Reflections on Playfulness, Imagination and Creativity, their Relations and Open Questions

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Abstract — **We are currently interested in the study of core concepts: playfulness, imagination, creativity. In here we are looking at existing theoretical perspectives on these concepts, trying to understand the relationships between them, to identify unanswered questions. While trying to put into evidence the relationships between these concepts for the study of creative processes, we aim at designing future solutions for digital media or technological support for collective creation. At the moment we realize that there is a lack of consensus around these concepts and the way they interrelate, how they can be studied and their relationship with technological innovations. Finally, we enumerate several unanswered questions in this context.**

Keywords – playfulness, imagination, creativity, contexts for collective imagination and creation.

I. INTRODUCTION

This study is motivated by the investigation of the existing and possible relations between three core concepts that have long been present in the diverse sets of literature and that are transversal to several distinct, yet complementary domains of knowledge and research. These concepts are playfulness, imagination and creativity. We conjecture the way these concepts interrelate may provide insightful perspectives on how to organize and intervene in creative processes, especially with implications for pedagogical, social and cultural practices, where the playful quality of certain individual and social human activities seems a key characteristic.

In this paper we present a brief literature review on the above mentioned concepts. From the readings concerning play/playfulness, imagination and creativity, we try to define them, provide a vision on how they may relate and come forward with a first attempt of an operational proposal for a pathway from play to creativity. We conclude by enunciating some questions that we envision to answer with further work.

II. CORE CONCEPTS AND THEIR POTENTIAL RELATIONSHIP

A. Play

As evidenced by literature review [1], [2] play is a large and diffuse area of activity and has increasingly been recognized as integral to lifelong learning [3].

Play is considered a complex phenomenon, not easily defined or even described [4], and its definition is not a consensual one, ranging from an exclusively human pursuit, to a highly structured activity or to a complex manifestation of human emotions [1]. Several authors ([5]; [6]; [7]) have enunciated distinct, yet complementary, definitions of play.

We must acknowledge the early contribution of [6] sociocultural theory, that introduces a wide range and very fundamental notion: that "play" is the imaginary realization of unrealizable desires.

In his works [6] studied play; however, for pre-schoolers and school aged children, the author did not include many kinds of other spontaneous activities that others refer to as play, considering that in play, children create an imaginary situation, and that this is possible due to children capacity of separating vision and meaning.

[6] states that "the child in wishing carries out his wishes; and in thinking he acts. Internal and external action are inseparable: imagination, interpretation, and will are internal processes in external action" (p.13). In play, an imaginary situation is created. Within a play situation, with an imaginary situation, children begin to act independently of what they see, hence learning to guide their behavior, not just by perception, but also by the meaning of the situation.

Furthermore, the imaginary situation is the crucial attribute of play in general. Furthermore, for [3] the three components of "real play" are: the creation of an imaginary situation, the taking on and acting out roles, the setting and following of a set of rules.

[5] defends that the "play spirit" is the civilizing factor in human development, and provides an anthropological definition of play as a "magic circle" that enables make believe or alternate modes of behavior, of voluntary nature and negotiable consequences; [8] tries to dissect the play forms and to identify specific play components: agon or conflict, mimesis or roleplay, chance, and vertigo, that can mix to originate a diversity of play forms.

Moreover, [8] considers that the term "play" covers more specifically the "spontaneous" manifestations of play, introducing the idea of a continuum of related activities

ranging from Paidea (greek for the free from of play) to Ludus (greek for games or highly structured forms of activity).

Later, recovering the psychological study of play and playful behavior, [7] concludes that "play" is an essential infrastructure of creative thought.

To enrich this discussion on play, [7] has brought into focus the element designated as playfulness and defined it as physical, social and cognitive spontaneity, manifest joy, and sense of humor. This element of playfulness is considered as a quality of play that eventually survives the age of play, hence becoming *a personality trait* of the player in adolescence and adulthood.

