Play Partners: Evaluating the effects of embodied cognition as a learning process for children

Moyosore Ale
School of Computing and Communication
University of Lancaster,
Lancaster, UK
m.ale@lancaster.ac.uk

Elisa Rubegni
School of Computing and Communication
University of Lancaster,
Lancaster, UK
e.rubegni@lancaster.ac.uk

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Abstract
"Learning by play" has been demonstrated to be a solid concept to support the design of educational technology. However, the learning systems today are less about encouraging natural curiosity and more about achievements and benchmarks. Embodied cognition answers this as it predicates that we learn not through our minds alone but with our bodies. Children present the perfect template for embodied cognition. Hence, it is advantageous not just to the child but also for us as a specie to understand and encourage the natural way children learn. This position paper argues for the need to further understand how sensorimotor information affects children's cognitive development and use that as a source for designing interactive technologies that enable effective learning.

Author Keywords
Embodied Cognition, Embodied learning, Play partners, Child Learning, Child-Robot interaction

CCS Concepts
•Human-centered computing → **Human computer interaction (HCI);** *Haptic devices;* User studies;

Introduction
In philosophy, embodied cognition as a learning process has been explored for over 50 years. However, it has been

relatively under-looked in Human-Computer Interaction research and particularly in Children-Computer Interaction [1]. The metaphor of embodied cognition is one that describes the mind as one that learns not in isolation but in a situated body. The implication is that we think not just by using our bodies, but through and as a result of our bodies. That is to say, without sensorimotor experiences gained by the body interacting with its environment, what we perceive to be would be incomplete [23]. It takes the marriage of external and internal factors for cognitive processes to be successful [7]. Clark [7] quoting Thelen and Smith [21] remarked that knowledge is built "through the time-locked interactions of perceiving and acting in particular contexts", so we learn through the cognition of multiple mental and bodily factors which are dynamically encapsulated within a context [20].

Clark [7] argues that the mind is a controller of its situated body and environment rather than a mirror thereof and pushes for action-centred representation in artificial agents. He explains that the mind should not be seen as "primarily a locus of inner descriptions of external states of affairs" but as an agent who via actions has a "locus of inner structures that act as operators upon the world". Pulvermuller and Garagni [16], take a slightly different view to embodiment, explaining that cognitive processing involves different levels of embodiment. Hence, while some processes stored in long-term memory are embodied, working-memory does not necessarily require such embodiment. Rather than argue for which form of embodiment is valid, we ought to focus on investigating the importance and influences of embodied cognition in different contexts [25].

Many scientific fields attempting to decode human thought operate on the assumption that the most important thing to replicate is the brain [14]. There is the pervasive sentiment, that building an accurate model of the brain is all that is needed to get a simulated agent to think like a human. However, the premise that embodiment is required for high-level cognition implies the need for accurate real-time simulation of physical sensations. Similar to how humans ease the process of digestion by partially offloading food breakdown to cooking, in learning-by-doing, we can also offload the cognitive load and functions involved in learning to physical movements rather than abstract representations alone [8, 3].

This can be observed by how we extend parts of our cognition from everyday objects such as our phones for memory when remembering contacts, spatial recognition [18] with map navigation to more complex technologies like augmented and virtual realities [12], which extend mind by simulating certain environmental factors and conditions. However, the influence of embodied cognition can also be seen in how we design our robots and social agents. Humans being agents themselves serve the model for artificial agents; hence if we learn by embodied cognition, it would be assumed to design tangible interactions [11, 9] with human-like intelligence, they would need human-like bodies as input devices. According to Hornecker [9, 10], designing such tangible interactions hinges on understanding and taking into account tangible manipulation, spatial interaction, embodied facilitation, and expressive representation.

Children are the perfect example of embodied cognition. Antle highlights that certain concepts are important in understanding child cognitive processes; exploiting external scaffolding, exploiting physical activity and exploiting embodied knowledge [12, 1]. Antle argues in their work on embodied Child-Computer Interaction [2] that an embodied view on designing interactive systems for intelligence development is focusing on the "development trajectory" and designing for children’s future abilities and thoughts rather than assuming current capabilities. This focus on the development trajectory also warrants that there be a difference between designing for current skills and designing for developing abilities. There have been speculations that by mimicking and reflecting on past experiences [4] and repetitive activities such as parentese ("baby talk"), children learn to speak [25] and interact with their environment. This can be attributed to the existence of mirror neurons [17, 5, 15]. However, there has been little focus on designing systems which apply this idea even though they hold the potential for new ways of interactions [13].

