Why and How Serious Games can Become Far More Effective: Accommodating Productive Learning Experiences, Learner Motivation and the Monitoring of Learning Gains

Wim Westera
Open University of the Netherlands, Valkenburgerweg, The Netherlands // wim.westera@ou.nl

(Submitted October 18, 2016; Revised May 29, 2017; Accepted July 26, 2017)

ABSTRACT

This paper aims to improve the design methods for serious games (games for learning) by identifying a set of well-established pedagogical misconceptions and presenting design guidelines to avoid these. It analyses the pedagogical principles and models that are commonly used in serious game design, and contrasts these with evidence and advances in instructional psychology and instructional design research. The paper particularly focuses on (1) the concept of experience-based learning, which many serious games comply with, (2) the concept of learner motivation, which most games strongly claim to support, and (3) the score systems that many games use to track and display progress. Structural design weaknesses are exposed and countered with a large body of research evidence from the literature. A set of practicable design guidelines are presented that help to avoid the pedagogical flaws and contribute to improving the design methods for serious games.

Keywords

Serious games, Applied games, Game design, Learning effectiveness

Introduction

Games for learning are persistently gaining popularity. Many scholars and practitioners have recognised and embraced serious games because of their great potential for learning by predominantly referring to the dynamic, responsive and visualised nature of games, which produces high motivations, strong user involvement and penetrating learning experiences (Westera, 2015). Game development studios are a branch of so-called "creative industries," a term that emerged in the 1990s to connect the arts and other cultural activities with emerging digital technologies and the associated knowledge economy (O'Connor, 2010). The expected impact of the creative industries on society is substantial as the creative industry product is innovative rather than routine, and is generally characterised by originality, technical professional skill, uniqueness and quality (Caves, 2000). Creative industry product design goes with large degrees of freedom, while routine recipes are not available and in many cases not desirable. This certainly holds for the leisure game industry, but to some extent also for serious games. The appreciation of serious games is largely determined by their gaming properties, that is, the quality of game play, the fidelity of the environment and the fun they offer to the end-users. Serious games that lack the manifest features of commercial video games are easily disqualified by learners (Van Rosmalen & Westera, 2014). Less prominent seems the criterion of learning effectiveness. However, the effectiveness of games for learning and their supposed superiority over other teaching approaches are not self-evident. Various reviews studies (Connolly, Boyle, MacArthur, Hainey & Boyle, 2013; Linehan, Kirman, Lawson & Chan, 2011) show that among many thousands of serious game studies only very few try to evaluate the educational effectiveness of serious games in a rigorous manner by a sound quantitative or qualitative analysis of educational outcomes. Just asking end-users what they think about the game they played is less convincing a method for collecting evidence of effective learning than arranging a randomised controlled trial with calibrated pre-tests and post-tests. On the positive side, quite an increasing body of evidence is becoming available supporting the effectiveness of serious games for learning (Boyle et al., 2016; Connolly et al., 2013; Sitzmann, 2011).

This paper explores the main pedagogical concepts and principles that are relevant for serious game design, in particular those games that rely on an experience-based approach, and it critically evaluates these against available research evidence. It argues that serious game design may be substantially improved by taking advantage of the large body of empirical findings in half a century of teaching and learning research. In particular it identifies potential weaknesses in the ways serious game design deals with instructional guidance, motivation and the assessment of learning progress, respectively, and it formulates recommendations to address these for improving the effectiveness of serious games. First, a brief analysis is presented of the principle conflict between play and learning that arises when games are used for serious purposes.

The presumed conflict between learning and play

Abt (1970) introduced the term "serious game" as to contrast the purposeful application of games with leisure games. In practice, the term serious games is used as a container allowing for a wide variety of styles and approaches, including e.g., quizzes, interactive stories, sandbox virtual worlds and simulations. However, the term "serious game" is an oxymoron: a figure of speech combining two concepts that are contradictory (e.g., "old news"). In his seminal book "Homo Ludens" Huizinga (1938) describes game play exclusively as a leisure activity: the quintessence of play is in its voluntariness and openness, the freedom it offers and having no other purpose than playing. Play takes place in what Huizinga defines as the magic circle: a playground, which is a temporary world detached from real life, and which allows for fantasy and pretending, while special rules apply. However, these principles are readily undermined when a game is re-positioned as a serious educational endeavour with its obligations, regulations, imperative classes, homework and examinations. Still, play is not without effect. Whether pursued or not, playing a game involves experiences that influence the individuals' mental states at affective and cognitive levels. Play is generally considered a natural way of human learning (Blanchard & Cheska, 1985; Huizinga, 1938). Exactly because of their engaging and absorbing capacities games are increasingly being used in schools as they are supposed to support and enrich the curricula. Whether or not these serious games are capable of inducing play in its purest sense remains a philosophical question. A question of more relevance would be to what extent games are capable of supporting learners to master new knowledge and skills in effective, efficient and pleasant ways. A growing body of evidence supports a positive answer to this question (Connolly et al., 2013). Apparently fun and seriousness need not necessarily be in conflict, as fun doesn't necessarily mean "easy." The best fun is "hard fun" (Papert, 1980): people like to be challenged by difficult tasks, which require seriousness and dedication. Above all they are eager to see how they can stretch their own abilities. It is well recognised that games are capable of hooking and absorbing their players in such a way that they can hardly stop playing (Aldrich, 2005; Dickey, 2005; Gee, 2003). In extreme cases excessive gaming is known to display compulsive and addictive properties very similar to drugs and alcohol and producing similar damaging effects in individuals' mental health (Griffiths, Király, Pontes & Demetrovics, 2015). Since motivation of school children and students is generally known to be low, how nice it would be if a touch of the compulsive properties of games could be exploited to induce wholesome levels of engagement and the ideality of learners eager for extra challenges, extra homework, extra lessons and even staying after school hours (Westera, 2015).

