

# Learning, dynamic assessment and Serious Games

L. Anolli<sup>1</sup>, L. Confalonieri<sup>1</sup>

<sup>1</sup> Centre for Studies in Communication Sciences (CESCOM), Department of Human Science “Riccardo Massa”, University of Milan-Bicocca, U16 Building, via Giolli angolo via Thomas Mann, 20162 Milan, Italy

New trends in cognitive psychology are redefining the functioning of human mind, moving from a modular amodal to a situated, embodied and simulative mind. At the same time, studies on the so-called digital natives highlight how the continuous and early employment of new digital technologies in communication and knowledge construction affects human cognitive processes and phenomena as well as informal and formal learning. The main goal of this chapter is to outline how Serious Games, as contemporary cultural virtual artefacts, may be promoters of innovation and cultural evolution affecting, and in turns being affected by, learning styles and methods, standing for tremendous opportunities for the contemporary time.

**Keywords** Simulative mind; dynamic assessment; Serious Games

## 1. Introduction

The main goal of this chapter is to outline how Serious Games (SG), as contemporary cultural virtual artifacts, may be promoters of innovation and cultural evolution affecting, and in turns being affected by, learning processes standing for tremendous opportunities for the contemporary era. The chapter contents are divided in three main paragraphs.

In the first one, new trends in cognitive psychology redefining the functioning of human mind, moving from a modular amodal to a situated, embodied and simulative mind will be introduced. In the second one, studies on digital natives highlighting how the continuous and early employment of new digital technologies in communication and knowledge construction affects human cognitive processes will be described. In the third paragraph, learning will be reconsidered at the light of twenty-first century challenging evolutions and of opportunities given by SG. SG are conceived as interactive digital activities that through virtual simulations allow participants to make specific and precise experiences, able to promote active and involving learning paths through play activities. First, detaching from the idea of learning as transmission of declarative contents to passive learners employing symbolic and amodal knowledge representational format, Serious Games will be illustrated as promoters of appropriation and situated simulative learning. Following, innovations in learning will be elucidated showing how Serious Games endorse the combination of formal learning to informal play activities through the moderation of positive emotions supporting learning efficacy. Finally, overcoming the usual dichotomy between learning and evaluation in a “before-after” temporal sequence, a new construct of dynamic, *in itinere* and embedded assessment will be introduced within the framework of Serious Games highlighting related potentialities in terms of learning efficacy.

## 2. From modular amodal minds to simulative minds

### 2.1 The computational and modular mind

In psychology starting from the 60's, following behaviorism, the so-called cognitive sciences raised aimed at understanding the functioning of human mind, as system of knowledge with several functions as perception, memory, imagination, calculation, reasoning and planning. Within cognitive sciences the computational perspective of human mind [1] emerged as grounded in the theory of computability. According to this theory human minds are similar to computers since they share two relevant aspects: the ability to use symbols and to elaborate operations and calculi on these symbols. A specific pattern of simple elements can be employed to build complex cognitive processes: therefore any concrete reality needs to be represented in a symbolic amodal abstract format in order to be conceived and communicated.

Fodor [2] proposed a strong conception of *computational mind*. According to this view, the functioning of human mind is grounded on mental representations which are the combination of simple innate concepts as unique closed fixed entities elaborated employing formal logic and purely syntactic rules without any sensitivity to semantic properties. Therefore, the computational mind, able to translate mental representations in amodal symbolic propositions, acquires the essence of a *propositional mind*. Within this perspective the mind is conceived as system which, employing logic rules, performs sophisticate computations on amodal symbols, that are purely abstract arbitrary and not derived from sensory-motor modalities. Widening the conception of computational mind, Fodor [3] introduced the idea of *modular mind* as mind organized in innate specialized domain-specific and decontextualized modules with fixed neural

architectures. Modules are therefore encapsulated at informational level, as information contained in a specific module are isolated from other modules; only the output of other modules can be accessible but not the information employed to produce those outputs. Therefore according also to evolutionary psychology, modules can be conceived as universal and innate experienced systems aimed at mentally elaborating and treating issues related to specific domains. As universals, modules are grounded in the so-called “*darwinian algorithms*” which are rules able to transform the representation of an adaptation problem in an adaptive solution for that specific problem. According to this view it is reasonable employing the concept of *adapted mind* which involves a decontextualized, fixed, biologically determined and universal architecture of human mind [4].