Moreover, playfulness is conceptualized as the "disposition that is manifested by the qualities or attributes that individuals bring to their environment" [9] (p.749). So, we may say that being playful consists of engaging in play activities and being in a playful state of mind, i.e., injecting the essence of play in other actions [3]. Moreover, there seems to be a consensus that playfulness is supported along the lifespan, either in more structured or informal activities, thus increasingly being recognized as integral to lifelong learning, creativity and general well-being [3]

[10] explored multiple perspectives on play, mapping seven types of ambiguities that simultaneously provide richness and constitute challenges for interpreting play activities.

Currently, several disciplines converge on an Interdisciplinary Game Studies field that includes diverse facets on play and games ranging from media studies focusing on the relation between artifacts and activity forms, to critical theory focusing on critically questioning the relations and interventions of games in human society.

In summary, play is considered as a particular feature of pre-school age in the sense that the child plays without separating the imaginary situation from the real one. Moving towards school age, play is converted into internal processes and becomes a limited form of activity, thus allowing the creation of a new relationship between the semantic (thought) and the visible (real).

[11] considers that "play creates meaning", thus considering that play is a dynamic between affect (emotions and thoughts) and reality (external world). The creation of an imaginary situation, develops the ability to move to abstract thought. In adolescence, play is now intellectualized imagination. In adulthood, play is a set of social situated understandings.

Research seems to suggest that play contributes to all aspects of learning and development, tough dependent on the context in which it occurs ([3]; [2]).

Further readings frequently show that the diverse conceptions of play seem to be rooted in each disciplinary context in which the proponent and interpreters of the concept operate ([12]; [13]). To bridge these diverse concepts we envision the goal of an interdisciplinary and contextual perspective of play.

Considering the attention and references Vygotsky [6], made to imagination in the context of his play studies, we will want to explore if there could be an explicit link in the literature connecting all these concepts. Furthermore, [7] studies consider that, with age, the playful element is incorporated into experimentation. The underlying assumption is that spontaneity, manifest joy and sense of humor exist in a continuum in individuals, and it is to this degree that creativity can be established or recognized as part of a given individual's behavior. Hence, the playful element or disposition becomes a connecting link between play, imagination and creativity.

B. Imagination

Based on a person's behavior and activity we may distinguish two basic types of brain activity: i) reproductive and ii) combinatorial. This combinatorial ability of the brain, the ability of combining and reworking elements of our past experience to generate new propositions, images or actions, is called imagination [6].

Thus, through new combinations and relationships the mind builds a structure - **imagination –** that holds alone before being implemented in reality. In this sense, [6] (p.11) defends that imagination is present whenever an individual "(…) combines, alters and creates something new".

To understand the psychological mechanism of imagination, it is crucial to understand the relationships between fantasy and reality. Fantasy connects to reality in different ways. Again [6] proposes an explanation for this relation between fantasy and reality through the enunciation of the so called "laws" of imagination:

i. Law of association:

Creation is the result of a new combination of elements extracted from reality, that suffer the transformational action of imagination. The starting point of every act of imagination is the accumulation of experience, which is then followed by and incubation period.

ii. Law of general emotional signs

Every feeling has both an external and an internal expression. Elements from reality are selected and combined by emotion. Hence, images that have similar emotional effects have a tendency to cluster together, thus generating a combined product of the imagination based on a common emotional expression that unites these elements.

iii. Law of the emotional reality of the imagination:

"All forms of creative imagination include affective elements" ([14] in [15] p.19). The association of fantasy with emotion is extremely important in the sense that feelings strive to cast into certain images where they find an expression. This is the subjective value of fantasy: even though the construct of imagination does not correspond to reality (or is unreal), the feelings which it evokes are experienced as real [6].

Furthermore, from a psychological perspective, intellectual and emotional factors seem to be equally necessary for an act of creation.

Following on these ideas, the authors ([14]; [15]) consider that when and individual is perfectly adapted to his environment there is no need for creativity, thus considering that any need or desire can serve as a trigger to creation. Based on this ideias, we may enumerate the basic psychological factors on which imagination seems to depend [6] , such as:

- the perceived need to adapt to the context: the absence of an equilibrium between the individual and the environment/context represents a challenge for the individual looks for adaptation;
- experiences, needs, interests: the existence of needs triggers the working of imagination;
- combinatorial abilities (and their exercise): the ability to combine previous stimuli in ways that they do not exist in current experience, and to embody these imagination constructs in material forms;
- individuals' technical abilities and traditions: creative models to which the individual is exposed, since imagination and creativity are not just internal processes but also dependening on external factors.

