e-REAL:
Enhancing Intelligence by Visual Thinking

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Abstract—**e-REAL - enhanced reality lab - is a fully-immersive and multitasking environment, designed to experience challenging situations in a group setting, engaging all participants simultaneously on different levels: with peers, thematic experts and learning facilitators, both on site and remotely. e-REAL is a lab based on visual thinking and knowledge visualization, facilitated by enhanced (or augmented) reality tools. It is a highly interactive and face-to-face lab that promotes proactive data and information research (everything is available, but learners have to actively look for it) - allowing knowledge sharing with remote teams and integrating training on soft skills with those that are technical and specialized.**

Index Terms—**Visual thinking, knowledge visualization, immersive learning, augmented reality tools, new media in education.**

I.   INTRODUCTION

e-REAL - enhanced reality lab - is a fully-immersive and multitasking environment, designed to experience challenging situations in a group setting, while engaging all participants simultaneously on different levels. This includes peers, thematic experts and learning facilitators, both on site and remotely.

e-REAL is a lab based on visual thinking and knowledge visualization, facilitated by enhanced (or augmented) reality tools. Three representative classrooms are shown below and others can be found at www.e-real.net.
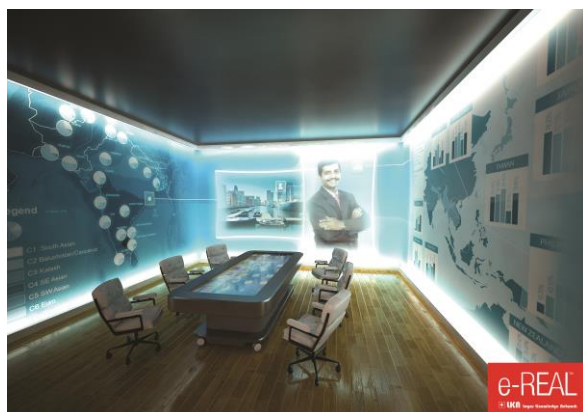
e-REAL focuses on making the intangible more tangible. It is a highly interactive and face-to-face lab that promotes proactive data and information research (everything is available, but learners have to actively look for it) - allowing knowledge sharing with remote teams and integrating training on soft skills with those that are technical and specialized.

Visual thinking, digital technologies and knowledge visualization are transforming the way in which people learn by opening up new opportunities for immersive training, as well as serious gaming. Similar to being immersed within a videogame, people are challenged by facing real cases within complex scenarios that present a "more than real" wealth of information - this occurs while the many levels of the situation are made available simultaneously.

Learners can have a complete overview of a case, access relevant information, take a look at professional literature and consult strategic guidelines. They will find everything needed to make a decision, such as information, benchmarks and so on. So many skills are

fostered: both behavioral and cognitive ones, as well as metacognitive skills.

Accordingly with our vision, fostering cognitive skills as well as metacognition - jointly with behavioral and technical skills - is very relevant because it helps people to perform many tasks more effectively. In particular, metacognition - "cognition about cognition," or "knowing about knowing" - is essential because the buzzwords of the times are creativity, innovation, cross-cultural intelligence and flexibility. Metacognition can take many forms; it includes knowledge about when and how to use particular strategies for learning or for problem solving. Strategies for promoting metacognition include self-questioning (e.g. "What do I already know about this topic? How have I solved problems like this before?"), thinking aloud while performing a task and making graphic representations (e.g. concept maps, flow charts, semantic webs) of one's thoughts and knowledge.

People who are high achievers in academic or professional learning domains, also exhibit higher levels of metacognitive knowledge (awareness and strategy) about the same domain and have developed greater abilities in self-regulation. Some psychologists hypothesize that metacognition is used as a survival tool, which would make metacognition the same across cultures [1]. So, fostering metacognition through a learning environment that is very immersive and quite futuristic is an added value for e-REAL.

Within e-REAL, skills and talents can be developed in order to create the next generation of global innovators and entrepreneurs, as well as good professional people.

