Games for Learning

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Abstract. This chapter discusses educational aspects and possibilities of serious games. For researchers as well as game designers we describe key learning theories to ground their work in theoretical framework. We draw on recent meta-reviews to offer an exhaustive inventory of known learning and affective outcomes in serious games, and to discuss assessment methods valuable not only for research but also for efficient serious game design. The implementation and design of serious games are outlined in separated sections. Different individual characteristics that seem to be strongly affecting process of learning with serious games (learning style, gender and age) are discussed with emphasis on game development.

Keywords: digital game-based learning; serious games; serious game design

1 Intro Overview of Subsections

To understand game as a specific and persuasive medium for learning is an approach with a rich history (See Chapter History of Serious Games). In recent years however, this approach has become increasingly sophisticated with the emergence of game-based learning as a research field, the development of digital technologies to support gaming, and the convergence of traditional theories of learning and games' design. In this chapter we will outline relevant aspects of serious games supporting a learning process. Under the term games for learning we refer to games specifically designed for learning as opposed to the use of games in learning - although many authors proved positive results within use of commercial games (e.g. Charsky & Mims, 2008; Chen & Yang, 2013).

This chapter discuss different theories of learning as a theoretical framework for researching and designing serious games (Section 2), describes the classification of learning outcomes (Section 3), proposes how to assess the serious games learning outcomes (Section 4), outlines recent research results in the wide area of affective dimension of learning with serious games (Section 5), discusses important individual characteristics of players' (Section 6), principles for designing serious games for learning (Section 7) and proposes how to successfully implement serious games in learning curricula (Section 8).

2 Theories of Learning

A recent study that explored the relationship between theories of learning and game-based learning designs neatly justifies the attention we are giving to theories of learning. Wu et al's (2012) meta-analysis discovered that the majority of games-based learning approaches do not explicitly align with the one of the four key learning theory paradigms (behaviourism, cognitivism, constructivism, and humanism). This of course has implications for the study of these games as there needs to be a clear conception of 'learning' as design and evaluation methods will be linked to this conception.

Surrounding each theory is an assumption about what we understand by 'learning'. For instance behaviouristic theories focus on a change of behaviours whereas cognitivist theories focus on structuring - and restructuring - of mental schemas. Therefore, it is necessary to understand the pre-eminent philosophical assumptions regarding the nature of knowledge (epistemology) that inform key learning theories.

It is worth acknowledging the anguish of all theories is that they show us only the part of reality that we question. Learning - regardless of your epistemological position - is a complex process with potentially many internal or external factors. There is therefore a difficulty in reconciling these theories as each theory assumes not only a different understanding of 'learning' but a different perception on surrounding processes such as design and evaluation.

This chapter will cover the pre-eminent paradigms - behaviourism, cognitivism, constructivism, and connectivism. As discussed above, the epistemology of paradigm will be identified before identifying key theories of learning. In addition examples will be used to connect these theories of learning with games-based learning design and evaluation processes.

2.1 Behaviorism

Philosopher John Locke's (1697) argued that children can be considered children *tabula rasa* - or blank slates. He argues that the mind is born perfect yet empty of knowledge and that knowledge comes through the senses. Therefore, pedagogy can be viewed as the practice of transferring knowledge from the teacher - or teaching material - to the student. Behaviourism builds upon this empirical notion of knowledge as a universal set of observable or measurable stimuli. However, it focuses on knowledge as learned behaviours and learning, therefore, as the development of behaviours.

Behaviourism first emerged through the work of John B. Watson (1913) , he argued that inner experiences are not observable and therefore not appropriate for laboratory experimentation. As a result Watson developed the *stimulus-response* model - a stimulus from the environment creates a response in an individual through formalising Ivan Pavlov's work looking at *classical-condition*. (Pavlov, 1927). This *stimulus-response* model was directly applied to learning through the work of Edward Thorndike (1898) in his concept of the *law of effect* - a behaviour that is followed by pleasant consequences is likely to be repeated (Thorndike, 1898). This notion was was further developed by perhaps the most well known behaviourist B.F. Skinner. In Skinner's theory of *operant conditioning* (Skinner, 1948).

The work of Skinner is perhaps the most evident in modern game-based learning approaches - and even general in entertainment games. In his discussion of *operant conditioning* he outlined *reinforcers, punishers,* and *reward-schedules. Reinforcers* refer to stimuli that encourage behaviour either by introducing *positive* stimulus or removing *negative* stimuli. *Punishers* are stimuli that are intended to weaken a behaviour. At this point it is worth considering the ease at which the idea of *reinforcers* and *punishers* can be applied to digital games. Games frequently reward behaviour in the form of in-game currency, power-ups, and points. Additionally, behaviour can consequently be punished through losing in-game currency, losing items, or player death.

