Natural User Interfaces as a powerful tool for courseware design in Physical Education

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This article aims to describe a possible scenario for the applications of e-learning solutions to the field of Physical Education. Knowledge related to Physical Education is here defined as enactive knowledge, codified in the form of motor responses and acquired in the action, not mediated by the iconic and symbolic plan. The iconic and symbolic dimension, typical of Graphical User Interfaces, has been a barrier to the creation of e-learning strategies in Physical Education. The new paradigms of Human Computer Interaction such as Natural Interfaces, the spread of "everyday" technologies that retrieve to HCI the physical dimension, and the diffusion of exergames in education, now make it possible to imagine large-scale creative and collaborative elearning-based physical education. The article describes coarse-grained theoretical and methodological approaches underlying learning of motor skills and indicates the possible technological scenario, according

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to the type of interaction determined by the Natural Interfaces.

1 Introduction

The difficulty, as evidenced by the absence of specific literature on the subject, of the development of e-learning experiences in Physical Education, is related to the type of knowledge linked to Physical Education. The knowledge codified in the form of motor responses was defined enactive knowledge. “Enactive knowledge is not simply multisensory mediated knowledge, but knowledge stored in the form of motor responses and acquired by the act of “doing”. A typical example of enactive knowledge is constituted by the competence required by tasks such as typing, driving a car, dancing, playing a musical instrument, modeling objects from clay, which would be difficult to describe in an iconic or symbolic form. This type of knowledge transmission can be considered the most direct, in the sense that it is natural and intuitive, since it is based on the experience and on the perceptual responses to motor acts”.(Bergamasco, 2005).

According to Bruner, the interaction with the information mediated by computers is based on a iconic or symbolic knowledge. If, in this approach, knowledge is coded by symbol systems or in the form of images, on the enactive approach knowledge is not simply mediated by motor skills, but it is encoded in the form of motor responses and acquired in action (Bergamasco, *op. cit.*).

The encoding of knowledge through symbol systems or in the form of images has found a natural fit in HCI systems based on GUIs, because the interaction which is realized in the GUI is a discreet and dialogical interaction, which well combines with the cognitive theoretical of Human Information Processing mold that includes discrete and non-overlapping stages. In essence, this model is functional in an interaction that excludes or minimizes the embodiment and that considers space and time as separate elements, consistent with a conception of time as something moving with respect to a static observer, a linear path from A to B in which to place our body. Not surprisingly, we often hear about the “flow” of time. Against the flow metaphor, Merleau-Ponty stated: “time is not like a river, not a flowing substance” and “it is not the past that pushes the present, nor the present that pushes the future, into being “I belong to space and time, my body combines with them and includes them”(Merleau-Ponty, 1962).

Merleau-Ponty’s reflections are echoed in Deleuze, that juxtaposes the idea of time-image (Deleuze, 1983, 1985) to the movement-image idea. In this view, “each movement is not just a change of place within a whole but a becoming in which the movement is a transformation of the body which moves” (Colebrook, 2002).

The idea of becoming, which is at the basis of continuous, enactive interaction, is also central in HCI: "today's creative computing system can present powerfully evocative meanings by invoking a sense of the "becoming" whole in spatiotemporally embodied interaction. This means that users are engaged in interfaces that highlight perceivable continuity and variation. Hence, we argue, in creative computing systems the idea of embodiment must be reconsidered from the perspective of engagement in a holistically transformative and partially responsive world" (Chow & Harrell, 2011).

The new paradigms of Human Machine Interaction can be a tool to give back to man-machine interfaces the enactive dimension, representing a simplex strategy (Berthoz, 2011) in design of courseware dedicated to Physical Education, in the awareness that "the degree of physical involvement is the measure of immersion" in a digital context (Krueger, 1991).

