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By Martín J. Mazzoglio Y Nabar, Rubén D. Algieri & Elba B. Tornese
Buenos Aires University

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Gamification or Gaming Techniques Applied to Pedagogy: Foundations of the Cognitive Neuroscience Applied to the Education

Martín J. Mazzoglio Y Nabar [α], Rubén D. Algieri [σ] & Elba B. Tornese [ρ]

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I. Introduction

Not only the teaching strategies have evolved over the years, but also the teaching models according to the educational paradigms of each period. Students have changed, and the teacher must adapt to this new group of learners to generate the necessary cohesion and to extract the maximum potential from them.

In this context, two factors sum up as inflection points:

- The explosive spread of the Web and its social meddling since the late 90's, which showed us the transformation by the new technologies, its diffusion, and the adaptation in various fields, among which the education sector received the greatest revolution both in the teaching and the learning processes because the web technologies forever changed the focalization, conceptualization, memorizing, and task resolution (each of these processes correlate with specific neuroscientific activities).
- The development of the neuroscience, which has evolved thanks to several types of research in the various levels which shone with findings during the *brain* decade - the 90's, but especially in the level of the clinical application and the utilization of many postulates in heterogeneous fields, such the education.

The rate of school dropouts in the superior courses is high in our country. However, without referring to dropout itself, the low cohesion of the students in many subjects is notorious, and it is a factor which triggers disturbance in the learning process and its continuity.

At the university level, the adherence to several courses is also low, and it triggers the minimal effort will: to simply pass the course. The lack of cohesion is detrimental to the marks of the subject and the significative learning that the student is meant to achieve. The adherence is associated with the lack of motivation that most students feel in relation to the traditional lessons and to the educational resources applied with old-fashioned didactics techniques; when they exist.

The classical paradigm in the education follows a logical reasoning based on the assumption the person who has the knowledge would teach it and would also explain the lessons in a one-directional way. The focus was on the teacher, the knowledge, and its learning. Nowadays, the current paradigm implies a dissolution of the teacher-student asymmetry, the learner faces the search for the knowledge and its acquisition in a non-structured process. The student has a dynamic and active role in the processes of teaching and learning, must have a proactive attitude to "build" one's own knowledge (with attention to the neurocognitive construct) and should have the aim in generating the competences to materialize the learning.

There are many didactic strategies to achieve and go in-depth into the postulates of the current paradigm, among which the learning is directed by the game – also known as ludic learning or gamification – a term whose origin took place in the computer software field. The game-design premises implement procedural aspects, the implication of neurocognitive processes, the neuroscientific bases and the pedagogic impact.

The construction of the knowledge is not opposed to the training, the existence of the learning demands the activation of several brain areas, among which it is important to highlight the reward system of the brain and the medial structures of the temporal lobules (hippocampus cortex) and the amygdala nuclear complex. These brain structures and the circuits which interconnect them are activated by the practice of the game due to the intrinsic motivation this activity generates – rising the dopamine levels in the reward circuits, the uncertainty and the newness regarding each

Author α σ ρ: Pedagogy Laboratory and Education Sciences, 3rd Chain in Anatomy, Medicine Faculty, University of Buenos Aires.
e-mails: mazzoglioynabar@hotmail.com, mazzoglioynabar@gmail.com

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change, the emotions that produce curiosity and stimulate the attention to ease the learning.

The aim of this work is to describe the bases of the cognitive neuroscience applied to the ludic techniques in the context of teaching.

II. Development

Games are as old as humankind, but it was Huizinga who took the concept of the ludic activity to reshape it into a teaching resource related to the culture in his work *Homo Ludens,* from 1938.

The ludic learning or the learning by games, or ludic techniques applied to the education was developed as a didactic strategy by the driving forces of the *new school.* Several authors, such as Brunner, Frebel, Decroly, Montessori, Cossettini, and Freire have analyzed its essential function in the children's growth and the didactic projections that are deduced from the activity. The experts highlighted the educational value of the games and their impact in the cognitive strategies for task resolution, attention improvement, and memory retention, and as a motivating and creative element during/after the lessons, and as a supportive and deepening resource. Decades after, neuroscience researchers, such as Jiménez and Francisco Mora, described the pedagogic foundations related to cognition and emotion, as well as the utilization of cognitive neuroscience and clinical studies in the educative context (neuroeducation) to understand the neuroscientific foundations.