Reward schedules refer to the time intervals of a given stimuli reward in relation to the intensity of the respondent behaviour, and the time taken for the behaviour to disappear after removal of the initial stimuli - referred to as the *response rate* and *extinction rate* respectively (Skinner, 2015). Skinner identified that a *continuous reinforcement* in which behaviour is reinforced after every occurrence. This is common in the development of games-for-learning as it involves a simple mechanism - for every right answer, the player receives a reward. However, this reward schedule is identified as producing a *weak response rate* and *fast extinction rate*. Skinner of course identified other reward schedules (Skinner, 2015) and for the purpose of games design we will focus on *variable ratio reinforcement* and *variable interval reinforcement.*

Variable ratio reinforcement refers to the reinforcement of a behaviour after a random number of occurrences. It has been identified that this creates a *strong response rate*, and *slow extinction rate*. This is supported by the problematic addictive nature of gambling. Furthermore, this approach of random reward intervals has been heavily adopted by video games to promote engagement (Hopson, 2001; Nagle, 2014, Sylvester, 2013). For example, the random dropping of loot after killing enemy. Implementing this in learning games has been shown to create additional motivation and engagement (Howard-Jones, 2011). In these instances players received a random reward for the correct behaviour - correctly answering a question - rather than

In the case of *variable interval reinforcement,* given the 'correct' behaviour, reinforcement is given at a random time interval. This is a popular approach in the development of games generally - the random dropping of items or resources that can be collected (Farmville, Plants vs Zombies). MeTycoon (PlayGen, 2013) is a game designed to teach players about different post-compulsory education pathways and employment options. Throughout the game rewards - in the form of items and new job opportunities - will float along the screen at random intervals. This is an example of the use of a *variable interval reinforcement* schedule to engage students in the learning game. It can be argued however, that this is not a behaviourist approach to learning, but rather a behaviourist approach to engage players in a learning game (Allsop, 2013).

This is often a key criticism of behaviouristic approaches to learning, it focuses primarily on the engaging with learning activities - through rewards - rather than learning itself. Additionally, it's use in games-based-learning relies predominantly on extrinsic motivational factors (Ang, et al. 2008). For these reasons, behaviouristic games designs are often well suited for the rote memorization of facts, or 'learning' that requires the repeated practice of mental processes.

2.2 Cognitivism

During the 1950s the startings of a revolution began as the behaviorist paradigm began to lose ground to the growing world-view of cognitivism. This shift captured by Noam Chomsky's work A Review of B.F. Skinner's *Verbal Behaviour* (1967). Chomsky argues that a limit had been reached for the behaviorist approach's ability to inform our understanding of linguistics. Along with other writing of the time (Miller, 1956; Newell, 1958; Neisser, 1967), Chomsky's review of B.F Skinner's work was a key catalyst for the retroactively called cognitive-revolution (Pinker, 2002).

Chomsky' began to frame the formation of language as an internal, functionalized mental process that follows a model of taking sensory input and providing an output (1972). Applied to learning, the cognitivist approach features a preeminence of this structural approach to knowledge combined with an information-processing model of learning. Preceding this cognitive revolution, Jean Piaget developed the notion of mental structures as *schema*, building blocks of intelligent behavior and a means of organising knowledge (Wadsworth, 2004). Learning, then refers to the increasing number and complexity of these *schemata.*

In this instance learning is viewed as the *assimilation* and *accommodation* of mental *schema. Assimilation* is the process by which new knowledge is acquired and captured in an existing *schema* - *accommodation* is the modification of an existing *schema* to account for new information. In addition to the demarcated structuring of knowledge, two other conceptualisations are apparent from this simple introduction to Piaget's work. Firstly, knowledge units are internally constructed and secondly, these structured units are constructed with connection to other units.

A key contributor to cognitivist learning and instructional design Robert Gagne, developed this notion further (Gagne, 1972) in the development of *situated learning*. Digital games are seen as an apt way to support situated learning as they are able simulate meaningful real-world contexts (Gee, 2007; Lowrie, 2015) and emphasize player agency and discovery (Gros, 2006). The development of computers in the 1950s or 1960s had a significant influence on our conceptualisation of mind. *Information processing theory* models the human mind as a computer. For instance, when remember information sensory information first enters *sensory register* - for very short term storage; before then entering *working memory*, and finally being stored in *long-term memory* (Shiffrin, 1970).

This cognitive understanding of memory follows the seminal work of George A. Miller. In his article The Magical Number Seven, Plus or Minus Two (1956) he postulates that our *working memory* has the capacity to store seven pieces of information (plus or minus 2). Along with theory of *cognitive load* - our brain's cognitive capacity is a function of the complexity of the process and the quantity of information (Sweller, 1998) - has had profound implications for instructional design (Mayer, 2001) and - of course - games based learning (Huang, 2009).

Cognitive theories emphasize knowledge acquisition, mental structure construction, and information processing of individuals and the factors that would promote their active involvement (Ertmer & Newby 1993). Therefore learning through serious games emphasizes the context-dependent nature of knowledge where learning is promoted through *scaffolding* - additive learning based on previous learning - for task completion. At this point it is important to acknowledge the considerable conceptual overlap between cognitivist, and constructivist approaches - Piaget himself is considered a key contributor in both paradigms. Although both focus on learning as an structured internal process that actively constructs knowledge, constructivism focuses on this active construction.

2.3 Constructivism

As mentioned the conceptual lines between constructivism and cognitivism are blurry. This confusion is further confounded by the different positions that can be adopted within constructivism itself. Building on the work of John Dewey, Piaget is largely responsible for the notion of *cognitive constructivism* - the internal construction of knowledge structures - whereas Vygotsky's notion of *social constructivism* refers to the social construction of knowledge. That is knowledge and learning is socio-culturally situated and has meaning in relation to specific socio-cultural contexts. Additionally, Seymour Papert's (one of Piaget's students) notion of *constructionism* - the construction of an artefact as a pedagogic approach - adds further complexity.