This strategy is possible because of the spread of Natural User Interfaces (NUIS), "an emerging computer interaction methodology which focuses on human abilities such as touch, vision, voice, motion and higher cognitive functions such as expression, perception and recall. A natural user interface or "NUI" seeks to harness the power of a much wider breadth of communication modalities which leverage skills people gain through traditional physical interaction (NUIGroup, 2009).

The NUIs include natural inputs and outputs based on the movements, and evolve towards an efficient use of the senses in the interaction with machines, capitalizing on the characteristics of the new generation of devices that can detect movement and location of points in space. For example, Microsoft Kinect, an accessory for the Xbox, is able to detect the segments of the body of a user placed in front of the camera and to use this information to move an avatar in a video game.

2 Motor control and motor learning

In this section we present a summary of certain currents of thought in motor learning and motor control, to assess the resulting methodological educational systems and investigate the possible application of existing methodologies to e-learning solutions, by virtue of the above. In the context of sport and physical training most common approaches to motor control are:

- the cognitive approach
- the ecological approach

The motor control theories developed in cognitive psychology have generated a substantial amount of educational applications. Based on these theories, the human being possesses, at the cerebral level, a series of motor programs, or sequences of commands that coordinate the execution of the movements.

According a preliminary formulation, the processing of information from the sense organs and proprioceptors enables the system to correct the movement during the performance (closed-loop motor control, Adams (Adams, 1971). The closed-loop motor control assumes that the movements are sufficiently slow to allow the correction during the implementation, on the basis of data from the feedback. The longer the execution time, the wider the possibility of using the circuits of motor control based on feedback (Schmidt & Wrisberg, 2008). In shorter times, the movement is not susceptible to correction during execution and is completely programmed at the level of central nervous system (open loop motor control, Schmidt (Schmidt, 1975), Keele (Keele & Jennings, 1992)). The cognitive theory of motor learning derives directly from the integration of open loop motor control (motor programs) and closed loop motor control (feedback). Learn movements is to develop cognitive structures (the motor programs) through information processing. These processes allow the ability to compare real-time (closed loop) or later (open loop) results and expected results, triggering a process of adjustment of the same motor program.

The generalized motor program "is a program that defines a motor pattern of movement, this flexibility allows you to adapt it to produce variations of the motor pattern adapted to changed demands of the environment" (Schmidt & Wrisberg, 2008). Its structure is such that allows the performer to adjust the movement in order to cope with the changing needs of the environment.

The ecological approach does not refer to prescriptive mental structures: the action is directly available for those who act in their own environment. In other words, the sensorimotor system possesses the property of self-organization that does not make it necessary to use a motor program. In the ecological approach, the central nervous system develops from environmental influences on the neuronal groups that specialize on specific tasks (Edelman *et al.*, 1995). In this approach, learning is defined as the education of attention (Gibson, 1986). Learning means optimizing perceptual processes.

Learning, in ecological perspective, is defined as the construction of a new coordination adapted to the needs of the prescribed task. This construction is not realized ex novo: the novice, which addresses for the first time a task, uses some spontaneous types of coordination, which may refer to behaviors acquired before, or even be implied by very general coupling trends. It is on the basis of this repertoire that will be realized the construction of new models of coordination.

In the two approaches presented here, the perception of the environment is different and is defined otherwise the learning process.

In the first approach, motor learning means to stabilize a motor program effective in function of a particular information processing.

In the other, motor learning is a question of the adaptability of the movement, matching the diversity of the environment and the specificity of the individual (Carnus, 2010)

The direct consequence of cognitive theory in educational applications is a prescriptive approach: the structuring of motor programs increasingly articulate and the optimization of their parameters. The aim of exercises will be to stabilize and refine motor program by reducing the variability of execution. On this basis, in the context of cognitive psychology has been developed massive quantity of results on strategies and techniques for structuring the exercise in order to achieve optimal learning.

The main ways of structuring the exercise are partial exercise, randomized exercise and varied exercise.