The gamification or ludic learning is the process of incorporating the mechanics and techniques associated with the game design to non-ludic environments *per se.* However, the education goes beyond that initial stage because it also consists of motivating the students to go through the transforming rewarding experiences of the learning process. The technology is a resource that sums up to the service of the learning objectives as an instructional means or as an element to fix special moments of the learning and teaching processes.

The game is an activity which takes place within certain limits (regarding place, time and will) following rules freely agreed previously. The games generate enthusiasm, emotivity, tension-distension, curiosity, among other reactions. There are two phases of this process:

- Phase 1: productive activity, without competition. The participants get fun.
- Phase 2: competition, the realization of the goals and achievements.

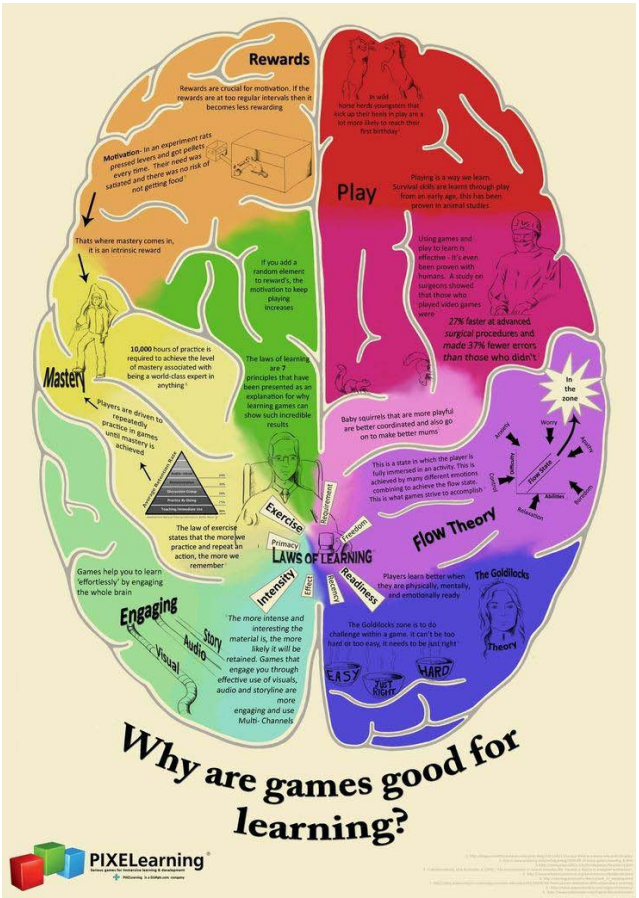

Figure 1

According to the researchers in the education and informatics fields, the students require at least 4 positive impacts to succeed:

1. *Motivational:* Produces a continuous increment as the game progresses.
2. *Cognitive:* Improves the attention (focalization and executive) and the reaction times.
3. *Social:* Translates the social abilities learned with the relationships outside the ludic environment.
4. *Emotional:* Promotes a positive mood and the adaptive regulation.

The integration of the ludic component in the teaching methods enables an indispensable tool which can be applied to any subject, in any educative stage, being the most important condition the existence of a clearly-defined objective for the learning. In 2009, Ana Forés and Marta Ligioiz described various factors which they identify as learning promoters:

- Stimulation of the curiosity: the game allows the discovery of new opportunities, more creativity, and the progress in the game questions about the decisions to make.
- Encouragement of the self-improvement and challenge of self-confidence: the *feedback* from the game generates perseverance and resilience.

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- Interiorization of patterns and rules: the rules of the game delimit the space and the structure of the logical thinking.
- Stimulation of physical, psychical, affective and social functions: the characteristics depend on the type of game. The groups facilitate the cooperative learning.
- Generation of pleasure and satisfaction: the student tests, explores and takes over the mistakes to improve. Enables the reward mechanism.

Researchers have carried out scientific studies to test the differences in the brain level among people who perform tasks in ludic learning environments and those who take part in classic learning tasks. The studies conducted by Howard-Jones et al in 2016 showed a high activation of the corpus striatum (especially in the ventral region or the nucleus accumbens) and the subcortical region related to the brain reward system and underactivity in the neuronal network which intervenes in the attention during the wakefulness.

Previously, in 2014, Gruber et al had explained that the most important factor is not the value of the reward but the unexpectedness and the uncertainty that the process generates. For that reason, the activation of the reward system is a crucial point, and unsurprisingly it plays an active role in the gamification.