The work of Piaget, Papert, and Vygotsky can be categorised under the umbrella term of constructivism and they have direct implications for games-based learning. Therefore, for posterity we will revisit Piaget's cognitive constructivism, followed by briefly discussing Seymour Papert's constructionism, and then finally finishing with Vygotsky's social constructivism. Note that these areas are often conflated, and there is little agreement in the way of universal boundaries or definitions for these paradigms. The categorisation we have adopted is designed primarily for comprehension and readability. The reader may note that with further investigation into this area slightly different categorised are offered, occasionally directly misconstruing the three areas.

In the early 20th century John Dewey advocated for a learner-centric approach in pedagogic practice, and a move away from repetitive, rote learning (Dewey, 1938). This was the beginning of the constructivist approach in education - a position that priorities *active inquiry* and *reflection* in the learner. This approach has obvious overlap with *problem-based* and *experience-based (or experiential learning)* learning (Ultanir, 2012; Dewey,1998). *Problem-based learning* is a popular approach in games-based learning (Walker, 2008; Reng, 2011) due to opportunities for active inquiry, added meaning, and additional levels of engagement.. Similarly, *experiential learning* is frequently used in game-based learning as games can add contextual meaning to the learning content (Whitton, 2009; Li, 2010).

Although not directly concerned with systematic approaches to education like Dewey, his work did lay the foundation for Piaget's constructivist approach. For Piaget the need for *accommodation* when current experience cannot be *assimilated* in existing *schema* is a key catalyst in learning (Piaget, 1977; von

Glaserfeld, 1989). In addition he argued that learning is an active process informed by previous experience (Piaget, 1953).

A seminal figure in the use of educational technology and student of Piaget, Papert argued that the most effective learning takes place during the active *construction* of a real or digital artefact (Papert, 1991). He was one of the first to explore the role of software in education - inventing the now ubiquitous programming language logo (Papert, 1980). Currently, researchers are now exploring this approach through the production of digital learning games as a learning process in its own right (Kafai, 1995, 2006, 2009; Li, 2010).

Piaget reflects Dewey's prioritisation of inquiry through the theory of *discovery learning*. According to Piaget *"Understanding is the process of discovery or re-construction by re-discovery". (Piaget, 1973). Discovery learning* focuses on independent - but teacher facilitated - inquiry based learning, often using problem-based approach. The initial theory was developed by Jerome Bruner (1951) - a key proponent of *social constructivism* - and is applicable to games-based learning (Dong, 2012; Jong, 1998). Again, proponents of games-based learning argue that games intrinsically follow an approach akin to *discovery learning* (Gee, 2003; Prensky, 2005).

2.3.1 Social Constructivism

Discovery learning as developed by Bruner extends *constructivist* thinking into a *social constructivist* paradigm as it highlights the potential need for a facilitator. When applied to educational games this is illustrated through the use of *intelligent tutoring systems* (Virvou, 2002) and *personalised feedback* (Kickmeier-Rust, 2008). A key concept developed by Bruner is that of *scaffolding* (Wood, 1976) - it is the role of the educator to *scaffold* learning through providing guidance. In Bruner's words:

> *"[Scaffolding] refers to the steps taken to reduce the degrees of freedom in carrying out some task so that the child can concentrate on the difficult skill she is in the process of acquiring."* (Bruner, 1978)

When applied to digital learning games this concept of *scaffolding* is illustrated through the limiting of player choice, signposting goals, and using dynamic-difficulty (Melero, 2011). This notion of *scaffolding* has obvious parallels (and is frequently conflated with) with the work of key Lev Vygotsky. Vygotsky's *zone of proximal development* illustrates a learner's sphere of knowledge in relation to their potential knowledge should they be assisted by a *more knowledgeable other* (Vygotsky, 1978). Vygotsky differs from Bruner and Piaget however, as he prioritised the role of the socio-cultural context in learning. He argued that knowledge is culturally created and situated and - counter to Piaget - models of cognitive learning are not culturally universal (Vygotsky 1978). Therefore, when applied to games-based learning social constructivists will prioritise the socio-cultural context that the games will be played in, and the role of the players peers or teacher (Foko, 2008).

To summarise, social constructivism emphasizes the interactions between learning and social, cultural, historical, and institutional contexts (O'Loughlin, 1992). Constructivism in serious games research and design stresses the interaction among players, games, and this socially situated context (Wu et al., 2012; Barab et al., 2009).

2.4 Humanism

Reflecting the emergence of cognitivism, humanism emerged in the 1950s as a counter to the reductionist nature of behaviourism largely due to the work of Abraham Maslow (Hoffman, 1988) and Carl Rogers (1969). Both humanistic proponents - like their constructivist counterparts - postulated a learner centricity when understanding learning. However, they adopt a holistic perspective on learning generally and attempt to account for the cognitive, physical, emotional and social l needs of the learner (Johnson, 2014). To quote Rogers highlights the social constructivist-humanist similarities whilst illustrating this holistic approach:

"The facilitation of significant learning rests upon certain attitudinal qualities that exist in the personal relationship between facilitator and learner"(Rogers, 1990)

Maslow and Rogers argue that learning is a natural human desire for growth. Maslow refers to this as *self-actualizing* (1968), and Rogers described this as an instinct to move towards an individual's full-potential (Rogers, 1969). When adopting this paradigm, education - and by extention games-based learning - becomes the facilitation of a learning experience that aligns with an innate human desire. For instance, Maslow's (1943) seminal work A Theory of Human Motivation he stratifies what he sees as basic, unconscious, human motivations to satisfy certain needs. This *hierarchy of needs* has implications for games based learning as it captures the emotional, self-esteem, and motivational needs of the learner. Through the development of affective computing (See Chapter 'x'), it has now become possible for educational game developers to create emotionally sensitive, responsive games (Wilkinson, 2013).