In the ecological approach, to practice does not mean repeating over and over again the same solution for a given task, but repeating the process of solution of the task itself. Teaching, in the ecological approach, aims to stimulate the emergence of spontaneous solutions (heuristics) to motor problems, implementing a process that passes through the continuous variation of the motor gestures.

In heuristic learning, the teacher must assist the student in finding autonomous solutions. If the learning task is too complex, teachers do not have to impose constraints on the learner, pointing out in a how to simplify the motor execution, but have to apply constraints to the environment

The prerequisite for an effective strategy for facilitating teaching is that the unitary structure perception / action, postulated within the ecological approach, is not altered. In the ecological approach, the execution variability is not seen as a limiting factor, but as an inherent property, index of the non-linear interaction of the system with the constraints imposed by the body, the task and the environment in the search for solutions.

3 Exergames

The recent spread of exergames, videogames which require a high involvement of the body and movement of the player, has triggered an extensive series of studies in the field of physical education, to evaluate the possibility of using these technologies in educational, performative and rehabilitative field.

With the term "exergames" we refer to games that integrate the traditional system of videogame the element of the user's movement, a movement which is digitized and made to gameplay by a series of new-generation controller, such as the Wiimote and Balance Board accessories of Nintendo's Wii console and the Kinect sensor, originally created as an accessory of the Xbox and evolved as an independent device interfaced with personal computers (A. Di Tore

& Raiola, 2012). In this broad sense, the exergames reproduce in the digital environment, the fundamental questions of perception and phenomenology, confirming how the actions embedded within a digital interface are "fluid and functional crossings between physical and digital realms" (Hansen, 2006).

Historically, the literature has pointed out before the potential of exergames for wellness and education, in particular in the fight against sedentary lifestyle (Chamberlin & Gallagher, 2008); Within studies related motor learning, Staiano and Calvert pointed out a lack of specific research:

"Because many exergames such as DDR or Wii Sports tennis require rapid hand–eye or foot–eye coordination, they may improve general coordination skills. However, the majority of research on coordination benefits involves elderly people playing sedentary video games, not exergames. Video game play increased perceptual-motor skills including hand–eye coordination, dexterity, and fine motor ability (Drew & Waters, 1986). At present, there is no exergame research on this topic." (Staiano & Calvert, 2011). The added value of exergaming in terms of user involvement has been studied (and recognized) by Baranowski and Wigdor (Baranowski *et al.*, 2008; Wigdor & Wixon, 2011).

The exergames, as complex games, create an experience of immersion in a virtual environment that sparks interest in the game. A deep learning requires an extended commitment and this commitment is favored by a process of identification, challenge and control. The ability to transfer skills acquired in the activity of gaming in other contexts is widely discussed in the literature. Silberman (Silberman, 2009) provides a comprehensive account of the different positions.

For exergames, transferability of skills is an issue addressed, once again, by Staiano and Calvert:

"The skills that young people acquire during the game with the exergame move to other activities, for the benefit of the physical, social and cognitive development. [...] The exergame interpret a player's body movements as input associated with specific meanings for the game, translating the actual movements in three dimensional space on the two-dimensional screen. As the player exergame is physically distant from his avatar on the screen, it requires visual-spatial skills, hand–eye coordination and fast reaction times to be successful in the game." (Staiano & Calvert, 2011).

A further example, focused on special education, comes from the research of Cai and Kornspan, who argue that the movement-based games have the potential to support psycho-motor and cognitive learning for students with disabilities.(Cai & Kornspan, 2012)

Sheehan has emphasized the added value in terms of motivation in the specific field of education, addressing design issues, in a paper entitled "*The practical and theoretical implications of flow theory and intrinsic motivation* *in designing and implementing exergaming in the school environment*":

"The intentional design of educationally appropriate video games that require the use of the whole body to play already affords students the personalized experience needed to find balance between the level of difficulty and their skill level. Once that agreement exists, other aspects associated with intrinsic motivation and e creative flow can be attended to (achievable goals, perception of control, prompt feedback, focused concentration, etc.)(Sheehan & Katz, 2012)

The use of exergames in the school system needs to balance the needs of the student with curricular expectations. Researchers have recently begun to study the factors that motivate students to participate in such activities (Staiano & Calvert, 2011).