Learning from experience as the basis of game-based learning

Learning from experience is the dominant pedagogical paradigm in serious game design (Gosen & Washbush, 2004; Canhoto & Murphy, 2016; Connolly et al., 2013; Aldrich, 2005; Gala, 2014; Reese, 2011; Schank, Berman & Macpherson, 1999; Catalano, Luccini & Mortara, 2014; Arnab, Lim, Carvalho, Bellotti, De Freitas, Louchart, Suttie, Berta & De Gloria, 2015; Rooney, 2012). It refers to learning by active exploration and self-direction rather than learning from instruction. Many related terms are used to indicate comparable approaches, such as discovery learning (Bruner, 1961), problem-based learning (Barrows & Tamblyn, 1980), inquiry learning (Papert, 1980), experiential learning (Kolb, 1984), constructivism (Jonassen, 1991), situated learning (Lave & Wenger, 1991) and learning by doing (Schank, 1995; Aldrich, 2005), respectively. Well before the wave of constructivism Dewey (1916) stated that learning should be connected with some real world context in order to allow the learner to relate symbolic content (e.g., concepts and principles) to real-world referents. The same holds for its recent descendents. Such model of learning from experiences that result directly from one's own actions is often contrasted with the information transfer model, which describes learning from e.g., reading instructions or listening to lecturers. The knowledge transfer model and the experience-based learning model essentially deal with distinct types of knowledge that is learned: explicit knowledge versus implicit knowledge, respectively. Explicit knowledge refers to all knowledge that can be codified, that is, written down in texts and formulas, and that thereby allows for being transferred directly from one person to another. Alternative terms are declarative knowledge, formal knowledge and articulate knowledge. In contrast, implicit knowledge is the knowledge that is hidden in the action. One may readily learn explicit knowledge - say about bicycles - from a textbook, e.g., about the different parts and components, but riding a bicycle requires experiencing the essential subtleties of timing, balance, power and sudden disturbances, which just cannot be explained in words, but can only be learned by doing. Such implicit knowledge is also referred to as procedural knowledge or tacit knowledge (Polyani, 1966). The difference between explicit and implicit knowledge is also referred to as "knowing that" and "knowing how" (Ryle, 1949).

As serious games are readily positioned as the attractive alternative of traditional teaching practice many games tend to avoid the explicit knowledge transfer model and promote experience-based learning to achieve learning

goals (Schank et al., 1999). Various authors consider serious games as pedagogically-driven games while referring to such experience-oriented models as a theoretical foundation (Catalana et al., 2014; Canhoto & Murphy, 2016; Rooney, 2012). A recent survey among game developers revealed the same preference, while guidance and instruction were reported to be seldom used during the game (Saveski et al., 2015). Many games rely on offering the "experience" and stay aloof of learner guidance (Canhoto & Murphy, 2016).

Issues with experience-based learning

Rote learning rather than deep understanding

As experience-based learning focuses on contextualised actions, many serious games in e.g., math, geography or language teaching are based on drill and practice approaches, which may support the successful reproduction of knowledge and automation of operational skills (rote learning), but fail to support deep level insights and generalised understandings that are based on conceptual background facts, principles and theories. Although the engaging experiences of serious games are valuable as such, a lack of explicit framing may impede deep understanding of the patterns and relationships of the content at hand (Mayer, 2004). Occasionally, these limitations are recognised and removed by adding a debriefing, which include reflective evaluation of the events in the game (Crookall, 1995; Saveski et al., 2015; Garris, Ahlers & Driskell, 2002). This is in accordance with Dewey's claim that learning is the product of experience and reflection (Dewey, 1938). Still it means that instructional events are either neglected or positioned outside the game rather than inside the game, possibly to allow the game to be shielded from any reference to traditional teaching practice (Malone, 1981; Gee, 2003; Aldrich, 2005). The strive for fun, however, may have taken its toll when the game just produces routines without the required deep understanding: a missed opportunity that can be easily restored.