Additionally, *rubber-banding* - the changing of difficulty - is frequently used as to not undermine a learner's confidence and manage levels of anxiety (Liu, 2009). Motivation is of course, a key area of research (Wouters, 2013) and a core justification (Gee, 2003; Prensky, 2005) in game-based learning. From a survey exploring the use of digital games in a classroom context there are reportedly two primary reasons for the use of game-based learning. First, a belief that learning by doing through contextually meaningful simulations is an effective pedagogic approach and second, a desire to harness the motivational capacity of games (Groff, 2010).

Relating this desire to create motivation, experience based learning opportunities back the humanistic paradigm of learning illustrates two key aspects - the assumption of intrinsic motivation in the learner, and the perceived supremacy of *experiential learning.* Maslow argues that effective learning takes place when learner is intrinsically motivated - after all of their baser needs are met - and the are no longer aware of the passing of time. This has considerable overlap with the notion of *flow* - the experience of 'effortless effort' - conceived by Csikszentmihalyi (1990).

Both Rogers and Maslow advocate for the importance of *experiential learning*. For instance, Rogers made a distinction between experiential, and cognitive learning referring to them as meaningful (real-world, applied knowledge) and meaningless (academic, abstracted knowledge) (Rogers, 1968). Additionally, many games-based learning proponents - or game as educational tools generally - argue that games intrinsically follow Kolb's *experiential learning cycle* theory of *concrete experience, reflection, conceptualisation,* and *experimentation* (Kolb, 2012; Gee, 2007; Prensky, 2005). Additionally there has been interest in the direct modelling of this experiential learning with game-based learning (Killi, 2005; Ruben, 2002).

Given the above information regarding different learning paradigms and subsequently theories of learning two things should be apparent. Firstly, there are multiple paradigms that are conceptually blurred, and that these paradigms may manifest themselves in different ways through game-based learning. As mentioned earlier, due to the lack of use of theories of learning in the design of games-based learning (Wu et al., 2012) it is perhaps worth considering games, not from the position of the theories that are informing their design, but their intended learning outcomes.

3 Learning outcomes classification

Learning with digital games and simulations needs to be viewed by special optic, they are dynamic systems of information representation that are in comparison to other media able to provide some additional representational aspects. In particular they can attribute sound and visual characteristics to specific details, portray inter-relations of its subsystems and simulate its behavior in various situations (Buchtová, 2014). Through appealing audiovisual design and narrativity the players often feel immersed and emotionally attached to the presented theme. For this reason games might facilitate not only a knowledge acquisition but understanding of complex systems and phenomenons.

Wouters et al. (2009) proposed a model of four kinds of learning outcomes that games might have; cognitive learning outcomes (divided into knowledge and cognitive skills), motor skills (its acquisition and compilation), affective learning outcomes (divided into attitude and motivation) and communicative learning outcomes (communication, collaboration, negotiation). To the evaluation of games for learning Connolly et al. (2012) apply as well other important variables that includes motivational outcomes, interest and effort, as well as learners' preferences, perceptions and attitudes to games. We partly focus on those in the Section 5.

3.1 Cognitive learning outcomes

Cognitive learning outcomes are mostly understood as knowledge and cognitive skills (e.g. problem solving, decision making) gained through game-play. Those has been analyzed by many studies and in their meta-analyses Vogel et al. (2006), Wouters et al. (2009, 2013) and Li (2009) proven that compared to traditional teaching practices (e.g. passive treatment and classic lecture) facilitate interactive games higher cognitive gains. Moreover such knowledge tend to persist over long time (Sitzmann, 2011).

The best results (and as well most studies) can be observed in science education as biology, physics and math. Huge amount of games and studies in this area corresponds with reality that the process of measuring learning outcomes in this area is well established and the outcomes can be well quantified and observed. Overall very positive outcomes were also measured within game-based language learning (Wouters et al., 2013). On the other hand only small number of studies comprehend as well social science games or simulations; they still show only mixed results in cognitive learning outcomes (Druckman & Ebner, 2008).

3.2 Motor skills

Recent reviews bear mixed but promising results in the area of motor skills development through serious games (Connolly et al., 2012; Wouters et al., 2009). Real-like simulators seem to help specialists in task performance, hand-eye coordination (Hogle et al., 2008; Stefanidis et al., 2008; Wouters et al., 2013), depth perception (Hogle et al., 2008) and visual search (Wouters et al., 2013). As well frequent video game players develop such skills faster but eventually do not perform better than non-video game players (Hogle et al., 2008).

3.3 Affective outcomes

Affective outcomes belong to those worst measurable. They can be influenced by individual, social, cultural characteristics or situational feelings, moreover generally they are changing through time. As affective outcomes of serious games we often understand personal attitudes toward specific theme, and motivation to some action or learning itself. A valuable approach to affective domain made Krathwohl with his taxonomy containing five stages of affective outcomes in learning (Krathwohl et al., 1964). Educational practices mostly endeavor to deepen affective states from something what Krathwohl described as receiving - awareness of or sensitivity to existence of certain ideas, material, or phenomena and willingness to tolerate them - to characterization by value or value set - or likely acting consistently in accordance with the values the individual has internalized; the active element. From Wouters' et al. (2009) meta-review emerges that serious games facilitate attitudinal change, but individual characteristics needs to be taken in account. In research studies within the game use attitudes and motivation toward learning are often analyzed; a meta-analysis of gaming conducted by Vogel et al. (2006), reported better attitudes toward learning compared with those using traditional teaching methods.