II. ENHANCING INTELLIGENCE BY VISUAL THINKING

"It is possible to teach every branch of human knowledge with the motion picture," observed Thomas Edison in 1913 - predicting that books would soon be obsolete in the classroom [2]. In fact, motion pictures have had little effect on education and training. The same, until recently, was true of computers. Today, in most of the world, learners use computers to do research and type essays at every stage... from primary to post-graduate education or vocational training. But the core of the system has changed little since the Middle Ages. A "sage on a stage" teacher, still spouts "lessons" to rows of students.

Now we live within a networked society and, at last, a revolution is under way due to a number of big changes that are emerging at the same time: high-speed mobile networks, cheap tablet devices, the ability to process huge amounts of data cheaply, sophisticated online gaming and adaptive-learning software, "stellar" contents available for free and "superstar" lecturers and experts are remotely available.

At its heart is the idea of moving from "one-size-fits-all" education, to a more personalized approach, with technology allowing true human centric processes to enhance learning by utilizing augmented reality tools. The job of the classroom's teachers and trainers, at every education and training stage, will move from orator to coach and learning facilitator, with adaptive computer programs and augmented reality tools allowing each learner to be actively engaged at his or her own pace.

e-REAL is the place where it is possible to teach every branch of human knowledge with motion pictures, as well as with 3D images, movies and augmented reality tools. Visual thinking, digital technologies and knowledge visualization are transforming the way in which people learn by opening up new opportunities for immersive training. Much like being immersed within a videogame, people are challenged by facing real cases within complex scenarios that present a "more than real" wealth of information - this is because the many levels of the situation are made available simultaneously.

As information technologies evolve, so do the possibilities for more immersive learning and teaching techniques. e-REAL is using cutting edge technologies to create both a virtual and a physical environment in a room, which immerses people in real life situations (e.g. negotiation with a client, opening a new shop abroad, crisis management or decision making within a networked virtual team), with possibilities to interact simultaneously with peers, tutors and learning facilitators, thematic experts and colleagues (both on-site and remotely), as well as consulting literature, records and other written information (that are available as multimedia content).

e-REAL submerges learners in an immersive reality where the challenge to be tackled is created by sophisticated, interactive computer animation in three dimensions and holographic projections. It further includes live and real time interaction with peers, trainers, tutors, facilitators and mentors. And thus, adds a very important social component that enhances learning outputs, as well as metacognitive processes (and skills).

The primary concepts and issues of a particular case can be dealt with by visualizing them with the use of holograms (to be seen without 3D glasses or any particular tool), on big screens, or by projecting them directly on walls, ceilings and floors. By moving the body, or with a flick of the hands, people can experiment with dynamic images, sound and vision, including holograms and 3D visualizations; all creating a profound emotional impact. So, it's quite a "futuristic" educational environment, very fitting with tertiary education and vocational training, and is an ideal environment to foster innovation and entrepreneurship.

In the image below, a representative classroom is shown, highlighted with some commentary to provide a deeper understanding in regards to some of the tools available in the immersive room.
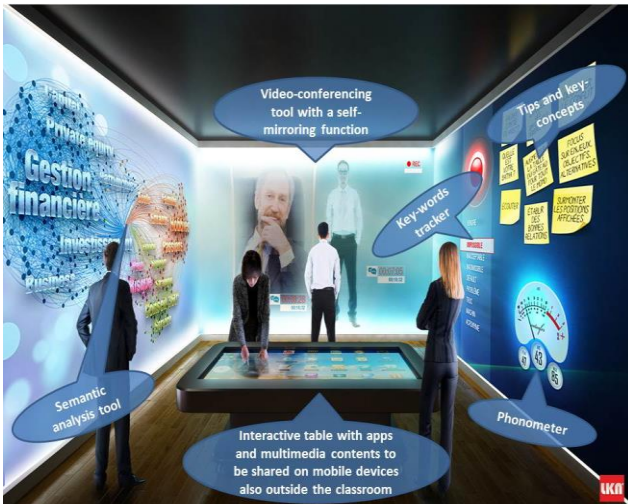
The process of "learning by doing" within an immersive lab, based on knowledge visualization by interactive surfaces (walls, mobile devices, electronic tables, etc.), leaves the attendees with a profound and memorable experience.