Even though highly permeating the domain of psychology for about twenty years, the conception of amodal and modular mind has not received so far compelling empirical supports both in terms of neuroscience and behavioral studies [5] and it has been subjected to relevant criticisms [6, 7]. Most importantly, a high number of neuroimaging studies does not reveal any empirical proof regarding the existence of amodal symbols as exclusive core representational formats in human mind [8]. However, it has to be acknowledged the presence of some computational and syntactical aspects in the functioning of our mind although they cannot be considered more as exclusive and unique representational formats of our cognitive life [9]. Therefore, at present our mind cannot be conceived as autonomously generating amodal abstracts models employing formal rules and hence being decontextualized, universal and isolated from specific contingencies [3, 10]. Such conception of human mind plausibly suffers the so-called *error of essentialism* consisting in conceiving mental states as fixed regular entities; it implies a sort of *platonian blindness* as inability to consider the crucial relevance of the context [11].

## 2.2 The situated and simulative mind

Currently it would be more reasonable considering the human mind as *flexible and adapting* to specific contingencies [12] than as a fixed modular and *adapted* mind. Starting from connectionism [13], as relevant premise towards a dynamic conception of a mind able to instantaneously adapt to contingencies, within the contemporary scientific view the human mind is strongly conceived as grounded and *situated* in sensory-motor interactions with the environment, immerse in specific contexts [14]. Context therefore affects and leads cognitive activities according to its stimuli. Our minds more than elaborating, computing and storing abstracts and amodal symbols, have the main function of guiding and controlling our behaviors moment by moment in specific contingencies. The *situated mind* involve that knowledge, contexts and actions are tightly linked and not merely separated in different modules. The ground of knowledge are the actual daily activities and practices: to reliably and valuably have knowledge of a specific object or event is essential including information regarding the situation in which that object (or event) is situated involving actions performable on it. The meaning of a object (or event) is not a-priori fixed but it is radically dependent on its immediate context [15, 16].

The situated mind is also an *embodied mind*. Numerous empirical evidences support the “*grounded cognition*” perspective as knowledge is not based on amodal abstract symbols but it is grounded in experience, employing multimodal information derived from different sensory-motor systems [17]. The primary mental representational format consists therefore in elaborating multimodal simulative maps of a specific situations: according to this view, the *simulative mind* is able to know the reality through mental simulations. Starting from the 80’s Damasio [18, 19] showed how information coming from different sensorial and motor modalities, instead of being translated in amodal abstract symbols, are elaborated by related specific cerebral areas (visual, auditory, olfactory, etc.). By means of convergence-divergence zones (CDZ) and interconnection neurons information coming from different sensorial and motor modalities are integrated and reciprocally affect each others to elaborate a whole multimodal representation of the object or event. Each CDZ is an ensemble of neurons within many feedforward-feedback loops make contact. A CDZ receives “feedforward” connections from sensory areas located “earlier” in the signal-processing chains which begin at the entry point of sensory signals in the cerebral cortex. A CDZ sends reciprocal feedback projections to those originating areas. A CDZ also sends “feedforward” projections to regions located in the next connectional level of the chain and receives return projection from them [19].

Barsalou [20, 21] widening Damasio’s contributions, elaborated the perspective of *situated mind* implying that our knowledge is grounded in our experiences: the core representational formats of our mind are the perceptual symbols. A *perceptual symbol* can be defined as a recording of activations of a neural population derived from a perceptual or motor process. Perceptual symbols are generated for each aspect of experience: from vision, to other sensorial modalities, to proprioception and movements. As consequence, a wide variety of perceptual symbols is stored in a distributed manner in brain areas. The pattern of distributed activations regarding a perceptual symbol is integrated within a frame regarding a category (e.g. car): within this framework, visual information are associated and integrated to acoustic, motor, proprioceptive, motor and emotional information related to experiences with that category. Therefore, perceptual symbols are multimodal, derived by the entire sensory and motor modalities involved in our daily experiences and extensively distributed across different brain regions. The mental representation of the category “car” is hence grounded in a multimodal distributed systems across different modalities and associative areas of our brain. Barsalou [20] defined “simulator” the above described distributed multimodal system: simulators are dynamic open systems grounded in the context and flexibly able to enrich and modify our knowledge according to new experiences. A