During the investigation by Howard-Jones et al a sustained hyperactivation was observed in the ventral striatum in the precise moments than the participants received a positive feedback, information that allowed the researchers to know what and how the subjects learn, easing their autonomy, the precision of the significative learning and the modulation of the progress according to the subjective pace of the learner.

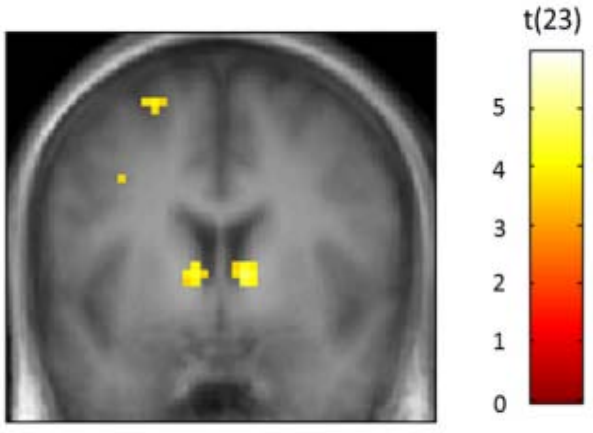

Figure 2

Figure showing the bilateral hyper activation in the level of the ventral striatum when the participants answer correctly to the question in a gamified environment in relation to someone who studies in a different environment (Howard-Jones et al, 2016).

The authors observed and described facts related to the underactivity of the wakefulness' attention net during the gamification experience would be related with the necessity of the learner (and the brain) to focus the attention to the external stimuli which the gaming experience provides to ease the learning by the connection these associate areas along with the focalization and the executive attention and the circuit mnesic connections.

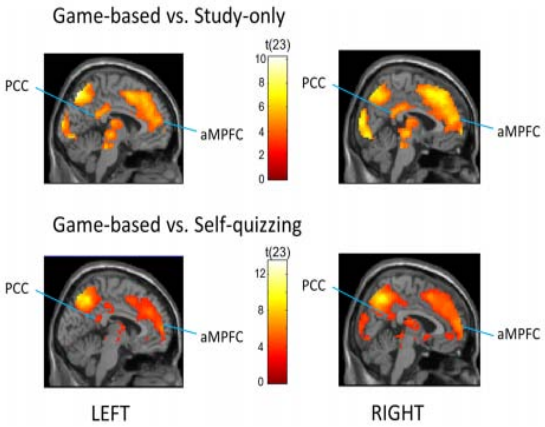

Figure 3

Figures where we can visualize the under activation of the neuronal network wakefulness' attention in gamified environments in contrast to non-ludic ones. (Howard-Jones et al, 2016).

During the process of an experience in the ludic context, a series of neurochemical events related to various neurotransmitters activate (dopamine, serotonin), endorphins and hormones (oxytocin) which motivate and improve the learner's mood, strengthen the bonds within pairs for cooperation.

The relation of the amygdala corpus with the reward system and the hippocampus cortex lies in the emotion as an axis around which the whole experience spins. Precisely there lies the foundational basis of a good education and it opens the learning by the attention. The emotion interweaves the curiosity, which sustains the attention when facing a cognitive challenge.

Resuming the postulates from Gruber, the behavioral neuroscience focalizes in the anticipation of the reward, the activation of the neurons in the accumbens nucleus release dopamine that impacts in the intrinsic motivation levels. In the brain level, the motivation self-reinforces with the continuous predictions in a ludic environment, this the reason why the choice of the game must provide suitable cognitive challenges with continuous feedbacks to keep the interest and the motivation.

The largest activation takes place when an answer surpasses the initial expectations, in other words, when the forecast bias is positive. The unexpected rewards generate curiosity due to the newness status they imply and drag the attention that is

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needed to learn. This curiosity and the associated uncertainty also increase the motivation and the learning with impact in the memory.

In 2015, Rodríguez and Santiago commented the 10 pedagogic aspects behind the necessary fusion of the game and the learning. They described the following:

1. Motivation
2. Focus on the student
3. Customization
4. Increase of the learning
5. Contextualization
6. More multimedia richness
7. Failure without risk
8. Immediate feedback
9. Practice and reinforce generation
10. Collaboration encouragement

Out of these ten factors, the researchers highlight two which are especially relevant in any ludic environment: the challenge that is associated to the game, as a motivating element, and the feedback provided during the activity which briefs about the progress and creates a student/player duality in the learner to reach the suggested goals.