"Exergaming and interactive fitness activities could provide the stimulus for engagement to those students who have started to lose interest in more traditional forms of physical activity and reengage them towards lifelong physical activity"(Sheehan & Katz, 2012).

The point of view of ecological psychology emphasizes the primacy of the principles and objectives intentions that guide the perception-action within the limits of game design and user interface.

From the ecological point of view, therefore, the task of game design becomes to select targets and create environments in which these objectives can be pursued in an optimal way, taking advantage of those qualities that make gaming an engaging experience".(Young, 2004)

The peculiar characteristic of the movement also adds another layer of complexity to the design: the mechanisms of detection accuracy of the gesture (Gesture Recognition).

In a work on gesture recognition in prototyping software, Gacem has identified two trends:

1. Trigger based. Is a particular gesture executed?
2. Quality based. Is a particular gesture executed correctly? (Gacem *et al.*, 2011)

4 NUIs and Enactive Interaction

From the literature review, the exergames were assessed first as a tool which supports a less sedentary lifestyle among gamers. In a second step, they were assessed for their potential in education. Although the general trend is to consider exergames as a useful tool in the field of Physical Education, there are still many doubts about the possibility of assessing the correct execution of motor gestures in the digital environment. The thesis that we want to support here is that exergames may constitute a useful tool, and therefore suitable for the development of courseware, only if they were seen in a perspective of interface design which enhances the enactive component. The NUIS, in fact, allow to retrieve to the Human Computer Interaction "simplifying it principles that reduce the number or complexity of processes and allow it to very quickly develop information and situations, taking into account past and anticipating the future, facilitating the understanding of the intentions without distorting the complexity of the reality" (Berthoz, 2011).

Specifically, these media involve two distinct aspects of sensory-motor connections:

1. the components of user input related to movement are representative of his intention;
2. user input is in relation to a changing environment.

The paradigm of continuous interaction mechanisms that these two qualities contribute to build can be called "enactive interaction", with different characteristics from the conversational, discrete interaction" based on GUI point-and-click. (Chow & Harrell, 2011)

The enactive interaction involves not only the idea of space (changes the relationship with the space that becomes sensitive), but also the idea of time: movement is "not just a change of place within a whole but a becoming in which the movement is a transformation of the body which moves". (Chow & Harrell, 2011)

If the peculiarities of repetition in classic videogames seemed to suggest affinities with the cognitive approach (see the concept of repetition set out in paragraph on the cognitive approach), the enactive interaction favored by NUIS seems to have strong links with the ecological approach, valuing the uniqueness motor intentionality and its implementation at the expense of rigid and preordained sequence of motor responses.

This type of interaction provides the opportunity to create environments and tools that can translate into educational practice a conception of knowledge and learning that, in theory, recognized the role of body and movement, struggling on the operational level to define methodologies and tools used in everyday.

In fact we witness, not in the MIT labs, but in the bedrooms of middle school students, to forms of HCI (Human Computer Interaction) that go beyond the flattening on the Cartesian plane that has characterized the video game phenomenon(Di Tore *et al.*, 2012).

The analysis of the educational potential of gesture-based technologies is developed from the knowledge that the devices that encourage to touch, move and tend to explore are considered interesting for education and training. The gesture-based computing will probably take control of the educational experience through the body and voice, to transform the educational act in digital contexts in natural and interactive experience and to interact with an augmented environment to "manipulate", influence and transform it intuitively (Faiella & Mangione, 2012).

Knowledge becomes "embodied" in the corporeality of the subjects they learn and environments that synergistically incorporate them, converging more and more towards the idea that the body can be considered as one of the fundamental dimensions in the formation of knowledge architecture (Santoianni *et al.*, 2010).

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