simulator shows two structural levels: on the one hand, it operates as a framework which integrates perceptual symbols of a category referring to the experience of its many occurrences; on the other hand, it functions as device generating and producing numerous *mental simulations* starting from the available framework. A mental simulation is a central nervous process which in absence of real perceptual stimuli (offline) is able to reliably represent sensory-motor properties in order to mentally reproduce, in a simulative way, the original experience in its various components. Therefore, each simulator is able to re-activate perceptual symbols in its contained in order to generate specific mental simulations. A simulator may reactivate numerous mental simulations according to organism's needs, environmental affordances and stimuli in a specific contingency. A mental simulation is necessarily *situated* and *dynamic* as it refers to a contingent aspect of experience.

In conclusion, each mental simulation is a *multimodal situated conceptualization* related to a specific situation, able to represent and re-activate a certain aspect within a given context. The simulation creates the experience of «being there» and to operate “as if” events would occur following a defined path analogous to reality. According to the grounded cognition perspective [20], mental simulations are identifiable at the basis of a wide range of cognitive functions, as mental imagery, memory, categorization, conceptualization and language. Therefore, mental simulations hold a central role in knowledge, thinking, and learning processes of the human mind.

### 3. Digital natives: Evolutions of cognitive psychological functions

Besides new evidence highlighting that human mind is essentially simulative and situated, researches in psychology show how new generations encompass specific evolutions in their cognitive functions referable to prompt and constant employment of new technological digital artifacts [22, 23, 24]. In our contemporary time a cultural change can be identified as the so-called “Digital Natives” generation originates [25], also known as “Game Generation”, “Net Generation”, “Digital Kids” [26, 27]. For digital natives the so-called “new technologies” represent a natural dimension of their growing environment [28]. The regular employment of these media promoted the development of specific styles of learning and of acquisition of information. Digital natives show a prevalence of forms of parallel than a linear elaboration of information, of iconic than a linguistic system, and a high level of activity than a passive profile in the fruition of knowledge [22, 23, 24]. Digital natives are used to play videogames, exploiting mobile devices and Internet for abundant scopes, from information research in formal and informal activities to socialization. Essentially Internet is then modifying how kids read, remember and think [29].

Given these premises, digital natives show a diverse approach to *learning*; learning can be defined as relatively persistent modifications of behaviors following experiences generally repeated across time and it involves multiple cognitive functions as for example, attention, memory, and thinking. In terms of learning, digital natives seem systematically employ the “trials and errors” method [30] consisting in acting trying several behaviors as long as the correct one occurs. In digital natives the massive employment of “trials and errors” method is grounded in a different and innovative awareness and concept of mistakes and errors. While in old traditional schooling settings error may be viewed as a wrong answer, written on a paper sheet, unalterable and with no remedy, for digital natives employing new technological artifacts, both in formal and informal activities, the error is considered as contingent and transient, intrinsically involved within the learning process itself. Errors are in some way naturally foreseen as once made a mistake, using digital devices or Internet with a mouse-click users can start again the whole learning process. Again, in traditional school settings, teaching (lesson), assimilation (study) and static evaluation (exams) represented three distinct separate stages. Currently, digital natives are implicitly used to link these processes as new technologies promote the association of error and learning in a single process via dynamic assessments (see below paragraph 4.3).

Second, digital natives, skilled to immediate employment of new technologies, are used to obtain in a very brief moment information and answers that are searching for. Indeed, new media constantly and regularly provide a prompt fulfillment of expectations and requests, from searching a persons via mobile phone to download and replicates documents, etc. Especially digital natives, accustomed to fast rhythms, often show a low-frustration tolerance as well as low-waiting tolerance in every activity. As consequence, digital kids are not disposed to conceive learning as a gradual progressive path distributed and diluted in time. Instead, learning is viewed as *just-in-time learning* [31] since individuals from digital generations are ready to learn, acquire and get skilled just when it is needed. This form of ad-hoc learning is dynamic, fast, interactive and involving as it often implies immersion in virtual environments [32].