There seems to be evidence that the factors upon which the creative imagination process depends on, takes different forms in the different stages of development: children's experience, interest and relationship with the context (in its complexity, subtlety and diversity) is clearly poorer than at an adult stage; in adolescence a lot of experience has been accumulated and assimilated, imagination becomes intellectualized [16].

Adolescence is a period when a lot of experience has been accumulated and assimilated, there is also the development of permanent interests and of the intellect. Hence, imagination is now closely associated with thinking and keeps pace with it. If we may put it this way, in adolescence, the new "feature" is that imagination is now closely linked with thinking in concepts, that is, imagination becomes intellectualized.

Furthermore, authors defend that elements of abstract thinking are never absent from images and perceptions, because conceptual material exists in a form in which has been reworked by abstract thinking ([16] in op. cit.).

Adolescent's imagination is, indeed, a collection of all the elements of concrete visual thinking. Furthermore, in adolescence, the path of imagination is described by the movement from concrete through abstract to the construction of a new form of a concrete visual image, this is, fantasy moves from the concrete visual image through a concept to an imaginary image. Thus, imagination is the successor of children play…in their way to adolescence children replace play with imagination [16].

[17] summarized four key components of Vygotsky's theory of creative imagination:

1) Imagination is the internalization of children's play.

2) Imagination is a higher mental function of as such is a consciously directed thought process.

3) Creative thinking involves the collaboration of imagination and thinking in concepts, which occurs first in adolescence but mature in adulthood.

4) Both artistic and scientific creativity require the collaboration of imagination and thinking in concepts

C. Creativity

Based on this assumption, there seems to be a differentiation between the common ideas of imagination and of creativity and their scientific understanding.

Thus, considering that the phenomenon of collective creativity **– the combination of individual creativity** - is at the origin of an enormous percentage of human creations. Hence, creativity is "the rule rather than the exception" (op. cit.).

The main reason for the difficulty in studying the process of creativity resides in the complexity (elusiveness and inaccessibility) of the phenomenon of imagination.

By stating that "imagination by virtue of the strength of the impulses it contains, tends to become creative, that is, to actively transform whatever it has been directed at" [15] (p.4) introduces the concept of "creative imagination".

In adolescence occurs an enhancement of the imagination combined with the basics of mature fantasy. Furthermore, [17] (p.71) support this idea by stating that creative imagination "emerges when fantasy becomes infused with thinking in concepts", which is a characteristic feature of adolescence. Imagination and the ability to abstract and categorize become integrated into a functional system.

Hence, the integration of subjective imagination, objective imagination and thinking in concepts leads to creativity [18].

When a construct of fantasy that has no correspondence to any existent object in reality has been externally embodied (t.i., the mechanism of association of fantasy with reality completes a full cycle) this means that imagination has been crystallized. Thus, the products resulting from combinatory imagination become just as real as other things.

The mechanism of creative imagination rests upon two conditions: i) the presence of needs and ii) the activation of traces of neural stimulations. This mechanism maybe translated into 6 basic steps:

i) existence of a need of adaptation: the lack of equilibrium between the individual and the environment provides a challenge, a need that becomes a trigger for imagination;

ii) perception of the internal and external basis of experience;

iii) accumulation of elements/experience: previous experience provides the material from which the products of imagination are constructed;

iv) reworking/restructuring impressions: breaking up a complex whole into a set of individual parts, through dissociation and association;

v) transformation of dissociated elements and it's unification into a system: the unification of the altered elements towards the creation of a structure that holds on its own – imagination;

vi) crystallization of this structure in external images: creation of new real "things", embodiment of imagination.

Furthermore, creative imagination seems to be understood as a cumulative process where every succeeding manifestation was determined by a previous one, thus considering that every creation arises from needs, which may also be desires or specific challenges ([6]; [19]). Considering that "creative imagination permeates all life personal and social, abstract and practical in all its forms" ([14] in [15], p.42), both science and art allow the application of imagination, thus, technology is a product of crystalized imagination.