Neglecting the ineffectiveness of minimal guidance approaches

Many serious games offer an experience-based learning environment focused on exploration, discovery or problem solving that is devoid of instructional guidance (e.g., Canhoto & Murphy, 2016). However, evidence for the effectiveness of such minimal guidance approaches is almost non-existent: the far majority of research studies report that learner guidance approaches produce superior results as compared to approaches without or with minimal guidance (Mayer, 2004; Kirschner, Sweller & Clark, 2006). Kirschner et al. (2006) attribute the failure of minimal guidance approaches to the properties of human cognitive architecture: when learners are novel to certain learning content and thereby do not have detailed mental schemas that reflect the conceptual structure of the content domain, they are prompted to explore large search spaces that generate heavy loads on working memory, which is detrimental to learning. Worst case, the learner will adopt a thoughtless trial and error strategy, which eventually may lead to task completion be it without any learning gains. Moreover, research shows that exactly less able students suffer mostly from minimal guidance approaches. Tragically, they still favour those approaches although they learn less from those (Clark, 1989; Kyllonen & Lajoie, 2003; Kirschner et al., 2006). Mayer (2004) notes that in spite of the overwhelming evidence against minimal guidance approaches, the tendency to reduce or even eliminate learner guidance can be seen in many subsequent teaching alternatives that aim to abandon traditional teacher-lead instruction, e.g., discovery learning (Bruner, 1961), problem-based learning (Barrows & Tamblyn, 1980), inquiry learning (Papert,1980), experiential learning (Kolb, 1984), constructivism (Jonassen, 1991) and learning by doing (Schank, 1995; Aldrich, 2005), respectively: every decade the same set of minimal guidance principles are covered by a new label. Each generation of minimal guidance advocates seem to be unaware of the refutations of the previous approaches, and naively starts repeating the same mantra (Mayer, 2004). Serious gaming may readily become the next wave of counterproductive pedagogical innovation.

Altogether, it seems that in many experience-based serious games the pedagogical foundation is shallow, ill-articulated, erroneous, if not tendentious. It may be attributed to a lack of understanding of associated pedagogical labels (e.g., constructivism, experiential learning) or to the neglect of a vast body of empirical evidence in learning research that has been made available over the past 50 years. The neglect of scaffolding and other forms of instructional guidance seems to have become a goal in its own right as to avoid any contamination with traditional teaching models (Kirschner et al., 2006). The mantra of experience-based learning may be easily abused to stay away from traditional instruction and to focus on the gameplay rather than on the learning. Yet, the rich multimedia properties of digital games would allow for both challenging gameplay and dedicated instruction. Serious games could thus become far more effective.

Issues with motivation

Determinants of motivation

Games are valued for their motivational power. Players of a game are challenged to actively engage in e.g., problem solving, exploration, goal formation, critical analysis, strategic thinking and enhanced creativity (Westera, 2015). Motivation is a complex psychological construct that is related to energy, intention, direction, and persistence, which all bring individuals into action (Ryan & Deci, 2000). It is widely considered as a main determinant of effective learning (Keller, 1987; Keller, 2008; Ryan & Deci, 2000; Cordova & Lepper, 1996). Research into motivation has identified various favourable outcomes for learning, such as increased attention, enjoyment, engagement, depth of involvement, task persistence and cognitive flow (Cordova & Lepper, 1996; Garris et al., 2002; Csikszentmihalyi, 1991). A variety of theoretical models of motivation have been proposed (e.g., Keller, 2008; Malone, 1981; Malone & Lepper, 1987; Ryan & Deci, 2000), all recognising the distinction between intrinsic motivation and extrinsic motivation. Intrinsic motivation is the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn (Ryan & Deci, 2000). It is the personal drive to engage in an activity because of the activity itself. Extrinsic motivation in contrast refers to performing an activity driven by external factors, e.g., by external pressure or pursued outcomes such as rewards, prestige, diplomas or salary (Westera, 2015). Both intrinsic and extrinsic motivation are important determinants of learner behaviour. However, extrinsic motives are known to be often less productive than intrinsic motives: extrinsic motives are readily associated with shallow learning rather than deep processing (Habgood & Ainsworth, 2011). A large number of studies have demonstrated that intrinsic motivation as compared with extrinsic motivation leads to more interest, excitement, and confidence, which in turn contributes to enhanced performance, persistence, creativity, vitality, self-esteem, and general well-being (Ryan & Deci, 2000).

In their cognitive evaluation theory and self-determination theory Ryan and Deci (2000) identify three determinants of intrinsic motivation: competence, autonomy and relatedness. Intrinsic motivation has been demonstrated to increase when people feel “they can do it” (competence), provided that they “did it by themselves” (autonomy). The third factor “relatedness” is less prominent: it refers to the support from the social environment in terms of security and confirmation. The absence of relatedness, however, e.g., imposed tasks, directions, surveillance or deadlines, is known to diminish intrinsic motivation and to lead to poor performance or failure to complete. In games a number of motivation drivers can be distinguished: presentation style, gameplay scenario and reward systems. They should be used properly.