3.4 Social outcomes

While collaborative learning appears, social outcomes (e.g. communication, collaboration skills) often follow. As playing serious games is frequently individual activity, if the social learning is a desired outcome, training communication and collaboration should be an inherent part of instructional intervention (Wouters et al., 2009) (for more see Section 8). Other option is to implement Massive Multiplayer Online Games (MMOGs) or 3D graphical virtual reality games that reflect positive results in social interaction and communicational skills enhancements, tangibly science literacy (Steinkuehler & Duncan, 2009), reading comprehension (Steinkuehler et al., 2010), collective information literacy (Martin & Steinkuehler, 2010).

3.5 Complex learning

Different internal and external conditions are necessary for each type of learning but not all of them are well explored and not a good quality instructional design is always being proposed. The example of well described application area is cognitive learning, there we can find some clear proposition for user experience design and interaction design. Instead for example attitudinal learning is mostly unexplored area where learner must be exposed to a credible role model or persuasive arguments whereas many (individual, social, cultural etc.) influences upon the process appear.

In our everyday life we deal with complex problems and complex tasks that demand involvement of different types of knowledge and skills. In the complex world we need complex learning outcomes. Playing a serious game is surely a complex task involving all layers of human capacities; players have to visually attend different locations on the screen (spatial abilities), coordinate this with mouse or joystick movement (hand-eye coordination), interpret verbal cues (cognitive activity), and solve problems that occur during the game play (problem solving, dealing with complex problems). Ian Bogost (2007) proposes term “procedural rhetoric” to describe the specifics that medium of game incorporates in contrast to other mediums as book or movie. The theory argues that games can make strong claims about how complex systems or processes work, not simply through words or visuals but through the processes they embody and models they construct. Game rules, goals, feedback system, possible interactions etc. are all processes opening a new domain for persuasion. This kind of rhetoric can be highly efficient, maybe unconscious, thus Bogost explores its characteristics while used in politics, advertising and education. Learning within the environment of serious games might get different maybe more persuasive outlines than other learning possibilities.

Considering that still little is known about the cognitive processes that occur during serious gaming, Wouters et al. (2009) recommend more research in the area of effective and ineffective cognitive processes in learning with serious games.

4 Assessment of serious games

Although the up-to-date research responds with mixed results, while designing or using serious games, like with every other tool of education, we must be able to show that the necessary learning has occurred. As Plass et al. (2011) stated, when games are designed with the explicit goal of facilitating learning, game mechanics must go beyond making a game fun and engaging, they must engage players in meaningful learning activities. Therefore the very complex knowledge constructed by game-play is difficult to identify and measure by classic knowledge measurements used in schools and training classes (verbal or written knowledge tests and transfer tests). Promising outcomes brought some alternative measurements like ordered-tree techniques, hierarchical cluster analysis, relationship-judgment tests, concept maps, multidimensional scaling and network techniques for cognitive learning outcomes assessment (Wouters et al., 2011). For other than cognitive outcomes might be more appropriate the methods as essays, observation, psychometrics, physiological measurements etc.

One of the most appropriate approach is to make the most of the medium of game itself. Games can learn from the player's actions within the game and to customize its content or pace based on real time data as time required to complete the lesson; number of mistakes made; number of self-corrections made; and more (Chen & Michael, 2005). Such build-in game assessment features are called assessment mechanics. They create a new layer above game mechanics and Salen and Zimmerman (2003) defined them as patterns of behavior or building blocks of diagnostic interactivity, which may be *"a single action or a set of interrelated actions that form the essential diagnostic activity that is repeated throughout a game"*. Thus the game can adapt to the player's behavior and to give the player the appropriate feedback. Players come to understand the connection between their in-game actions and the outcomes. Meanwhile, the teacher receives detailed assessment results to properly gauge the student's progress. In addition, the assessment engine leads the student through a series of reasoning questions exploring real motivation of players' actions and/or choices. Therefore teacher can better judge the students' understanding of the material being taught (Chen & Michael, 2005).

5 Affective dimension of learning with serious games

In the affective dimension of learning we can find a wide variety of theoretical concepts describing combination of situational cognitive and emotional state determining involvement within topic. The mostly often used terms are motivation (e.g., Wouters et al., 2013), engagement (e.g., van Dijk, 2010; Parchman et al. 2000), flow (e.g., Brom et al., 2014) and interest (e.g., Ritterfeld et al., 2009).

Educational treatments that provide contexts highly appealing learners' affective states were confirmed to have a great influence on (1) process of knowledge construction; (2) situational involvement within topic and (3) later involvement within topic and its related areas. In 1978 Isen et al. suggested that a positive emotional state improves recall, and positive emotions help as retrieval cues for long-term memory. In his research more positive emotions also resulted in readiness to invest more effort in learning tasks. Alternative approaches suggest, that emotions may impact knowledge acquisition in a positive way, for example by increasing learners' interest and motivation. Hidi (2006) proposes that emotional arousal might affect situational or individual interests, which directly influence attention and levels of learning. Active engagement of learners fosters higher levels of knowledge transfer and better integration of new knowledge with prior knowledge (Chi et al., 1994). In a study by Craig et al. (2004), it appears that learning gains might be positively related to state of flow and slight confusion, and negatively related to boredom. Moreover, Litman and Jimerson (2004) pinpoint positive emotional connections as determinant factors of future information seeking behavior.