III. From play(fulness) to creativity: is there a pathway?

Through play children learn to create, manipulate and give meaning to signs and symbols. Through play, children tease out relationships, try on and practice different roles and exercise their growing capabilities. Play starts with social interaction with adults. Children pretend play and object substitution become internalized as fantasy/imagination. A child's play turns into adolescent fantasy.

Imagination and play in children are closely related. Play is a precursor of imagination [6], [20]. In adolescence, imagination and thinking in concepts become conjoined. Thus, in adolescence, subjective and objective imagination, intertwine in a more sophisticated manner ([18]). At this moment of fantasy development imagination becomes intellectualized. Thus, it is the successor to child's play: adolescents replace play with (internalized) imagination.

Hence, imagination strives for embodiment. Creativity is crystalized imagination. In adults, imagination and thinking in concepts become woven together. Creative imagination matures into artistic and scientific creativity, and plastic and/or emotional imagination ([14] in [15]) may be found. In adulthood, creativity creates the opportunity for the existence of zones of proximal development, through which adults adapt to an unsatisfying reality.

Play has been here understood as a symbolic capacity-building process leading to creative imagination.

Furthermore, imagination is a higher mental function that allows self-regulation and self-consciousness that matures into the creative thinking of the adult: "Like all functions of consciousness, it originally arises from action. The old adage that child's play is imagination in action must be reversed. We can say that imagination in adolescents (and school children) is play without action" [6] (p.93). Creativity requires the collaboration of imagination and thinking in concepts [20].

IV. Conclusions

Play, imagination and creativity are central vygotskian concepts, thus they are the basis of social-cultural theory [21] but are currently transversal to several domains of knowledge, research and implementation. These concepts and the way they interrelate may provide insightful perspectives on how to organize and intervene in pedagogical and social practices ([6]; [18]; [7]; [19]).

[19] sums all up by saying that imagination depends on critical thinking and poses a problem, then creativity comes in to explore how to solve the problem and how this can be translated into innovation, thus, embodied.

[7] adds to this that some characteristics of play are directly related to imagination and creativity: manifest joy (is a facilitator of socialization and imagination is also inspired by social experience); sense of humor (may contribute to the type of imaginative processes that result in creative products) and spontaneity (being intrinsically motivated, may contribute to creative production in later developmental stages).

At the moment we realize that there is not stil an unified view around these concepts, the way they interrelate, how they can be studied and their relationship with technological innovations.

Since play activity, in our understanding, is a socially mediated activity and information technology has introduced changes in society in what concerns its organization and proximity, one of our concerns is to understand how the above concepts and their interaction can be studied.

This concern raises some questions we find necessary to answer to:

- How can the imagination be externalized?
- What is the role of the collective in play, imagination and creativity?
- How do we promote engagement in playful activities?
- How to design a context for collective imagination and creation? Can this be done in a game space?

New media technologies and popular culture are enhancing the creation of new forms and contexts of play, thus promoting a research shift to broader theoretical and methodological frameworks of understanding, now focusing on different aspects of play behavior, the influence of play contexts and players' interactions [22].

All considered, major issues arise that need further development on the relation between the concepts of play, playfulness, imagination, creativity and the way they relate or integrate.

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A Mixed Reality Game using 3Pi Robots - "PiTanks"

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***Abstract*—In the growing field of Robotics, one of the many possible paths to explore is the social aspect that it can influence upon the present society. The combination of the goal-oriented development of robots with the interactivity used in games while employing mixed reality is a promising route to take in regard to designing user-friendly robots and improving problem solving featured in artificial intelligence software. In this paper, we present a competitive team-based game using Pololu's 3Pi robots moving in a projected map, capable of human interaction via game controllers. The game engine was developed utilizing the framework Qt Creator with C++ and OpenCV for the image processing tasks. The technical framework uses the ROS framework for communications that may be, in the future, used to connect different modules. Various parameters of the implementation are tested, such as position tracking errors.**