Attendees are challenged both cognitively and behaviorally in a fully-immersive and multitasking learning environment. So, e-REAL is an ideal educational environment in order to foster both technical and soft skills that are competency related, as well as cognitive and metacognitive skills.

Moreover, e-REAL is an environment that immerses the learners in an "augmented" reality where real life situations can be really lived (not only simulated) and the necessary lessons learned without the disadvantage of a negative impact in case of mistakes. So, e-REAL is very good with regards to constructivism in education, which showcases that learning is a process of social action and engagement involving different ways of thinking, doing and communicating [3]. Learning is a form of participation in social environments aimed at "co-constructing" knowledge: learning is an interactive, highly contextual process that leads to new interpretations of the world and creates a "social fabric." All of this has some very significant implications for the design of learning architectures [4].

By utilizing e-REAL, a myriad of skills are fostered: both behavioral and cognitive, as well as metacognitive skills. Finally, technical skills are also honed, because it is mainly by fostering technical and job-related skills that soft-skills are developed as well.

Another relevant added value of e-REAL is that an immersive lab can be built both as a permanent installation and as a portable setting, making the delivery incredibly flexible. e-REAL can be put in place virtually anywhere in the world. Technically, the only requirements are electricity (a few KWs in a basic configuration of the lab) and an internet connection, due to the fact that e-REAL is not a large consumer of bandwidth. So e-REAL can be shipped and put in place all around the world (from downtown to a desert, on a boat or on a truck).

e-REAL is unique in the market because the projecting system is based on short-throw projectors, while other immersive rooms devoted to educational purposes are currently developed using rear-projection systems that require screen-walls - which are both expensive and mostly suitable to permanent installations.

The images below demonstrate the basic portable configuration, as well as the elements to be shipped and put in place for an e-REAL lab.
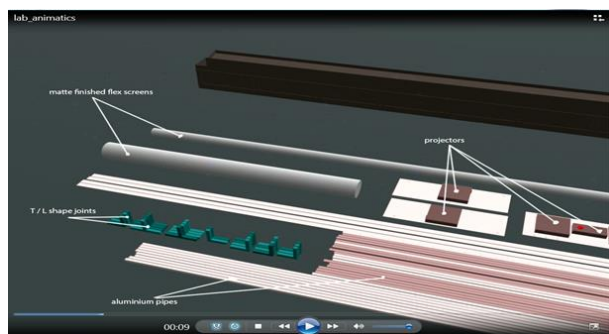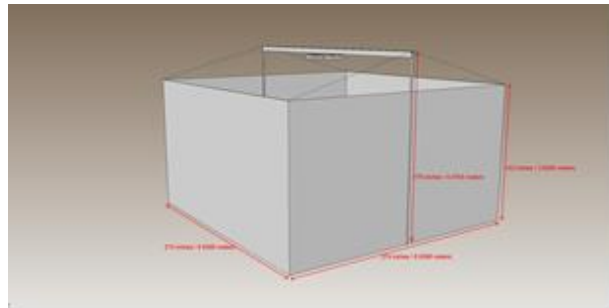
III. IMMERSIVE LEARNING: THE INTELLIGENCE OF PERCEPTION

e-REAL is an immersive learning environment. As we submerge ourselves in it and our bodies (as well), we will feel some sensation of what our ego may not necessarily be rationally and linguistically aware of. Learning happens through being immersed in a context. Even more relevant learning happens by encountering differences. Living in technologically evolved cities and rural areas, frequently visiting increasingly interconnected urban and rural landscapes, electronically navigating and travelling for business and pleasure... we need sufficiently fluid categories to understand the versatile realities of the multiple worlds we live in, as well as to explore the expressive, cognitive and imaginative possibilities of our times [5].