Digital games are often associated with positive affective states and it became the foremost reason to serious games use in education (Garris et al., 2002; Malone, 1981). Games generally provide a safe environment where fear of failure is minimized and curious behavior becomes a key to success. Game elements such as challenging tasks, narratives or perceptual changes might evoke curiosity and consequently motivate students to explore the game world and learn in an engaging way (Dickey, 2011). Digital games also provide students with instant feedback on their actions, which helps them to remain in a psychological state of flow (Csiksentmihalyi, 2008), wherein individuals become unaware of themselves, their physical environment and the passage of time. Their behavior is concentrated, goal-oriented, and associated with wider and deeper attention. All those qualities are also essential to curiosity. Indeed, even Kashdan and Roberts (2004) apply the model of flow to curiosity, employing the term "absorption" in that context.

However opinion spectrum in the question of positive emotional design within learning situations balances. In study of Um et al. (2012) multimedia educational programs with positive emotional design (arranged through color and shape design of multimedia materials) had a positive influence on comprehension and knowledge transfer, motivation toward learning and perceived difficulty of the task. On the other hand Richard Mayer in his cognitive load theory mentions problem of extraneous cognitive load (2001). In the context of cognitive load theory, emotional content as designed sounds, colors, shapes etc., is on the contrary typically understood as a source of extraneous cognitive load, and is considered a disturbing element for learning. Nonetheless, in their recent studies, Moreno and Mayer (2007) incorporated into the cognitive load theory some factors stimulating extraneous cognitive load but still having a motivational potential.

Positive effect of games on situational learning motivation was described in several meta-analytic studies (Ke, 2008; Wouters et al., 2011), nonetheless the latest meta-review of Wouters et al. (2013) provided mixed results; it did not show serious games as being more motivating than the instructional methods used in the comparison group but proved that serious games are more effective in learning gains and knowledge retention. Wouters et al. (2013) speculate classic design problems in serious games, i.e. lower decision control on game-play that is limited in sake of learning process regulation; problem of balancing entertainment and instructional design with a focus on learning. Last but not least problem stems from methods commonly used for the measurement of affective states (Wouters et al., 2013).

Emotional state is mostly monitored within class observations, direct questioning or questionnaires that may not always provide comprehensive data and largely lack the ability to capture inner emotional richness. Physiological or behavioral measures such as eye tracking or skin conductance seem to be more appropriate methods, because they can be collected during game play. Similar approach offer collection of in-game log-files that is even less invasive and discreet to the player.

6 Important players’ individual characteristics

Three big components need to be considered in the process of learning with serious games: game design (see Section 7), its application (educational treatment) (see Section 8) and a player(-learner)’s characteristics (see below).

As different people learn and process (convert, store, and retrieve) information differently, it is important to understand the characteristics predicting how learners will react on specific content, treatment and situations. Recently, most studies focus on learning styles, gender, age and game literacy.

6.1 Learning style

Learning style is both a characteristic which indicates how a student learns and likes to learn, as well as an instructional strategy informing the cognition, context and content of learning (Keefe, 1991). Previous studies have reported that students' learning performance could be improved if proper learning style dimensions are taken into consideration when developing adaptive learning systems (Hwang et al., 2013). One of the valuable theoretical approach to categorization of learning styles for serious game design was developed by Honey and Mumford (1982). They consider four types of learners: Activists, Theorists, Pragmatists, Reflectors. Activists learn by doing and they like to involve in new experiences; Theorists like to understand the theory behind the actions, they prefer to analyze and synthesise, to have clear models and concepts; Pragmatists need to be able to see how to put the learning into practice in the real world; and Reflectors learn by observing, they prefer to stand back and view experience from a number of different perspectives and to collect data (Honey and Mumford, 1982).

Chong et al. (2005) studied relationship between learning styles and effectiveness of learning within computer games. Based on the study building upon the Honey and Mumford (1982) four types of learning styles he proposes categorization of genres appropriate for learners with specific learning styles. Activists took advantage of role-playing game and puzzle where they could use their brainstorming skills to solve problems. Theorists and reflectors preferred and benefited from strategy game, contradictory they did not learn well from role-play and puzzle game. Pragmatists showed great interest in puzzle game, but disliked role-playing game. Reflectors appreciated observing activities, feedback from others and coaching interviews.

6.2 Gender

There is a long-term persisted hypothesis that gender partly determines motivation to play games, specific genre interests, and learning outcomes within game-play. Cassell & Jenkins (1998) indicate that within video games, girls tend to show more situational interest in story development, relationships, and collaboration, whereas boys tend to prefer competition and aggression. Even though percentage of girl-gamers and boy-gamers is comparable, in average girls still spend less time by playing (e.g. Lee et al., 2009; McFarlane et al., 2002).

There have been recently a number of studies investigating the impact of gender on students' performance when using digital games. They describe some gender-determined styles while interacting with serious game and learning with it; Nelson (2007) found girls to be more effective in using guidance and Barab et al. (2007) claimed that girls wrote more in their online notebooks when completing quests, they as well engaged longer time in reflections about their work. Despite those differences most studies did not find any differences in learning outcomes while comparing male and female players (e.g. Barab et al., 2007; Dede et al., 2004; Joiner et al., 2011).

Some studies confirmed lower visual-spatial abilities in girls, but those seem to decrease with increasing duration of gameplay (Nietfeld et al., 2014), e.g. Feng et al. (2007) propose that playing action video games might reduce gender differences in attentional and spatial skills.