Style elements

The rich soundscapes and dynamic visual sceneries in games unescapably trigger the senses and help to effect penetrating user experiences (Dickey, 2005). The associated motivation effects remain largely extrinsic in nature: players are hooked, if not seduced, by the appealing, dynamic sceneries as is the case in sales promotion and commercial advertising. As a side-effect, the rich, dynamic user interfaces may readily undermine favourable conditions for learning, because of unwanted distractions and excessive cognitive load. Likewise, the strive for realism in games may be counterproductive for learning. Although realism to some degree is needed to promote the credibility of practical skills training assignments (Westera, Nadolski, Hummel & Wopereis, 2008), reducing the representation of the synthesised world to the essential functional properties would favourably reduce the cognitive load for learners. Experiments based on media equation theory (Reeves & Nass, 1996) have demonstrated that human individuals respond socially and naturally to a variety of non-human objects such as robots, computers, games, avatars, or symbols. By the same mechanism simple, non-realistic game representations (e.g., the ghost characters in Pacman) may still raise exciting, dramatic, if not thrilling experiences. The human brain is simply not capable of suppressing natural interpersonal responses, as it has no neural circuits or anatomic regions that distinguish between inter-human and mediated or symbolic interactions (Reeves & Nash, 1996). Games displaying rich, realistic or dynamic visualisation styles may stimulate extrinsic motivation, at the expense of unfavourable distractions and cognitive overloads. A justified balance is needed.

Gameplay scenarios

In contrast with the manifest game sceneries and features the underlying gameplay scenarios are the true carriers of intrinsic motivation as the players are active participants in their stories, having adopted goals, roles, responsibilities (autonomy) and powers (competence) that put them at the centre of the action: By engaging in

the gameplay scenario the player gets involved in a sense making process. This refers to the search for appropriate relations of causality, space and time, which allows for the construction of the game's story (narrative or fabula) (Bordwell, 1989). This ongoing mental process of creating meaningful narratives from events and experiences is the main carrier of experience-based learning. As Gee (2003) explained, the secret of a videogame is "not the high quality, immersive 3-D graphics but in the underlying architecture, which balances the challenges offered to the player with the players' abilities seeking at every point to be hard enough to be just doable". If the game is fun, well-balanced and content-wise interesting, the players are likely to play the game because of the activity itself: intrinsic motivation. Scenarios that support the player's competence and autonomy would make serious games far more effective.

Reward systems

Motivation in games is also driven by reward systems, which may include scores, permissions, property, reputation and more. Three different reward classes can be distinguished:

Post-practice rewards

Post-practice rewards are obtained after successful game completion. These rewards enhance extrinsic motivation driven by a future promise related to the outcomes of the game rather than the game activity itself, for instance, a diploma or a certificate, enhanced reputation e.g., by a favourable appearance on a public leader board ranking, a monetary prize, or privileges such as access to a new level: playing the game is no more than a means to an end (Vallerand, Fortier & Guay, 1997).

Dynamic in-game scores

Dynamic in-game scores indicate progress of achievement, usually expressed as a number, a percentage, a set of stars, or similar. Such in-game scores are frequently updated, which re-establishes extrinsic motivation again and again. Most in-game scores are not directly fed back into the gameplay, but they are just used as monitors of achievements. It means that the rewards are oriented on results rather than the activities themselves.

Affordance-oriented rewards

Affordance-oriented rewards provide incentives or privileges that directly support and enhance gameplay. Rewards resulting from successful actions open up new powers, resources and opportunities for intensifying gameplay: the rewards are part of the narrative that the player is constructing, for instance, gaining a high profit in a management game would allow for more investment options or take-overs. This comes close to receiving natural feedback: being confronted with the direct or indirect consequences of decisions made during gameplay. Because their focus is on enhanced activity, affordance-oriented rewards are likely to support intrinsic motivation.

Most rewards systems, however, function as external drivers and thereby they trigger extrinsic motivation, which may be effective as such at activating people, be it not without limitations. A lot of games, for instance in math, spelling or vocabulary learning, offer a dressed up drill-and-practice, which uses the behaviourist notions of repetition and reinforcement (and punishment) to condition learners to routine tasks. As opposed to contemporary constructivist approaches these behaviourist approaches focus on automation, while deep thinking and reasoning are discouraged. Such operant conditioning is generally considered a truncated, low-level mode of learning most suited for teaching tricks to animals. Games thus run the risk of being reduced to skinner boxes, which are "incentive dispensers that dole out rewards for attention" (Bogost, 2007). By using the right reward systems serious games could become far more effective.