Finally, it is reasonable believe that given the massive and recurrent employment of videogames and virtual environments digital kids have acquired a higher level of *simulative mind* compared to non-digital generations; they are also highly used to switch between real and virtual simulated worlds [22] and to proceed in learning employing diverse knowledge and comprehension levels. Most importantly, virtual environments provide representational and sharing formats of knowledge not much amodal and symbolic but above all multimodal, simulative and experiential, involving at least visual and auditory stimuli, reproducing simulations of environments and situations in which users are asked to be actively involved, to imagine to “be there” and “acting as if”. Digital natives are therefore featured by a specific mental structuring, used to contexts rich of multimodal stimuli, where perceptual, iconic and motor components are prevalent than linguistic symbols.

In conclusion, digital natives share a specific mental structuring having cognitive and learning styles radically different than previous generations, as the employment of Internet and digital media implies a specific organization of knowledge, a diverse methodological structuring and evolution of data elaboration and cognitive styles [29, 33].

#### **4. Learning in the twenty-first century: Serious Games as new cultural virtual artefacts**

In previous paragraphs it has been highlighted on the one hand, how human mind is essentially grounded in situated, multimodal and simulative representational formats, more than in decontextualized abstract amodal symbols and propositions; on the other hand, evidence regarding new cognitive styles and learning approach of the so-called “digital natives” have been described. According to these perspectives on contemporary human mind and mental structuring of new generations, schooling and learning institutions as well as pedagogical sciences should take into account the above presented contemporary evidence to excellently and effectively accomplish their educative functions. Innovative models, practices and devices need to be proposed and actually implemented to better approach to principles which lead the functioning of human minds in the twenty-first century. From our point of view contemporary and outstanding challenges need to be faced in learning scenarios for digital natives having situated and simulative minds. To guarantee high level of involvement and motivation in learning processes, a radical redefinition of theoretical and methodological premises related to teaching-learning formats is required. According to this aim, a specific path of redefinition of learning processes will be described explaining how Serious Games represent a relevant opportunity to promote these changeovers and to achieve these challenging contemporary goals.

Serious Games can be conceived as interactive digital activities that through virtual simulations allow participants to make specific and precise experiences, able to promote active and involving learning paths in several domains through play forms [34]. Likewise, Bryan Bergeron [35] introduces a similar definition: a Serious Game is a digital interactive application entailing a challenging goal, being involving and fun, including a scoring concept, and providing participants an ability, knowledge or attitude to be applied in the real world. Thus, Serious Games are grounded in the combination between simulation, learning and game.

Covering the path of re-thinking learning processes involving Serious Games, three main challenges will be following introduced. First, we highlight how simulative situated minds, all the more so in digital natives, would gain greater efficacy, using Serious Games, in learning from multimodal simulative digital knowledge representation formats more than exclusively from abstract amodal symbols. Second, matching digital natives’ approach to knowledge construction, the challenge of merging formal learning to informal play activities via the employment of Serious Games and related positive effects on learning will be shown. Finally, an innovative conception of dynamic assessment which overcomes the traditional dichotomy between learning and assessment as two distinct, fixed and detached entities will be explained describing how Serious Games may be exploited to operationally boost this view.

##### **4.1 Situated simulative learning and Serious Games**

Traditionally learning has been viewed as “transmission of knowledge”, considering novices as sort of “bins to be filled in” with formal instructions by experts, therefore involving a strict dichotomy between active (teacher or expert) and passive (novice or learner) roles in learning. According to this view learning is conceived as faithful copy and repetition of contents transmitted by experts. The relationship of one teacher towards many students within classrooms and unidirectional transmission of knowledge promote the above described approach to learning. Moreover, the view of learning as transmission typically, and often exclusively, entails symbol-based knowledge representational and sharing formats: knowledge is translated in amodal, often decontextualized, linguistic and symbolic formats, within oral or written materials. The above described mechanical view of learning as cloning between models and copies is currently obsolete. At present, Serious Games may represent a valuable option to optimize the overcoming of the traditional knowledge transmission approach in several aspects.

