a training medium for producing outcomes that are not playful?' They conclude that for some of the desired learning goals, other means may be more efficient. Also, Piaget (1951) questioned the developmental function of play after reaching a more advanced cognitive state, and although his views with respect to the function of play have been questioned since then (e.g. Meyers, 1999; Sutton-Smith, 1998), studies by Pellegrini and Galda (1982) as well as by Udwin (1983) have found that the effectiveness of guided play for developing academic skills may be lower for older participants than for younger participants. Careful consideration of such factors as age, or expertise that may decrease the effectiveness of play for learning is thus paramount when implementing playful activities to reach learning goals.

Motivation

Games and playful activities can be fun, engaging, satisfying, exciting or challenging and thus *motivate* the player to continue their playful activities without any external values or real-world goals. Such motivation, without any external demands is called *intrinsic* motivation (Deci & Ryan, 2002). Several studies have shown that the immersion in a fantasy game world where players can try out different roles contributes to this intrinsic motivational quality (Yee, 2006). Nevertheless, there are also games that do not immerse the player in a rich virtual world with many different opportunities: for example, the games Patience or Tetris, although very simple, are just as engaging as the more sophisticated PC games. Interesting in this respect are extensive survey studies by Yee (2006, 2007), that have shown that players are motivated to play multiplayer online games for achievement, immersion, and social reasons, with achievement as the strongest predictor of playing time. Yee describes achievement as the desire to become powerful in the context of the virtual environment through the achievement of goals and accumulation of items that confer power. It incorporates competition as well as advancement and development.

To continue activities without any external goals, just for the sake of the activity, means that the person is intrinsically motivated. Csikszentmihalyi (1999) calls this characteristic *flow*. Flow is described as a state of deep concentration and involvement in an activity. It is one of the most enjoyable experiences, and people report feeling active, alert, happy, strong, concentrated and creative during the experience (Seligman & Csikszentmihalyi, 2000). Flow is supposed to occur when challenge (or difficulty) of a task is in balance with an individual's capacities to cope. Because of the intense, alert and concentrated nature of flow, it may be expected that, when a subject is in a state of flow, his/her brain is actively showing a high degree of metabolism. Since environmental stimulation and the resulting brain activity lead to precise and selective changes in structural neuronal interaction patterns and connectivity (e.g. Abbott & Nelson, 2000; Blakemore & Cooper, 1970; Churchland & Sejnovski, 1992; Hebb, 1949; Hirsch & Spinelli, 1970), we may suppose that flow enhances learning. Flow can be experienced during many activities, such as work, play, car driving, or exercise. The experience of flow will be most likely when a person experiences an environment containing high enough opportunities for action (or challenges), that are in balance with the person's own capacities. That is: the person is capable of mastering the challenges, but not without too much effort.

Other theoretical approaches to intrinsic motivation such as the cognitive evaluation/self-determination theory (Deci and Ryan, 2002) or the eudemonistic theory (Waterman, 1990) also recognize the importance of balancing the (relatively high) challenge of an activity and the skill level of the individual (Schwarz & Waterman, 2006). These theories also posit self-determination (i.e. the fact that an individual perceives the activity as chosen) and self-realization (activity of people to strive to realize their best potential) as additionally important predictors of intrinsic motivation. Interpersonal events and structures (e.g. rewards, communication, feedback) that lead toward feelings of competence and autonomy will enhance motivation.

However, when considering the intrinsic motivation to play games for learning purposes, we also have to take into account that in several studies a negative correlation between achievement and enjoyment has been found. Apparently, students often like the instructional approaches from which they learn the least, i.e. that pose the lightest workload (Clark, 1982; Bjork & Bjork, 2010). Thus,

serious games that are really entertaining may not always be optimal for learning, i.e. they sometimes do not pose the 'desirable level of difficulty' as Bjork (1994) states, or the 'level of proximal development' (Vygotski, 1978). It seems that enjoyment and workload experiences have to be balanced to create an optimal learning result. This balancing may be done by placing *external* demands on the individual: e.g. define a goal that needs to be attained, prescribe a performance standard, set a difficulty level, or include a competitive element that challenges the learner to put more effort into their game.