Extrinsic causes for intrinsic motivation

External reward systems are prone to undermine intrinsic motivation because they are easily perceived as external controllers of behaviours, associated with force, pressure or surveillance, which all affect the player's sense of autonomy. Nevertheless, Ryan and Deci (2000) have recognised the practical importance of extrinsic

motivation - our behaviours are for a large part externally driven -, and based on their self-determination theory they suggest that external drivers may amplify intrinsic motivation provided that there is sufficient room for perceived competence, autonomy and relatedness. For instance, children doing their homework may be externally motivated by the desire to satisfy their parents' expectations (social relatedness), to receive a diploma (post-practice reward) or to satisfy requirements for a future profession. Despite this external pressure they can be highly committed provided that the requested behaviours have been fully integrated and internalised so that it is perceived and accepted as a personal striving. This can be promoted by allowing for self-selected, not imposed, goals, which assumes the opportunity for choice and freedom of movement (autonomy). When in addition self-confidence and self-esteem are established and re-established (competence), personal goals will develop and motivation may become internalised. In games similar mechanisms apply. If players are allowed to pursue self-selected goals and if they feel competent, that is, they feel in control rather than being controlled, the activity and the goals get internalised and integrated in the self.

In sum, serious games have the inherent capacity to address both intrinsic and extrinsic motivation. Motivation should preferably be intrinsic, that is, associated with the activity, the gameplay and the game's content rather than the outcomes. Style elements may contribute to attractive gameplay, but they should not be distracting. Reward systems in games tend to be output-based but should instead be affordance oriented. Choice, freedom of movement, control and competence are crucial factors to support the intrinsic sense of achievement and self-fulfilment in the game. The best reward for an achievement is in the achievement itself. Many serious games violate these principles.

Issues with progress monitoring and assessment

The many traces that players leave during gameplay offer great opportunities for the detailed monitoring and assessment of players' behaviours, progress and achievements. Therefore game scores are not just included so often for motivation purposes only (see above), but also for informing the players how well they are performing. While in leisure games the score systems are self-establishing, viz., they are defined as part of the rules of play, in serious games the scores may be expected to reflect the progress toward the games' learning goals. Unfortunately, the score systems in serious games are likely to conform to gameplay standards rather than educational standards and to focus on events rather than the underlying skills, knowledge or competence frameworks. Consequently, game score systems seldom comply with the strict requirements of validity (whether or not the assessment measures what it claims to measure), reliability (whether the assessment produces consistent, reproducible outcomes) and fairness (whether the assessment is free from bias, e.g., racial, religious, gender, age) of educational assessments. A number of assessment issues are addressed below.

Assessment as a by-product

Assessment has been identified as the most powerful determinant of learning behaviours (Hattie, 2009; Brown & Glasner, 2003). Metaphorically this was expressed as "the assessment tail that wags the curriculum dog" (Hargreaves, 1989). It means that the assessment should not be considered as a final add-on to the game design, but instead should be the design's starting point. Serious game design, however, is likely to start at the wrong end by designing a (nice) game around some relevant content, and then adding some score mechanisms. Studies in evidence-centred design (Mislevy, Steinberg & Almond, 2003) have suggested that educational design should start with a detailed task analysis, identifying the right activities and composing favourable situations that would allow players to exert and demonstrate certain well-specified behaviours. In serious games, the assessments are likely a by-product, which is detrimental for their quality. Serious game design should start with an assessment analysis.

Complexity of covert, dynamic assessment

As one of the promises of learning analytics the continual stream of player interaction data can be used to extract player's progress indicators in a covert way. Such stealth assessment occurs on the fly without any specific testing assignments or other interruptions of the game (Shute, 2011; Shute & Ventura, 2013). Moreover, stealth assessment is based on sequences of highly dependent interactions in the game, which represent a large evidence base, while traditional testing approaches would only offer single, independent data points. However, as opposed to common game score systems, the implementation of stealth assessment is complex, laborious and time-consuming, leaving aside the tendency to view game scores just as a motivational add-on. In addition, game

designers, even experienced ones, may not have gained the level of assessment expertise that educational professionals, e.g., teachers, have. Nevertheless, stealth assessment could make serious games far more effective.

Performance versus learning progress

Most game scores are indicators of the player's performances, but they do not necessarily indicate learning progress. Learning and performance are conflicting concepts that often require opposite attitudes. Various authors (VandeWalle, Brown, Cron & Slocum, 1999; Fisher & Ford, 1998) explain the difference between a performance orientation and a learning task orientation. Performance is linked with achieving milestones (in many cases under time constraints), the swift completion of tasks, avoiding errors, and the use of proven methods for reducing risks. Aiming at high performance scores draws players toward activities that they are good at already: they are reluctant to try our new approaches because they are anxious for running into penalty points. Effective learning, however, requires spending sufficient time for in-depth understanding, having sufficient opportunities for reflection, revision, and self-evaluation, and being prepared to make mistakes (Westera, 2015). Errors and failure are productive sources of learning (Mory, 2003; Mathan & Koedinger, 2005), be it that the score mechanisms used should not discourage these by imposed penalties. In practice, game score systems often enforce the achievement of performance goals, which stimulates learners to demonstrate high ability and to avoid poor performance. In such contexts failure becomes a threat to success and thereby it affects self-esteem, self-confidence, and motivation. The resulting self-defence reactions (Mory, 2003) include discounting (Kelley, 1973), task avoidance, feigning boredom, and task-irrelevant actions to bolster self-image (Dweck & Legget, 1988), and learned helplessness (Seligman, Maier & Geer, 1968). To support a learning orientation serious games should lower the price of failure (Gee, 2003). Game score systems should not primarily be based on time-constraints and penalty points, but should focus on learning progress, while allowing players to make mistakes, to spend sufficient time and effort, to try and retry, to reflect on attainments and to decide upon their own strategies (autonomy). By promoting a learning orientation and applying learning-oriented score systems serious games could become far more effective.