Keywords-3Pi Robot, Mixed Reality, Game Engine, Qt, Robotics, Robotic Demonstrator, ROS

I. INTRODUCTION

The technology of mixed reality is not a novelty in the field of Robotics, but it is a subject with promising development. The definition of mixed reality is often ambiguous, merging with the one of augmented virtuality and augmented reality. Using the definition in [1], mixed reality is the usage of computer generated elements on the real world or it can be the opposite; representations of the real world to enhance a simulation, e.g., a photo on a 3D graphic model. The first example before is more representative of the definition of augmented reality by the same author, while the latter is of augmented virtuality. As such, our project resembles more closely mixed reality, taking in account that a program-generated image is projected to show various objects necessary to the game. Using such approach enables the use of features like shooting without implementing physical systems in the robot, sparing physical resources.

The development of any game concept follows the division defined in [2], where the two essential groups of elements are: rules and goals, which defines the founding guidelines of interaction of the different elements of the game and the objectives to accomplish in order to win and props & tools, which complements the rules, assisting them to make a functional game. PiTanks uses all those basic elements, having a great focus on multiplayer.

II. RELATED WORK

Projects with the same basis of concept were created before. Anki Drive of Anki Inc. [3], now acquired by Apple, is a racing game that utilizes an embedded system on miniature motorized cars using processing power from an iPad or iPhone. The small cars run on a track printed in a prepared mat and are controlled in a simulation that runs on the iPad/iPhone. Different weapons are available for the various existent models (but only on the simulated environment) and the racers can be either human or AI controlled, up to 4 cars at the same time.

Another project, developed by the Play Research Studio Interactive Institute, is the "Pirates!" game [4], which merges electronic hardware and elements of reality. It consists of a multiplayer game where players take the role of pirate captains with the objective of accumulating experience points and gold by completing missions and fighting other players in naval battles. The game arena is defined by a chosen region in the real world, having locations with radio frequency transmitters as beacons to map the virtual islands. The players use laptop computers with a graphical interface as the game controllers, simulating the boat movement with walking in real life.

Also using robots in a projected environment are the Robot ARena from Polytechnic School of the University of São Paulo in Brazil and the Augmented Coliseum from the University of Electro-Communications of Japan. The Robot ARena [5] is a hardware and software infrastructure with a similar concept of the proposed one (referring to the FootBot Arena prototype presented in that paper): remote controlled robots moving in a projected environment, enabling interaction between the virtual and real world. The robots used are Mindstorms NXT from Lego, having Lego pieces on top to serve as markers for localization. The projection is made on an acrylic table with a camera on top, serving as the hardware for the localization and interactivity with the virtual elements. The game engine is based on the open-source engine, created in Java.

The Augmented Coliseum [6] is also a combat game involving small robots with projected features in order to create augmented reality. The system uses two models of the robots (real and virtual) to coordinate the robot movements. Tracking is done using brightness sensors on the top of the robots in conjunction with a projected fiducial marker in order to obtain position and orientation of the robots. With those data, the model of the real object is updated and if the robot is moved in the simulation, the real robot is moved accordingly. The objective of the game is to destroy the other robots utilizing weapons like lasers or missiles, also having a shield to defend from incoming fire. All these functionalities are represented with the projection of generated images, giving information and feedback to the users.

III. System Description

PiTanks is a multiplayer game that utilizes mixed reality with the use of robots and projected images. Players interact with the game utilizing the game controllers, battling between themselves or in teams. Resorting to a camera, snapshots are taken from the game area (which is projected on the ground), informing the main program about the location of the physical robots and permitting the update of the game state by changing the projected scene. Various configurations are possible, such as the numbers of possible players (up to eight robots in the same map), the choice between two games modes (Timed Match and Last Team Standing) and the decision between premade maps or the creation of a new one via an application in the software. The photo-based tracking system is a dedicated program using created markers on the top of the robots.

The development of the project involved diverse technologies from both the software front and the hardware side. Various possibilities were studied, having the defined choices explained and shown in the next sections.