e-REAL is the union of perception and thought; which is not merely a specialty of the arts. It includes everything that you see, breathe, smell and touch in your experience and your training. When we design an educational environment, we try to pay particular attention to those "soft" factors that are perceptions, backgrounds, sensations, relational situations or emotions. Our departure points can be summarized by the title of a book by Maurice Merleau-Ponty: *The Primacy of Perception* [6]. Experience is lived and perceived as a focal point and as a key crossroads from which to start structuring those "hard" aspects and molds, the shaping architecture that connotes a specific training environment.

We could also say: architectures, not engineering. The allusive potential of engineering brings to mind the geometric spirit, the technical rationality that assumes (and unfortunately, sometimes "presumes") we are able to design "handbook" training structures and solutions, ones that are efficient and effective, that work... without much consideration of the receivers. The allusive potential of the architecture on the other hand, more than the geometric "technicality," brings to mind the art of teaching, utilizing projects suitable for context and the receivers, as well as being suitable for technical-constructive means - space that can be used for the human needs of living, reuniting and learning. Art should come before technique[7]; attention to needs that must be fulfilled in terms of building environments in which to see, breathe, smell, touch, feel, live sensations and situations that are emotionally "full" and which arise and create a space (for learning).

Therefore, architecture, more so than engineering, is a construction that is made for man and in his dimension, it is able to unwind between geometric rationality and the opening to that emotional dimension of the "living" that in the training ambit allows us to rub our brains against that of the others – as Montaigne used to say. A "rubbing" that brings to mind the discursive turn of psychology; that which characterizes the "second cognitive psychology" and – referring to linguistics, ethnomethodology and social constructionism – considers human beings as active subjects, their mind as a unit of discursive activities, learning as the result of dialogue interactions, backgrounds, emotions and intersubjective meaning constructions [8]. Meanings and visions that are as rich as they are the fruit of different points of view, perspectives and visions of the world, ones that may even contradict each other. Put to common factor, discussed, disputed and rethought (peer-to-peer dialogues, cross-fertilization, knowledge sharing, learning facilitation, etc.).

Within e-REAL, the idea of learning processes as discursive construction comes into its own. Such a learning environment is characterized by the primacy of perception, backgrounds and emotions, in counter position to a well-founded tradition based not only on an epistemology and a vision of science that is rather naïve (positivism, as "neo," or not as it may be), but also as a much criticized "metaphysical" thesis relating to human beings: dualism (as Cartesian, or not, as it may be) and the clean mind-body separation. The body – "physical substance" – with its chemical, pneumatic, mechanical and electrical mechanisms; the mind with its thoughts, sentiments, memories and images; made up of a totally separate "mental substance."

Even if the Cartesian body-mind dualism historically lost its attraction very early on, the notion that mental life is "internal," separate from behavior, which is "external," survived much longer and can still be found today in many psychological, pedagogical and andragogical approaches. With the consequences – often experienced by those who attend schoolrooms, universities, professional and corporate training centers and business schools – of uniting and managing impoverished, simplified models and conceptual human action that cannot be used in the dense and polysemic dynamics of our daily lives. Perhaps it is no coincidence that we still often bring into account learning environments that, doing a little archaeology of knowledge, we could trace back to the model of the Panopticon described by Jeremy Bentham, or rather prison (and then hospital, factory or learning institutes), "that shows everything" thanks to the spoke shape of the building: an environment where ideally a single observer may watch everything all the time, adding to the perceptions of the inmates (or patients, workers, students), a sort of omniscience and generalized control by the guardian [9].