Conclusion

Research in instructional sciences has produced a huge body of evidence over the past 50 years. In serious game design, however, many established insights in teaching and learning seem to be neglected. This neglect may be partially explained by the ambition to contrast serious games with existing teaching approaches, by emphasising their fun properties and excluding manifest references to school and classroom practices. Also, the high visual, acoustic and narrative qualities of entertainment games inevitably frame the expectations that learners and teachers may have and thereby urge serious game designers to focus on the gaming part at the expense of the teaching part.

Still, the ambition to make learning more attractive and joyful should never go at the expense of learning effectiveness. Although many serious game designers would concur with the paramount importance of pedagogy, they are readily in default when it comes to activity, either by misconceptions or ignorance. This paper has identified a variety of weaknesses in serious game design, which needs further attention from the field. Main conclusion is that serious games can become more effective if the considerations about experience-based learning, motivation and assessment, respectively, would be taken into account. Based on our analysis we present the following guidelines.

With regard to experience-based learning, serious game design should:

- explicitly base its design on advances and evidence in learning sciences research
- include instructions and explanations about conceptual background principles and theories, even if when these would require the interruption of play
- include adaptive scaffolding mechanisms and other forms of instructional guidance and learner support in the design.
- provide feedback on learning rather than feedback on performance
- include opportunities for reflection and metacognitive activity, even if when these would require the interruption of play.

With regard to motivation serious game design should:

- avoid distracting presentation style elements because of the unwanted extraneous cognitive load they induce

- start with an assessment analysis that identifies relevant tasks and content to be covered by the game, and base the gameplay scenarios on the assessment analysis
- offer gameplay scenarios that allow for sufficient freedom of movement and player responsibilities to enhance the player's sense of autonomy
- offer gameplay scenarios that pose cautiously balanced and just doable challenges for enhancing the player's sense of competence
- avoid external pressure, surveillance or time locks as to preserve the player's sense of relatedness.

With regard to scoring and assessment serious game design should:

- include affordance-oriented incentives that directly support and enhance gameplay rather than output-oriented rewards
- use dynamic in-game scores that provide a reliable monitor of learning progress
- benefit from stealth assessment based on evidence-centred design or similar, which allows for monitoring learning progress
- promote a learning attitude, which allows for failure, retrials, reflection and well-considered strategy development without time constraints or penalty scores.

For practical reasons this paper only looked into potential issues in instructional support, motivation and the assessment of learning progress, respectively. Still, various other aspects of serious games pedagogy deserve similar analysis, for instance the transfer of the knowledge learned in games to a variety of different operational contexts, the role of reflection, self-regulation and other metacognitive capabilities in games, the design of scaffolding, feedback mechanisms, and personalisation, the role of affective and emotional elements for learning, and the integration of serious games in the wider curriculum context. On all of these topics a vast body of research evidence is available, which only sparsely permeated the domain of serious game design. By putting more efforts in their pedagogical dimensions, serious games can become far more effective.

Acknowledgements

This research was partially funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 644187, the RAGE project (www.rageproject.eu).

Reference

Abt, C. (1970). *Serious games.* New York, NY: Viking Press.

Aldrich, C. (2005). *Learning by doing: The Essential guide to simulations, computer games, and pedagogy e-learning and other educational experiences.* San Francisco, CA: John Wiley & Sons.

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An Approach to medical education.* New York, NY: Springer.

Blanchard, J. S., & Cheska, A. (1985). *The Anthropology of sport: An Introduction.* South Hadley, MA: Bergin and Garvey Publishers Inc.

Bogost, I., (2007). *Persuasive games: The Expressive power of videogames.* Cambridge, MA: MIT Press.

Bordwell, D. (1989). A Case for Cognitivism. *IRIS, 9,* 11-41.

Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., & Pereira, J. (2016). An Update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education, 94*, 178-192. doi:10.1016/j.compedu.2015.11.003

Brown, S., & Glasner, A. (2003). *Assessment matters in higher education*. Buckingham, UK: SRHE & Open University Press.

Bruner, J. S. (1961). The Act of discovery. *Harvard Educational Review, 31*(1), 21–32.

Canhoto, A., I., & Murphy, J. (2016). Learning from simulation design to develop better experiential learning initiatives: An Integrative approach. *Journal of Marketing Education, 38*(2), 98 –106.