First, Serious Games promote a *balanced proportion of activity and passivity of learning between experts and novices*: learning always occurs in a physical and relational context where interactions between games’ designers (the so-called “experts”) and users (“novices”) takes place in a dynamic and open way through mutual sharing of activities. Within this exchange expert and novice are both active protagonists in jointly building the learning process; they are necessarily interdependent as Serious Game designers “teach” what users are actually able to learn and viceversa. At the same time, learning via Serious Games though participatory approach is carefully guided: the so-called “guided participation” implies not only a specific distinction between the expert (game’s designer) and the novice (game’s user), but also the sharing of meaning and reciprocal structuring of learning activities: learning grounds in a reciprocal connection between game moves expected by designers and those executed by players. Participatory appropriation, as active and participatory view of learning, is vital for learning processes in a wide variety of fields [36]. In particular, a Serious Game is designed and created according to a specific project (instructional design), so that it could be defined a “designed experience” [37] elaborated by multidisciplinary expert teams [38]. Therefore, the sequence of game’s moves

and operations to be carried out, and related learning, proceed in a designed progressive gradual manner [39]. At the same time, users have relevant degrees of freedom to think, experience and make decisions in performing game's moves within the simulated situation.

The immersion within the specific situations imply a profound experiential participation of users in learning activities, promoting high concentration on tasks and therefore a careful observation of each learning steps related to complex situations and actions.

Second, carrying out a Serious Game represents a precise experience, aimed at reaching a specific goal to acquire knowledge or improving competencies. Serious Games' experience is not an abstract theoretical decontextualized learning, but rather a *situated learning* as it is linked to specific situations and immersed in defined immediate contexts. In particular, the context is conceived as matrix of meanings, as set of conditions which allow the understanding of contents of proposed gaming and learning activities promoting versatility of acquired knowledge [16]. As consequence, situated learning is an experiential learning where experience is here conceived as what we know through our sensations and actions. Compared to the above described learning as transmission, Serious Games are open and interactive learning experiences, featured by a dense complexity of situations, by a robust architecture with many inferential potentialities, and involving important efforts in participating choices and moves to be executed. Serious Games users participate and experience the game with their identities, pre-existing knowledge, interests, ability to follow the proposed game-learning paths in order to improve their general and specific level of competency. Therefore, Serious Games allow a highly tailored individualized experience, as each user participates according to its background, level of encyclopaedic knowledge, attitudes and expectations.

As just above described Serious Games entail situated learning, as learning is constantly immersed in re-enacted simulations of specific events, operation or process. The re-enactment of simulated events or processes not only implies space-temporal coordinates, but it involves the adherence to real conditions through simulation; learning is hence grounded in a "situated knowledge" intrinsically linked to a contextualized local contingent situation [21;40]. Therefore simulation entails a strategic relevance as ultimate architecture for learning mediated by Serious Games. Unlikely than deductive reasoning, symbolic explanation or academic lessons which usually follow abstraction and linearity principles, the simulation entails multiple information regarding different levels of knowledge. Beyond logic and theoretical aspects, simulation refers to multimodal sensory-motor representational formats: visual and auditory formats are included, and within the sequence of a simulation users also perform gestures, movements and coordinated sequential actions through the computer.

Learning conveyed by Serious Games is therefore *simulative*. The form of simulative learning is consistent and in line with current evidence regarding the cognitive representational formats of human minds: the re-enactment of episodes, events or processes more than computational elaboration of abstract amodal strings of symbols characterize our cognitive functioning. Our mind simulates concrete and abstract concepts, from the concept of "car", "cake", freedom to the procedure to make a cake, to drive a car or performing tangos steps. Declarative is therefore tightly linked to procedural knowledge, as when our mind simulates the concept of "car", generally the simulation of behaviors to drive that car, or other affordable actions related to that concept are involved. Procedural knowledge also known as "knowledge in action" refers to ways and procedures to execute tasks in different situations according to different information provided moment by moment by working memory. Given this intrinsic feature, procedural knowledge can be learnt only by means of exercises and sharing of behavioural models via simulations.