DESIGN OF THE PANOPTICON
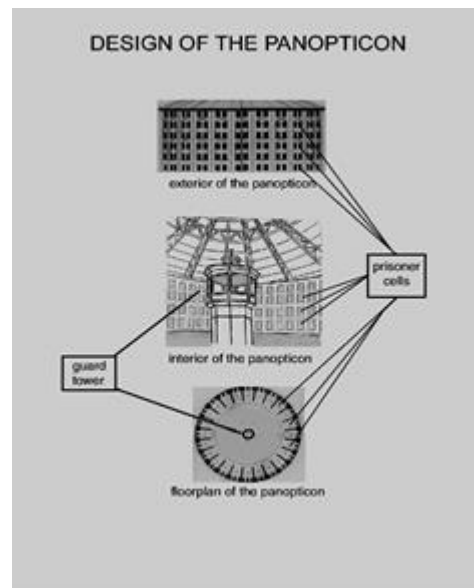
This occurs in an environment - the Panopticon - where learning is conceived as a passing of information from the lecturer to the student, following a communicative process that tends to be one-way (top-down) and within which the "retroactions," feed-back (bottom-up), take on the role of interrogations. Panoptism is a philosophy and a vision-guide, the discipline as a base assumption of the psycho-pedagogical procedures; taylorism (and its many "neo" variations) as an organizational model [10]. But the Panopticon is not exactly the type of benchmark to look towards for inspiration, unless you wish to "re-edit" Charlie Chaplin in "Modern Times," or any other form of neo-taylorism.

We live in increasingly 2.0 and 3.0 worlds, where cooperative learning interaction, that is not too structured and is a little centralized, helps a lot in terms of flexibility and enrichment of the individual and organizational cognitive maps. The supremacy of Panopticon, of the uniform look and single disciplinary and disciplining educational model, is better replaced by the supremacy of

perception, individual points of view and backgrounds as key dimensions from which to start to build learning systems and environments that can help us to understand the varieties of social and working realities in which we live, the plurality of our belongings and the ways of acting in different local worlds in which we live, study and work (like within the below Escher's masterpiece).
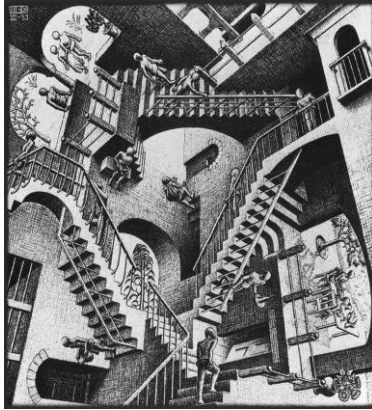
We should consider both educational environments, as well as the human mind, to be complex systems. In particular, the human mind works as a meeting point for a wide range of structuring influences, whose nature may only be represented on a much larger canvas than that provided by the study of individual organisms. And therefore, we should remember that each one of us lives many different discussions, each of which has its own set of meanings. Some of these discussions may be put into conflict among themselves, necessitating a negotiation and an adjustment to try and make them compatible. The discussions regard symbolic interactions as well as conventions and relationships in which these same interactions are bound by informal rules and interconnected to each other, in ways that reflect that which Michel Foucault [11] called "the order of things." People operate continually in the middle of evaluative and interpersonal influences that shape and manage their activities. People are "agents" who must produce their own constructive interpretations and the expressive acts starting from the contexts in which they are rooted and within which we all live, move and realize our being.

What we need – in universities and business schools, but above all in public and private organizations, active both in profit markets as well as in non-profit contexts – are new ways of thinking, which are able to process peculiarities, individualities, oddities, discontinuities, contrasts and singularities. Ways of thinking that are able to understand the variety, plurality of belonging and ways of being part of the many local worlds in which we live, study and work. We need to learn how to learn a potentially relativist (but not destructive or nihilistic), relational and self-aware thought that knows its requirements and that is left unsaid. A thought that is able to consider the cognitive restraints that make it up, that sometimes command and control it blindly and fideistically. A thought that is aware that knowledge is a mélange of rationality and rationalization, of true and false intuition, inductions, syllogisms and paralogisms, ways of saying and doing things, personal opinions and shared beliefs [12].