Catalano, C. E., Luccini, A. M., & Mortara, M. (2014). Best practices for an effective design and evaluation of serious games. *International Journal of Serious Games, 1*(1). Retrieved from http://journal.seriousgamessociety.org/index.php/IJSG

Caves, R. E. (2000). *Creative industries: Contracts between art and commerce.* Boston, MA: Harvard University Press.

Clark, R. E. (1989). When teaching kills learning: Research on mathemathantics. In: H. N. Mandl, N. Bennett, E. de Corte, & H.F. Freidrich (Eds.), *Learning and instruction: European research in an international context* (Vol. 2, pp.1–22). London, UK: Pergamon.

Connolly, T. M., Boyle, E. A, MacArthur, E., Hainey, T., & Boyle, J. M. (2013). A Systematic literature review of empirical evidence on computer games and serious games. *Computers & Education, 59*(2), 661–686. doi:10.1016/j.compedu.2012.03.004

Cordova, D. I., & Lepper, M. R. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88*(4), 715–730.

Crookall, D. (1995). A Guide to the literature on simulation/gaming. In D. Crookall & K. Arai (Eds.), *Simulation and gaming across disciplines and cultures: ISAGA at a watershed* (pp.151-177). Thousand Oaks, CA: Sage.

Csikszentmihalyi, M. (1991). *Flow: The Psychology of optimal experience.* New York, NY: Harper Perennial.

Dewey, J. (1916). *Democracy and education.* New York, NY: Macmillan.

Dewey, J. (1938). *Experience and Education.* New York, NY: Macmillan.

Dickey, M. D. (2005). Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. *Educational Technology, Research and Development, 53*(2), 67-83.

Dweck, C. S., & Legget, E. L. (1988). A Social-cognitive approach to motivation and personality. *Psychology Review, 95(2), 256–273.*

Fisher, S. L., & Ford, J. K. (1998). Differential effects of learner effort and goal orientation on two learning outcomes. *Personnel Psychology, 51*(2), 397–420. doi:10.1111/j.1744-6570.1998.tb00731.x

Gala. (2013). *R&D Roadmap on Serious Games*. Retrieved from https://www.biba-gaminglab.com/wp-content/uploads/GALA-Roadmap-sub-section-corporate-training-3.pdf

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A Research and practice model. *Simulation & Gaming, 33*(4), 441-467. doi:10.1177/1046878102238607

Gee, J. P. (2003). *What video games have to teach us about learning and literacy.* New York, NY: Palgrave/Macmillan.

Gosen, J., & Washbush, J. (2004). A Review of scholarship on assessing experiential learning effectiveness. *Simulation & Gaming, 35*(2), 270-293. doi:10.1177/1046878104263544

Griffiths, M. D., Király, O., Pontes, H. M., & Demetrovics, Z. (2015). An Overview of problematic gaming. In V. Starcevic & E. Aboujaoude (Eds.), *Mental Health in the Digital Age: Grave Dangers, Great Promise* (pp. 27-45). Oxford, UK: Oxford University Press.

Habgood, M. P. J., & Ainsworth, S. E. (2011). Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games. *Journal of the Learning Sciences, 20*(2), 169-206.

Hargreaves, A. (1989). *Curriculum and assessment reform.* London, UK: Open University Press.

Hattie, J. (2009). *Visible learning: A Synthesis of over 800 meta-analyses relating to achievement*. New York, NY: Routledge.

Huizinga, J. (1938). *Homo Ludens: A Study of the play element in culture.* Boston, MA: Beacon Press.

Jarvis, P. (1987). *Adult learning in the social context*. London, UK: Croom Helm.

Jonassen, D. (1991). Objectivism versus constructivism. *Educational Technology Research and Development, 39*(3), 5–14.

Kayes, D. C. (2002). Experiential learning and its critics: Preserving the role of experience in management learning and education. *Academy of Management Learning and Education, 1*(2), 137-149.

Keller, J. M. (1987). Development and use of the ARCS model of motivational design. *Journal of Instructional Development, 10*(3), 2-10.

Keller, J. M. (2008). First principles of motivation to learn and e3-learning. *Distance Education, 29*(2), 175-185.

Kelley, H. H. (1973). The Processes of causal attribution. *American Psychologist, 28*(2), 107–128.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An Analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Kyllonen, P. C., & Lajoie, S. P. (2003). Reassessing aptitude: Introduction to a special issue in honor of Richard E. Snow. *Educational Psychologist, 38*(2), 79–83.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Linehan, C., Kirman, B., Lawson, S., & Chan, G. (2011). Practical, appropriate, empirically-validated guidelines for designing educational games. In T. Desney, G. Fitzpatrick, C. Gutwin, B. Begole & W. A. Kellogg (Eds.) *Proceedings of the ACM Annual Conference on Human Factors in Computing Systems* (pp.1979-1988). New York, NY: ACM.