6.3 Age

Wouters (2009) points out that elderly learners might have problem to discern between relevant and irrelevant information in the game while the young learners can keep up well without any instructional support. Nevertheless such characteristic is more likely connected with proficiency in playing games than the age group. Moreover those characteristics are being shifted rapidly in the gamers' population. For more see Chapter Heterogeneous groups.

7 Designing serious games for learning

For an educational game to work effectively, the design of the game must incorporate the educational objectives and methods as well as motivational aspects from the field of game design (Connolly, et al., 2012). In the past decade, research has focused on two topics: whether games can be effective learning tools at all and how games can increase motivation for learning. However, with mostly positive results in these two areas, the next question becomes how to combine principles from education and game design to provide effective methods and mechanisms for integrated educational game design. The question for educational games is not whether they can be useful for learning, but how games can best be designed to support learning (McLarty et al., 2012).

To ensure that an educational game is effective in helping the learner to achieve the learning goals, it is important to consider how the learning content is embedded into the game. Scholars from the field of game design and from the field of instructional design and pedagogy have approached this question from different perspectives (Ryan & Charsky, 2013). One approach is to organise the learning content around the gameplay, interweaving or alternating the emphasis on learning and playing – this is called exogenous game design (Squire, 2006). Another approach is to integrate the learning content directly in the gameplay, such that the mechanics, goals, and rewards within the game foster learning (e.g., Habgood, 2010; Kelly et al., 2007) – we could label this as endogenous game design. A third option, following the constructivist approach and related to experiential learning, is to provide a narrative or environment for the player to explore and unfold the learning content as they go along (e.g., Barab et al., 2005). For example surprising or unexpected moments in the serious game's narrative yielded a higher level of deep knowledge without a decline in the reported engagement (van der Spek, 2011). While these approaches are being explored in academia, practitioners report a wider range of approaches, processes and barriers in the design and development of educational games (Lim et al., 2013; Popescu et al., 2012; Ryan & Charsky, 2013).

The endogenous or integrated approach to educational game design tries to reduce the discrepancy between design choice made from an educational perspective and those made from a motivational perspective, in order to design an effective and coherent learning tool. In a study on designing a game to teach basic arrhythmic (Habgood & Ainsworth, 2011; Habgood, 2010) compared two versions of the same game. Both games put the player in the role of a hero that has to combat various enemies in a medieval setting by selecting combat moves from a set of available options. However, in one version the arrhythmic is implemented extrinsically: enemies and combat moves are labelled with numbers, and a successful move is constituted by selecting a combat move with a number that divides the number on the enemy. In the other version, this relation is defined intrinsically by providing symbols that represent the numbers (e.g., the divisor five is represented by a five-fingered gauntlet combat move). They argue that the integrated design of the core mechanics of the game is critical to creating an effective educational game.

While the previous study remains inconclusive on the effectiveness of integrated game design, the need to combine insights from game design with those from instructional design receives wide support. Four leading questions from instructional design were proposed to structure the design of learning (Anderson & Krathwohl, 2001): the learning question, the instruction question, the assessment question, and the alignment question. Using this tetrad as a pivotal point, several existing approaches, frameworks and insights were combined into the game-based learning framework (Freitas & Staalduinen, 2009). In this framework, learning, instruction, and assessment are positioned to align game elements within the game design to address context (e.g., learning objectives), pedagogy (e.g., feedback), learner specific (e.g., previous knowledge or experience), and representation (e.g., learning content).

The derivative question of how game elements can be used to support learning has received further attention. Recognising that game elements may overlap and that it is sometimes unclear which aspects of them or interrelations between them supports which learning effects, (Bedwell et al., 2012) defined an extensive taxonomy of game attributes related to learning. Rooting the collection in existing literature, this provides a valuable initial overview of possible game elements to include and how they affect learning. Whereas this approach takes on an in-depth perspective on educational game design, other classifications attempt to describe and compare games by their high-level traits (Heintz & Law, 2015).

If we look at the interaction of a learner with an educational game, what matters is the activities that a player engages in: the gameplay or game activities as created through the game mechanics. The integration-oriented approach takes on the perspective that these activities need to be aligned with learning. The learning mechanics-game mechanics (LM/GM) model explores how this matching can be made effectively (Arnab et al., 2014). Such a model also supports the coming together of perspectives from domain experts, pedagogics, and game designers. Expanding the LM/GM model for serious games design, (Carvalho et al., 2015) used activity theory to discern between the layers of goal-oriented design. At the higher levels, with the goal of achieving the learning goals, the layers of instruction and learning define actions, tools, and goals for this purpose. At the instantiated level of gaming, again actions, tools, and goals are described to foster learning. By assessing these layers in a holistic perspectives, the elements at each level can be aligned to embed learning within gameplay effectively.

In addition to the mechanics of the game defining the game activities a player engages in, other aspects of the game design are relevant as well. To foster transfer, the transportation of in-game knowledge to applications in the real world, game designers need to consider the distance between these contexts. The taxonomy of transfer (Barnett & Ceci, 2002) describes how what is to be transferred (e.g., procedures, skills, principles) relates to the context of acquiry and the context of application, and defines several dimensions of this contextual distance. For example, in the temporal dimension acquiry and application may be separated in time by a small or a large amount, or in the physical context dimension the separation may be defined by the environment. To address these concepts of near and far transfer, game designers may seek to increase congruence between contexts (Holbert & Wilensky, 2006). When discussing integrated educational game design we have already addressed conceptual congruence. However, representational congruence seeks to align the game context with the transfer context visually and interactively as well.