IV. System Breakdown

The system breakdown is shown in Fig. 1 and the software architecture in Fig. 2. Game controllers are used by the players to control the robots, having their inputs transmitted to the game engine via ROS. The game engine is informed of the position of the robots analyzing the images received from the camera. It conjugates then those data with the inputs from the controllers to process the game state (see if a collision occurred, calculate bullet paths, wall destruction, etc.) and projects the output to the playing field.

A. Hardware

1) Robot – Polulu 3Pi [7]: The robot used is the 3Pi, developed by Pololu. It's a 9.4 cm diameter wide (hence the name) and two-wheeled robot with an ATmega328P microcontroller with 32kB flash memory, 2kB RAM and 1kB EEPROM. The wheels are locomoted by two micro metal gear motors (with a plastic ball caster on the front of the robot as a free wheel). It also includes five IR reflectance sensors, three push buttons, a buzzer, one green and one red LED, and 8x2 LCD screen. All of this is supplied by four AAA batteries. This robot was chosen for being low-cost and capable of differential traction (the closest to tracks), enabling rotation on itself. In order to enable wireless communication using XBee and implementing the marker for localization, the robot was modified, placing a board for the module circuitry and to support the marker, as shown in Fig. 3.

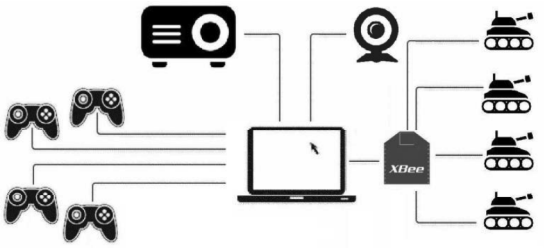

Figure 1. System Breakdown Structure.

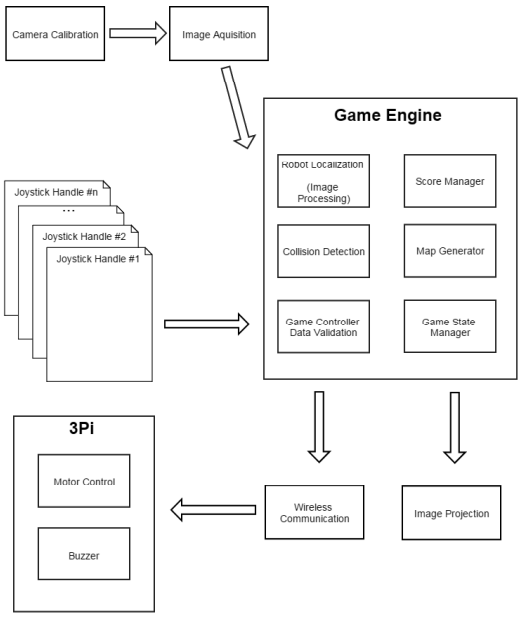

Figure 2. Diagram of the software architecture.

2) Camera – PlayStation 3 Eye [8]: To locate the robots in the projected map, the camera used is PlayStation Eye for the PlayStation 3 system. It possesses a field view of 56 degrees that can go up to 75 with the incorporated zoom lens and a frame rate of 60 frames per second with a video capture of 640x480 pixels. It also provides uncompressed video format, useful for more precise and efficient image processing.

3) Projector – Hitachi ED-X3270A [9]: A Hitachi ED-X3270A is used for the projection of the virtual elements. It's capable of a resolution of 1024x768 pixels and a focus distance between 0.9 and 11.0 meters. The maximum display size is 7.62 meters, which gives enough space for the robots to move on the projection of the map.

4) Controller - Gamepad controllers [10, 11]: Various game controllers are used, such as Trust GXT 24 Compact Gamepad, Logitech RumblePad2, and NGS Maverick. Having two analog sticks, one directional pad and at least 8 different push buttons (plus two from the analogs), they give all the necessary inputs to the users to control the robots.

5) Communication – Xbee [12]: The wireless communication between the game engine and the robots is made with the XBee 802.15.4 radio module from Digi International, having a range of 30 meters and a wireless data rate of 250 kilobits per second. Because communication time is a constraint in the project development, radio frequency proves to be a good solution, securing a quick and reliable way to transfer data, while permitting multipoint communication.