Given their simulative features Serious Games are suitable to effectively maintain, support and augment individual encyclopedic knowledge and competencies, both in terms of declarative and procedural knowledge. In other words, Serious Games can be conceived as situated simulated conceptualization [21] showing robust advantages to re-write the whole declarative knowledge in multimodal sensory-motor simulative formats and to significantly activate learners' mental resources.

#### 4.2 Merging formal learning to informal play activities: The moderation of positive emotions in Serious Games

The possibility to merge formal learning to informal play activities also represents a relevant challenge that new learning models should embrace in the twenty-first century. Traditional learning views show a clear-cut separation between learning as formal serious instructional activity and entertainment as opportunity to experience positive emotions, where these two distinct activities show different settings, environments, time ranges and rules: there are classrooms with chairs and desks dedicated to formal learning activities and spaces for having fun, specific time for play and time for learning, as well as rules that regulate formal instructional activities and amusement.

In our contemporary era, digital natives are used to interact within social networks, to play videogames and to live in virtual environments like Second Life choosing avatars and interacting in multimodal simulated worlds involving enjoyment aspects. Therefore, this generation shows a specific profile in knowledge searching, construction and sharing featured by the combination of play aspects with formal structured goals. The distinction between serious formal activities and hedonic doings is gradually decreasing in current years. However, the interplay between play aspects and learning is not new even for older generations, as actually, human mind is a play mind: in children cultural

appropriation occurs via play activities, and play also mediate the development of a wide variety of competencies, from fine movement execution, to perceptual discrimination, lexicalization, conceptualization as well as social competencies.

Serious Games, as new methods for learning, combine a serious goal (e.g., learning or increasing awareness in some domain) with play aspects. Especially they refer to an optimal valorisation of emotions and as games they are able to trigger important emotional experiences implying positive outcomes on learning. Serious Games entail intrinsically pleasant and gratifying tracts, with a high level of involvement, and promote the repetition of gaming experience. The hedonic aspect of Serious Games refers to different pleasure levels. From a sensorial pleasure, triggered by multiple visual and audio stimuli with rhythmic sequences, to the pleasure for the success or victory, as reaching a goal elicits high level of satisfaction [41]. The pleasure for the success is featured by the awareness to perceive oneself efficient, achieving good results and performance, even facing against difficulties and solving problems [42]. This kind of pleasure may be identified as “functional pleasure” [43]. Moreover, Serious Games may generate a pleasure for discovery related to curiosity. Curiosity is a relevant factor to direct psychological resources to explore the unknown. The discovery and curiosity pleasure is related to emotional demands to complete a task living a completed meaning to a mental activity [44]. Finally, multiplayer Serious Games produce pleasure related to social interactions, as competition, comparison, and cooperation are undeniably present.

Dealing with general aspect related to learning processes and outcomes, Serious Games given their emotional components, not only accomplish a merely entertainment function but more importantly promote attention, memory and learning processes. As far as regards attention, Serious Games, as emotionally marked activities, attract attentive resources distracting individuals from divergent stimuli. Therefore, the emotional valence of Serious Games promote tasks’ execution and learning focusing mental resources and pointing consciousness processes [45]. This phenomenon is generally identified as “narrowing of attention”, as attention reduces the focal field of activities’ orientation, neglecting marginal aspects [46]. Referring to the psychological function of memory, Serious Games as activities prompting medium-intense emotions, have the opportunity to produce a strengthening of memory. In fact, tasks triggering a not traumatic medium-intense emotional activation, promote more precise, detailed and enduring recalls than neutral tasks [47]. Neurobiological studies highlight the potentiality of positive emotional activities in strengthening learning and memory as supported by specific neurophysiologic processes. For example, noradrenaline and cortisol involved in pleasure activities impact on the amygdala consolidating explicit memories [48].