Although intrinsic motivation is clearly important, demands, resources or rewards externally motivate most of the activities people do: i.e. activities done to attain some separable outcome. Similar to some of the effects of feedback, these external goals may have detrimental effects on peoples' intrinsic motivation for an activity. A meta-analysis confirms that virtually every type of expected tangible reward, but also threats, deadlines, directives and competition, undermine intrinsic motivation (Ryan, Koestner & Deci, 1999) because people experience them as controllers of their behavior. Rewards or directives are supposed to shift the locus of control from internal to external, which may have detrimental effects on self-determination and hence intrinsic motivation. Ryan and Deci (2000) view extrinsic motivation as a continuum ranging from *external regulation* to *integration*. Externally regulated behavior depends on the demand and control of other people, the environment and other extrinsic factors. The other side of the continuum is the most autonomous form of extrinsic motivation: integration. This occurs when identified regulations have been fully assimilated to the self through self-examination and bringing external regulations and demands into congruence with one's own values and needs. This type of behavior shares many of the qualities with intrinsic motivation, such that a person feels self-determined and engaged. The difference, however, is that the behavior is undertaken to reach an external goal.

Considering successful games we can thus reason why people feel motivated to play. These games pose a challenge for skilled gamers (achievement and flow), they let the gamer control the course of actions (self-direction) and also through Web-based fora it is possible for gamers to compete and compare with others and build a social network (self-realization, social reasons, achievement). However, when we choose to apply games for job-training purposes, we may place external goals and demands on the players, thereby diminishing their intrinsic motivation. It is then important to focus on minimizing the detrimental effects of external demands on the one hand, while still obtaining learning goals on the other. This can be accomplished by designing a game where the goals are similar to the learning objectives. In that case, the rules of the game reflect the learning content and the external demands on the player can be minimal. Furthermore, instructional strategies such as self-reflection may facilitate integration of the external demands, thus creating an environment where the individual feels self-determined despite the external demands placed upon him/her.

Conclusions and research questions

Games may provide meaningful and valuable learning environments if they are embedded in a training program that optimally exploits their opportunities and offers an educational approach that is congruent with the game features. This includes the focusing on integrated, authentic, self-initiated practice, and collaborative reflection. According to this approach, the control over instructions, interventions and performance assessment, shifts from instructional agents (e.g. coach, instructor, teacher, computer system) to the learner and his/her peers. Serious games may provide sufficiently realistic, meaningful, and adaptive learning environments, to facilitate this self-regulated or self-directed learning of job related competencies. However, games for educational purposes can only be successfully implemented if instructional personnel learn to become more of a non-directive *coach* than a *teacher* in the traditional sense of the word. Their main objective should be to guide the learner through their experiences and guard the quality of the learning experiences in the classroom (Hulst *et al.*, 2008). He/she should ask questions, prevent stagnations or mental overload, encourage an active and explorative disposition, challenge students, and instigate reflection and interaction. Still, some research may be required to develop an adequate theory of education for game-based learning. Other typical related research questions will be: how to enhance meta cognition, self-efficacy and self-regulation with serious games; what degree of (automated) instructional support is needed, how this support should be incorporated to foster the learning process, and how interaction and active participation, and peer-to-peer learning with serious games should be enhanced.

Next to adequate instruction and coaching, game-based training requires good curricula, carefully chosen training scenarios, relevant performance measures, and adequate feedback. In addition, the synthetic world of the game should resemble the real working environment on key physical and psychological aspects of the specific task and competencies to be trained. The task-taxonomy can be used to help game designers start the development of games for specific kinds of training objectives, or to analyze which kinds of tasks can be included in a specific serious game. Expert-scores on this taxonomy indicated that except for many perceptual-motor skills, most other types of competences may be effectively acquired on a typical PC game configuration with standard commercial displays and controls. We suppose that what gaming primarily contributes here is *interactivity*, *meaning*, and *context* instead of 'look and feel' and physics. From an M&S point of view, an interactive and meaningful job-context is provided by a synthetic task environment that includes a high amount of ambient information and feedback to actively practice and learn. Interactivity, meaning and context are embedded in a mission or story-line with goals, (other) actors, obstacles, and events that are relevant for the job. It should be noted, however, that serious gaming will only be an efficient training aid when the trainee *needs* to have this explicit presentation of rich contextual and ambient information and meaning in order to learn. This is for example the case with novices lacking contextual knowledge and experience. In contrast, when experienced professionals are confronted with serious gaming, we may hear statements like: 'this seems a waste of time, just give me a textbook and . . . '. This also means that gaming will not be very effective for further development of academic knowledge or higher-order generic skills (such as academic writing or people management), as far as these are relatively, generic, abstract, and independent of job context. This may also be part of the explanation why gaming especially seems to attract young people, who are (often) less experienced and lack generic competencies. Future research will have to establish for which kinds of tasks and target groups gaming is most beneficial, and how a game should be optimally designed to obtain its training goals. Typical research questions will then be: what the relative contribution to transfer of gaming of physical, functional, and psychological fidelity should be. More specifically, this involves questions regarding the amount of required interactivity, meaning, context, immersion, and authenticity and how to obtain these. Finally, how can this be embedded in a plausible, relevant and attractive storyline including job-relevant scenarios offering the required learning experiences?