The research team in the University of Auckland, led by John Hattie, analyzed over 15 years over 50,000 studies in which 240 million students took part worldwide with the aim of recognizing the most important factors which influence the academic performance. They used a methodology based on the classification according to a statistical parameter (size of the effect "d"). Those factors which had d > 0.60 were considered as good or excellent due to high impact, whereas those with d < 0.20 were labeled as negative or irrelevant.

They found that the cooperative learning, the feedback, the influence of the classmates, the implementation of programs based on metacognitive strategies and the use of simulations and game designs has a high effect (d > 0.60) Therefore, all these factors are involved in the ludic learning.

Last, and in relation to what was mentioned about the traditional paradigm in education, Prof. Eric Mazur from the University of Harvard researched about the learning process among his students and verified that there was a predominance of superficial knowledge along with difficulties to abstract theoretical contents to every day's contexts.

Precisely the didactics carried out by him and his colleagues were characterized by the traditional master classes with the expository methodology. In 2010, Poh et al conducted a research-based in the use of a device to measure the electrodermal activity, a register of the activity of the nervous sympathetic system while doing physical, cognitive and emotional activities. They applied this methodology to college students to extract daily patterns of physiological activity and they found peaks in the activity when the subjects were doing academic tasks, lab work, and during the exams, surely related to the cognitive demand and stress that these activities produce. But the amplitude and the frequency of the recorded waves decayed significantly when the students listened to master classes from their professors, reaching similar values to other records, such as watching TV or even some phases of relaxation during the sleep.

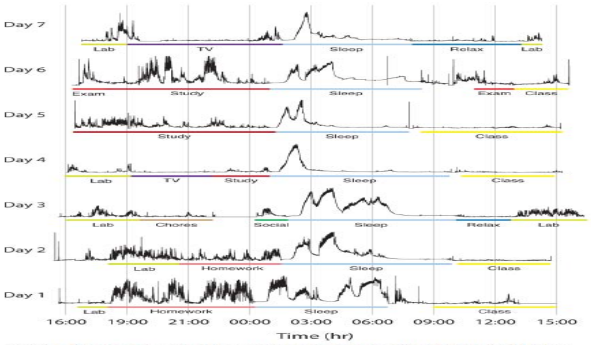

Figura 2. Registro de actividad electrodérmica de un universitario durante las 24 horas del dia al realizar distintas tareas cotidianas en su casa y en el aula (Poh, Swenson y Picard, 2010).

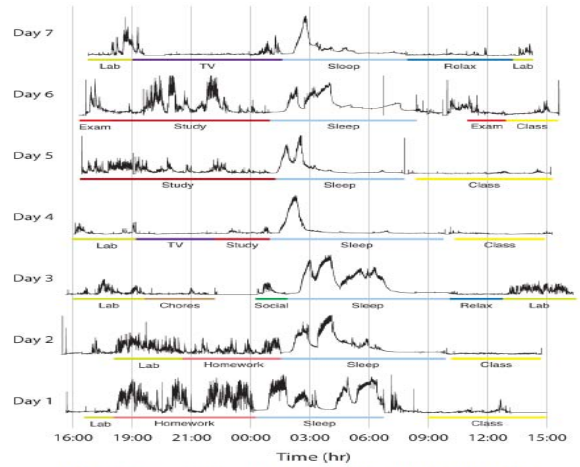

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Figure 4

Register of the electrodermal activity in different tasks performed by college students. (Poh, Swensony Picard, 2010).

Although these results do not imply that the master classes and that certain concepts or topics should be addressed that way, the predominant choice of this didactic resource places the student as a passive receptor and jeopardizes his/her motivation and learning.

Dolana y Collins from the University of Texas described that whenever a professor transfers the voice to the student and the pupil participates actively his/her performance improves.

Although it is not the purpose of this article, there are several ways to generate gamified environments. Likewise, the technology provides various software tools to create the activities in these

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environments, but the teacher should not forget that it is the training the leading force of this process.

III. Conclusions

The learning mediated by the game, known as ludic-learning or gamification, is an innovative proposal which complies with several pedagogic and didactic postulates, and with the theoretical framework of the cognitive neuroscience. The recent studies in applied neuroscience to education account for its importance and the impact in different brain areas related to the learning and the necessary factors to build up a significative teaching process.

The main advantages of the gamification are related to the activity that the game designs generate in the neuronal circuits linked to the motivation, the response to uncertainty, the cooperative learning, and the improvements in the executive attention with impact in the memory.

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