Having discussed the specific design choices within educational games, it is important to emphasize that motivation and learning does not work the same for all people. In instructional design, much attention has been given to the differences in learning styles (Coffield et al., 2004; Peterson, et al., 2009; for more see Section 6.1), and in game design the player's preference is widely discussed (Bartle, 1996; Lessard, 2015; Squire, 2003). Some scholars have studied the implications of learning style for educational game design (Hwang et al., 2012) to personalize games. One important distinction that seeps through in educational game design is the goal orientation of the learner, distinguishing between performance-oriented and learning-oriented learners (Dweck, 1986). Counterintuitively, performance-oriented learners underperform under stress, whereas a growth-oriented attitude leads to increased performance. This raises questions around the commonly adopted competition-based nature of many games, whereas cooperative goal structures have been shown to be more effective in promoting a positive learning attitude (Ke, 2008a).

8 Instructional design and support

Game designers need as well consider the specific needs of teachers, parents, instructors or non-formal educational institutions who are responsible for implementation of serious games into their educational praxis or curricula.

Even though games are complex environments that do not require additional instructional support, in serious games is believed that some support to engage in relevant cognitive activities is essential (Wouters & Oostendorp, 2013). In recent meta-analysis of instructional support in digital game-based learning Wouters and Oostendorp (2013) propose especially modeling (showing which information is important in order to solve a problem and how to solve a problem), modality (the use of the audio channel for verbal explanations to limit visual search) and feedback (information whether and/or why an answer is correct) as effective techniques to support learners in selecting relevant information. Mayer (2008) proposes 10 principles for efficient instructional design; specifically five principles for reducing extraneous processing: (1) coherence - for reducing extraneous material that could mislead students' cognitive efforts and thus limit their engagement in core learning material; (2) signaling - highlighting essential material to structure learning content; (3) redundancy - for reducing extraneous load by respecting cognitive load capacity of each sensory channel (visual and auditive memory); (4) spatial contiguity - placing text near to corresponding visuals; (5) temporal contiguity - presenting visuals with corresponding narration in the same time (voiceover); three principles for managing essential processing:

(6) segmenting - assuring that visuals are presented in learner-paced segments; (7) pretraining - in key components; (8) modality - presenting words as spoken text rather than printed text; and two principles for fostering generative processing: (9) multimedia - presenting words and pictures rather than words alone; (10) personalization - using conversational style rather than formal style.

On the other hand the instructional support that would motivate learners to engage in the organization and integration of new information is more difficult. So far the best way is a reflection and debriefing session. Hays (2005) strongly recommends to include debriefing after the game. Debriefing is crucial and should be more than a simple recounting of the game. It should be a structured, guided, activity that brings meaning to the experience and fosters learning from that meaning. Debriefing gives the learners the opportunity to reflect on their experience with the game and understand how this experience supported the instructional objectives of the course or program of instruction.

Research Questions

Mayer (2011) proposed very nice outline for future research questions while he divided game research into three categories: a value-added approach, which questions how specific game features foster learning and motivation; a cognitive consequences approach, which investigates what people learn from serious games; and a media comparison approach, which investigates whether people learn better from serious games than from conventional media.

The future research in serious games for learning might focus on decomposing games and finding specific elements efficient in the process of learning. As well developing intelligent in-game assessment systems that help to evaluate players' activities and to adjust game walkthrough to the player's individual needs and learning path. Moreover so far not much is known about cognitive processes occurring while interacting with such complex systems as serious games. More experimental studies involving psychologists and digital engineers will be needed.

Conclusion and Outlook

In this chapter we attempted to describe all known important aspects of serious games influencing their capability to provide an efficient learning environment. Wide theoretical background was provided; behaviourism, cognitivism, constructivism, social constructivism and experience-based learning are theoretical approaches that offer an efficient framework for researching and designing serious games for specific learning purposes. Their concepts help us to assess educational outcomes and coverage of learning fundamentals identified by each of the theories.

The process of serious games assessment is an inseparable part of design and implementation. All discussed outcomes: cognitive learning, motor skills, affective and communicative - create very heterogeneous group that is furthermore often interconnected in complex learning outcomes. Assessment mechanics seem to be the most valuable approach today but as well other appropriate methods for qualitative assessment are discussed.

To ensure that an educational game is effective in helping the learner to achieve the learning goals, it is important to consider how the learning content is embedded into the game. In this perspective, while designing a serious game, we need to consider the learning question, the instruction question, the assessment question, and the alignment question. Some important rules for instructional design were as well described - principles for reducing extraneous processing, managing essential processing and fostering generative processing.

As the important questions for the future research in this area we consider decomposing games and finding specific elements efficient in the process of learning and exploring cognitive processes while interacting with environment of serious games.

Further Reading

- Video Games and Learning: Teaching and Participatory Culture in the Digital Age by Kurt Squire (Teachers College Press, 2011)
- Games, Learning, and Society: Learning in Doing: Social, Cognitive and Computational Perspectives by Constance Steinkuehler, Kurt Squire, Sasha Barab (Cambridge University Press, 2012)
- Persuasive Games: The Expressive Power of Videogames by Ian Bogost (The MIT Press, 2010)
- Values at Play in Digital Games by Mary Flanagan and Helen Nissenbaum (The MIT Press, 2014)

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