This latter question relates already to our final main issue, i.e. play and its effects on motivation. In general, the elements of play in serious gaming make this technology most preferable in situations where motivation is a crucial factor determining behavior of learners. Based on its possible evolutionary utility, play is *internally* triggered and supported by rewarding experiences, like fun and flow. Competence, autonomy and self-realization are three major influences in the internal motivation of people to undertake or like activities that are enjoyable or entice flow. If the play or game environment elicits behaviors that are relevant or needed for the development of the individual's job-related competencies, gaming may thus motivate and encourage learning. This is especially relevant when the learning process itself requires extra effort that may not always be perceived as enjoyable. Therefore, enjoyment and workload experiences have to be balanced to create an optimal learning result. Learning effort may also be stimulated by placing *external* demands, resources or rewards that may motivate the individual. However, external motivators may negatively affect a person's feeling of autonomy and competence, and thereby *internal* motivation; it is then important to strive at minimizing the detrimental effects of external demands on the one hand, while still obtaining learning goals on the other. One way this can be accomplished is by designing a game in which the goals of the game are similar to the learning objectives. In conclusion: when considering the application of gaming for educational and training purposes, it is important to address internal and external motivators in relation to workload and effort, taking into consideration the necessary didactical prescriptions that restrict the extent of playful behavior. Future research questions will then have to ask how games should be designed to maximize intrinsic motivation, when and how to use external rewards or competition to motivate learning, how to increase engagement, enjoyment and flow, how these emotional phenomena contribute to learning, and how to balance them with effort in a restricted and structured, didactic setting. Finally, future research questions may concern factors such as the individual's age, educational and professional level, and experience. These factors may substantially affect the added value of play and the possibilities and optimal design of a serious game.

In summary, in the design and application of serious gaming with maximal transfer of training to the workplace, one has to consider many factors such as: training program and instructional features, serious gaming didactics, fidelity, validity, types of tasks and competences, target groups, learning goals, and intrinsic and extrinsic aspects of motivation. We conclude that games and play can have a valuable role in schooling and job training; not to fully replace traditional training methods, but to substantially enrich existing training curricula, and to inspire and challenge learners.

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Note

1 Virtual Battle Space is published by Bohemia Interactive Studios.

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8 Technology-enhanced learning in the workplace

Marcel van der Klink, Hendrik Drachsler and Peter Sloep

In spite of its long history, workplace learning has gained only modest recognition as something valuable for human resource development in organizations. Lately, interest in workplace learning has grown. A number of developments contributed to this, including the emergence of various learning technologies. Through them, workplace learning has also acquired a more prominent position in today's human resource development policies.

This chapter first explores the concept of workplace learning, to be followed by a section that details how the field of workplace learning has evolved over the past few decades. Then, its fundamental features are discussed. What are they, and which factors predict opportunities for learning in the workplace? Subsequently, the focus shifts to how technology enhances workplace learning. Attention is paid to the evolution of technology from media-supported learning, via computer-based training and Web-based training to what now is called technology-enhanced learning. Interestingly, these learning technologies now are deemed prerequisites for creating and organizing learning in the workplace. Technology's power to expand the opportunities for and value of workplace learning is elaborated in a section that presents three examples of contemporary workplace learning. These examples show that modern workplace learning could not flourish or even exist without such technologies as learning networks, micro-blogging and personalized learning environments. The final section summarizes some main trends and discusses topics that deserve further research attention.

The evolving field of workplace learning

Table 8.1 details how perspectives on workplace learning have shifted over time; it also shows the role technology plays in each period.

Learning in the era of the human relations movement and beyond

From the Second World War onwards until the late 1960s, training sought to prepare employees for entry-level jobs. In many industries new employees received some firm-specific and job-specific training during their entrance period, partly off-the-job but partly also in the actual work setting itself. The latter