Malone, T. W. (1981). What makes computer games fun? *Byte, 6*(12), 258-277.

Malone, T. W., & Lepper, M. R., (1987). Making learning fun: A Taxonomy of intrinsic motivations for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction: Conative and affective process analyses* (Vol. 3. pp. 223-253). Hillsdale, NJ: Lawrence Erlbaum.

Mathan, S. A., & Koedinger, K. R. (2005). Fostering the intelligent novice: learning from errors with meta-cognitive tutoring. *Educational Psychology, 40*(4) 257–265.

Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The Case for guided methods of instruction. *American Psychologist, 59*(1), 14–19.

Mislevy, R. J., Steinberg, L. S., & Almond, R. G. (2003). On the structure of educational assessments. *Measurement: Interdisciplinary Research and Perspectives, 1*(1), 3-62. doi:10.1207/S15366359MEA0101_02

Mory, E. H. (2003). Feedback research revisited. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp.745-783). New York, NY: MacMillian Library Reference.

O'Connor, J. (2010). *The Cultural and creative industries: A Literature review (2nd ed.).* Newcastle upon Tyne, UK: Creativity, Culture and Education. Retrieved from http://www.creativitycultureeducation.org/wp-content/uploads/CCE-lit-review-creative-cultural-industries-257.pdf

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York, NY: Basic Books.

Polanyi, M. (1966). *The Tacit dimension.* Chicago, IL: University of Chicago Press.

Potts, J., & Cunningham, S. (2008). Four models of the creative industries. *International Journal of Cultural Policy, 1201*(1), 163-180. doi:10.1080/10286630802281780

Reese, H. W. (2011). The Learning-by-doing principle. *Behavioral Development Bulletin 11,* 1-19. Retrieved from http://psycnet.apa.org/journals/bdb/17/1/1.pdf

Reeves, B., & Nass, C. (1996). *The Media equation: How People treat computers, television, and new media like real people and places.* Cambridge, UK: Cambridge University Press.

Rooney, P. (2012). A Theoretical framework for serious game design: Exploring pedagogy, play and fidelity and their implications for the design process. *International Journal of Game-based Learning, 2*(4) 41-60. doi:10.4018/ijgbl.2012100103

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Ryle, G. (1949). *Knowing how and knowing that. The Concept of the mind.* New York, NY: Barnes and Noble.

Saveski, G. L., Westera, W., Yuan, L., Hollins, P., Fernández Manjón, B., Moreno Ger, P., & Stefanov, K. (2015). What serious game studios want from ICT research: Identifying developers' needs. In A. De Gloria & R. Veltkamp (Eds.), *Proceedings of the GALA 2015 Conference* (pp. 1–10). doi:10.1007/978-3-319-40216-1_4

Schank, R. C., Berman, T. R., & Macpherson, K. A. (1999). Learning by doing. In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A New paradigm of instructional theory* (Vol. II, pp. 161-181). Mahwah, NJ: Lawrence Erlbaum Associates.

Schank, R. C. (1995). *Engines for education.* New York, NY: Lawrence Erlbaum.

Seligman, M. E., Maier, S. F., & Geer, J. H. (1968). Alleviation of learned helplessness in the dog. *Journal of Abnormal Psychology, 73*(3), 256–262.

Shute, V. J. (2011). Stealth assessment in computer-based games to support learning. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and instruction* (pp.503–524). Charlotte, NC: Information Age Publishers.

Shute, V. J., & Ventura, M. (2013). *Measuring and supporting learning in games: Stealth assessment.* Cambridge, MA: The MIT Press.

Sitzmann, T. (2011). A Meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology, 64*(2), 489-528. doi:10.1111/j.1744-6570.2011.01190.x

Technology Strategy Board (TSB). (2013). *Creative industries strategy 2013-2016*. Swindon, UK: Author. Retrieved from http://www.innovateuk.org

Vallerand, R. J., Fortier, M. S., & Guay, F. (1997). Self-determination and persistence in a real-life setting: Toward a motivational model of high school dropout. *Journal of Personality and Social Psychology, 72*(5), 1161-1176.

Van Rosmalen, P., & Westera, W. (2014). Introducing serious games with Wikis: Empowering the teacher with simple technologies. *Interactive Learning Environments 22*(5), 564-577. doi:10.1080/10494820.2012.707128.

VandeWalle, D., Brown, S. P., Cron, W. L., & Slocum, L. W. (1999). The Influence of goal orientation and self-regulation tactics on sales performance: A Longitudinal field test. *Journal of Applied Psychology (APA), 84*(2), 249–259.

Westera, W. (2015). Games are motivating, aren't they? Disputing the arguments for digital game-based learning. *International Journal of Serious Games 2*(2). Retrieved from http://journal.seriousgamessociety.org/index.php/IJSG

Westera, W., Nadolski, R., Hummel, H., & Wopereis, I. (2008). Serious games for higher education: A Framework for reducing design complexity. *Journal of Computer-Assisted Learning, 24*(5), 420-432.