Starting with the study of perception, Merleau-Ponty reaches the conclusion that the body is not just a "thing" (the Cartesian res extensa), but is also the necessary condition of experience: the body makes up the perceptive opening to the world. The primacy of perception means the supremacy in experience, in the moment in which the perception takes on an active and constitutive role. Recently, researchers from Aalto University have revealed how emotions are experienced in the body. Emotions adjust our mental and bodily states to cope with the challenges detected in the environment. These sensations arising from bodily changes are an important feature of our emotional experiences [13].
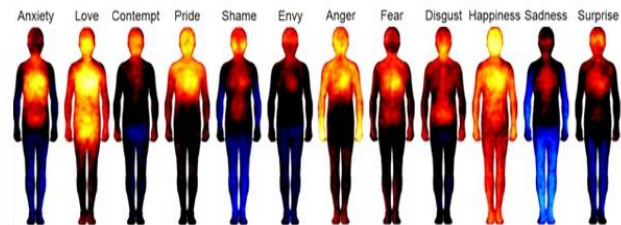
Emotions adjust not only our mental, but also our bodily states. In this way, they prepare us to react swiftly to danger, but also to opportunities such as pleasurable social interactions present in the environment.

Emotions, visual and perceptual thinking, are central within e-REAL. Concepts that take shape, as well as emotions, become part of the discursive scenario thanks to several tools from cutting-edge discoveries in the neurosciences.

IV. ENHANCING MULTIPLE INTELLIGENCES WITH E-REAL

With powerful tools and enhanced reality resources within the e-REAL labs, people improve their abilities and skills. e-REAL is based on cutting-edge research in the neurosciences. We are writing a book on that, to be published by the end of 2014. Some of those outcomes are partially available within a previous book we co-edited, *Learn How to Learn! Knowledge Society, Education and Training.* Among the contributors is Prof. Howard Gardner from the Harvard School of Education, who developed the multiple intelligences model that also grounds e-REAL [14].

"It's not how smart you are, but how are you smart that matters" – says Prof. Gardner. An intelligence is an ability to solve a problem or fashion a product that is valued in one or more cultural settings. This is the way e-REAL is conceived and allows skill development: both soft skills - as personal attributes that enhance an individual's interactions, job performance and career prospects - and hard skills, which encompass a person's skill set and ability to perform a certain type of task or activity.

e-REAL also enables effective cooperative learning - based on team-working and knowledge sharing on a peer-to-peer basis, visualizing knowledge and know-how in order to simplify the complexity of the real world – making the "intangible" more tangible. Learning also happens with the "extended mind." Our mind is the result of an exchange process with other people and the external

environment. The separation between the mind, the body and the environment, is an unprincipled distinction. Since external objects play a significant role in aiding cognitive processes, the mind and the environment act as a "coupled system." This coupled system can be seen as a complete cognitive system of its own. In this manner, the mind is extended into the external world.

Summarizing: e-REAL is an environment that immerses the learners into an augmented, or enhanced, reality, where real life situations can be experienced (interaction with peers and trainers, tutors, facilitators, mentors): becoming part of a living, serious 3D game - not only playing within a role-play game in a classroom or interacting with an artificial scenario (as within existing e-learning), but with the added value that the lessons are learned within a real-life environment. Only without the disadvantage of a negative impact in case of mistakes. Last, but not least, e-REAL enables processes aimed at fostering metacognition.

Networked knowledge societies and digital technologies are radically transforming what people learn, how they learn and where they learn. This transformation is already under way. Technology does not transform learning by itself, but only in conjunction with other social, cultural and economic factors. Knowledge is socially constructed, so learning is a process of social action and engagement involving ways of thinking, doing and communicating. e-REAL is the ideal environment to have improved metacognition, cognitive flexibility and the ability to self-monitor a professional performance, through the interaction between humans and technology.

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