Given the above described emotional features and characterization as emotionally-marked activities, Serious Games encompass high potentialities to become “optimal experiences” for users. The idea of “optimal experience” [49] refers to the awareness of trade-off between high challenges provided by the environment and adequate personal skills to cope with them, as the activity turns out to be not too easy (triggering apathy and indifference) and not too difficult (triggering disengagement and drop-out). It involves clear goals, a high degree of concentration on a limited field of attention, a loss of the feeling of self-consciousness, direct and immediate feedbacks (successes and failures in the course of activity), a sense of personal control over the situation, a distorted sense of time, intrinsic rewards of the activity performed without efforts, a lack of awareness of bodily needs (to the extent that one can reach a point of great hunger or fatigue without realizing it).

Serious Games given their specific features entail the premises to promote a “optimal experience of learning”. Specifically, they involve a high degree of concentration of mental resources on the activity without external interferences [50] and a profound immersion and absorption into the activity [51]. Individual cannot choose or decide when to enter in a optimal experience; instead it occurs when there is a specific interaction between individual competencies and interests, while the person is involved in a given task with defined goals, when an adequate trade-off between perception of challenge and competencies exists, and if immediate and clear feedbacks are given while performing the activity in order to proceed towards suitable adjustments. Clearly, Serious Games highly satisfy the above cited conditions, and as potential optimal experiences, promote forms of hyper-learning [49]. Hyper-learning consists in mental ability to totally concentrate on a given task, referring to visualization, simulation and analytic attention on single action; hence it allows a huge expansion of own learning abilities and achievement of excellent performances [52]. Finally, Serious Games and related optimal experiences induce positive emotions and increase self-efficacy, which in turns support learning efficacy in a virtuous circle. In conclusion, Serious Games, as emotional experiences and potential triggers of optimal experiences of learning, provide a clear benefit compared to traditional forms of learning and teaching, which are usually rational, abstract, emotionally neutral, and conceived as a plain duty. In this way Serious Games fade away the clear-cut border between formal and informal activities embracing digital natives’ trends in managing learning and knowledge sharing processes.

### 4.3 Overcoming the dichotomy between learning and evaluation: Dynamic assessment in Serious Games

Serious Games also foster new challenges for the concept of assessment as crucial phase of each kind of learning process. In traditional learning systems assessment is usually performed via interviews, questioning, examinations and a variety of tests, within a “pre-post” temporal articulation. Traditional learning view implies that assessments are localized before and after the learning phase putting a clear cut distinction between these two processes. Employing tests the measurement of a wide variety of competencies is feasible, as for example numerical ability, verbal reasoning,

spatial relations, memory, linguistic comprehension, attention, etc. Whereas many validity criteria would be satisfied, using tests and questioning a standardized measurement of specific competencies can be achieved [53]. Beyond undisputed benefits, these traditional assessment methods show high risks of distortions, generally due to reliability constraints (higher probability of error with lower number of test's items), validity constraints as well as to emotional states and attitudes of individual subjected to the assessment situation [54, 55].

Serious Games provide a new method of assessment for learning, since beyond employing traditional techniques, they offer more complex and complete measurements, as the so-called "*in itinere* evaluation". This form of dynamic evaluation allows to provide feedbacks and evaluations not only at the end but even during the learning process itself (at the end of a specific subtasks or game phase or after a specific user's game move or choice) [56]. Therefore the traditional dichotomy between time frames for learning and for estimation of outcomes can be overcome via Serious Games' dynamic evaluation focusing not only on the assessment of outcomes but also of the process of learning. As consequence, it implies huge opportunities to better adjust learning experience deepening the ways users are learning, difficulties and learning styles, and giving immediate feedbacks.

However, Serious Games must face important challenges in order to ensure adequate and efficient dynamic assessment processes. In particular, key questions regards how Serious Games may verify that users are actually learning according to specific learning goals, how Serious Games can ensure that what we are measuring truly coincide with what they aim to measure, and how to make measurement processes involving and attractive.

Currently, Serious Games entail sophisticated assessment techniques, regarding several aspects. First they entail the assessment of the task completion, with indexes like users ability to ride over trials and time employed to finish tasks, degree of data retention and accuracy of memories' recall. Beyond this aspect, *in itinere* assessment involves the evaluation of reasons grounding games' choices and moves performed by learners, as well as the number and types of self-corrections that users made in re-experiencing the game. Dynamic evaluation may also entail the assessment of errors in terms of frequencies, types and localizations within the learning path, as well as the evaluation of the timing and capacity to learn from errors. Even more finely, Serious Games allow to evaluate behavioural models, as tendency to risk taking, timing and modality of decision-making processes, or the employment of stereotypical and conventional behavioural models; the assessment of ability to embrace strategic perspectives or tactical conceptions, or vice versa more temporary and impulsive viewpoints, as well as the evaluation of perseverance in executing tasks may also be included.

In this way Serious Games allow constant and complete assessment through a continuous tracking system of users' learning and gaming experience. Learning activity may be analyzed and measured moment by moment, verifying the more difficult or easier steps for learners. Therefore, it is possible to make a sequential, continuous and complete "diagnosis", with a combination of multiple reliable data and indexes that hence strengthen the validity of the assessment itself. As already cited above, Serious Games can be conceived as a potential revolution in the assessment processes: differently than in traditional learning views, the separation of learning and assessment (pre and post), between process (before) and outcome (after) is cancelled. In Serious Games learning and evaluation occur at the same time: the learner is evaluated at the same time in which he is actually involved in learning activities, and he receives in-time feedbacks during the act of learning itself. Hence, as already [57] mentioned introducing the concept of "zone of proximal development", a relevant learning expansion is achieved since learners are able to correct their mental structuring, to consider alternative aspects, to focus attention on more peripheral elements and to combine them in innovative ways. Conversely, in traditional learning settings the static evaluation assesses the outcome of learning and errors at the conclusion of learning process lacking the chance to adjust it toward greater efficacy.

The intrinsic interdependence between learning and assessment exemplifies a recursive virtuous cycle which allows not only to correct possible distortions while they occur, but also to profoundly strengthen learning processes given these constant feedbacks. This kind of assessment *embedded* in learning is mostly valuable in Serious Games conceived as promoters of optimal flow learning experiences. Thus, the assessment can be defined as "formative evaluation" as it allows to further potentiate the optimal learning experience within a "flow and growth" logic. However, dynamic evaluation does not exclude traditional assessment methods since they may be included in Serious Games employed at the beginning, at the conclusion and in a follow-up phase to respectively measure entities and persistency of learning outcomes. The combination of assessment performed during and before-after Serious Games, takes a relevant motivational value constituting a significant incentive to repeat gaming and learning activities: these before-after evaluations within a play setting of learning trigger the desire to challenge and improve oneself getting enhanced performances in repeating the experience. This self-competition device entails a self-corrective facet as it gives the opportunity to better comprehend errors and to implement alternative solutions. In conclusion, even if research on Serious Games as assessment method is currently still in development requiring complex and precise designing, it is however evident that Serious Games may be conceived as intrinsic forms of evaluations [58] with relevant future potentialities in a wide range of fields.

## 5. Conclusion remarks

At present Serious Games represent a cultural revolution, since being able to simulate each aspect of the experience, can be conceived as the royal road to acquire and improve competencies in each field of human existence. As new method for learning and training, they succeed to mutually summarize the simulative, learning and play dimensions: as a matter of fact, they give the opportunity to become experts in specific fields via simulations while playing and enjoying. Learning through Serious Games means a innovative way to learn that, matching needs of digital natives' generation, lead to overtake massive milestones of traditional learning approach as the pure transmission of knowledge via abstract amodal symbols, the detachment between declarative and procedural knowledge, the classic dichotomy between instructional formal and informal play activities, and the distinction between evaluation and learning phases. It is not a dramatization to say that SG can be the future of learning.

Therefore, Serious Games have the capabilities to jointly satisfy teachers' didactic needs and matching the expectations of digital native learners in terms of attractive learning experiences, featured by multimodal simulative representational formats, the involvement of play aspects and in-learning embedded evaluations which rebuild new conceptions of errors and learning processes.

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