There has been some progress in designing interactive products that support child interaction and learning, but there is still a plethora of research opportunities [2], especially in dynamic development trajectory, offloading cognition, and movement.

What is play?

In recent times, there appears to be an increase in the complexity of child learning. Children from early ages are made to consume and interact with flashcards and other tools to learn big words and skills, focusing heavily on the mind interaction rather than allowing them explore their natural curiosity. It is easy to understand what the sentiment for this is. There is an almost overwhelming pressure to build the perfect "genius child". Almost every parent today has some story of how their child performs some super feat compared to and faster than other kids their age. And while this might be beneficial to an extent, it can be argued that parents are more focused on their needs to show off rather than the natural cognitive development of their kids.

Play can be defined as any mental or physical activity that is self-directed, and solely for the sake of itself. There is generally no purpose to play or any form, it is focused on the 'process' of play than the 'result' of play. It is often difficult to describe it as anything other than it simply being "play". Play is an essential building block for creativity and opens children up to experiment by building and sometimes even breaking things. By touching, feeling, tugging, pulling, and dancing, children are continuously forming perspectives about the world. When learning, children easily remember songs they dance to or bodily actions they see and repeat rather than materials that only engage either their eyes and ears. So rather than replace play with more serious activities, we should ask how we can enable play?

How can we redefine learning through playing?

The definition of play is broad as there are different forms of play. Play itself seems to be a naturally unstructured art but we can observe that there is some structure to play. Kids in their natural play environments, often come up with imaginary rules to guide their playtime. Perhaps the key to designing play partners is building multi-sensory environments with gamified rules that enable play rather than one-dimensional learning cues. In redefining learning through play, there are certain areas and questions that we need to explore:

- How is the adult view of "faster equals better," affecting how children learn or are taught?
- Is it sufficient to allow infants and toddlers to learn independently by their 'own' curiosity and a little assistance from their guardians?
- How do we create such opportunities and scenarios for children to abstract experiences from their environment?

- What is the boundary of organisation for play? Do we need to build gamified rules around play or let children form their own rules?

By exploring these questions, leveraging existing works, we can understand how to design ’natural’ "play partners" focused on different stages of child development.

Beyond infant-hood; How Play and Embodied Cognition can redefine Artificial Intelligence

As established earlier, children are seen as the perfect example of embodied cognition. How we learn as humans and our ability to be "human" stems from how the child-brain works. From learning to talk to learning to walk and manipulate objects with our hands, these were done through our bodies’ interaction with our environment. This exploration of how children abstract from their environment via embodied learning has the potential to influence robots that are more human-like in ’movement’ and ’thinking’. It can be said that the understanding of children’s simulation of ’self’ can help pave the way for simulating AI consciousness and artificial general intelligence. An application of this is studying how children learn to move their limbs and navigate their environmental scaffolds and embedding such contextual behaviours into robot actions like jumping, emotion detection and expression, and object manipulation.

Aside from this, child-environment interactions can be used to design AI-enabled systems that are perceived to be more friendly by children. One issue that often arises when designing robots is the uncanny valley effect. This is due to the clash between the robot’s non-human-like appearance and the "human-like contingent actions" [24]. By observing how children interact with their parents and other environmental agents, the kinds of movements, shapes, and sounds associated with such interactions can help develop "learning and play" robots that do not trigger infants’ sensitivity to such social or behavioural contingencies. For instance, children are not often as affected by uncanny valley when relating with stuffed animals and dolls [6, 22], designing robots with similarly moderate anthropomorphic structures and behaviours rather than highly human-like robots can help with easing the tension associated with robotic learning agents e.g. Jibo [19].

Conclusion and Further work

Although there was an initial concentration of research in educational technology and embodied cognition between 2003 to 2012, there has been a huge decline from then onward [25]. This could be due to the isolation of these research themes and the inability to tie it back to external fields. Focusing on embodied cognition in relation to learning and child-robot interaction offers the opportunity to explore novel applications, not just in children. Some of these possible applications include stimulating children to make critical reflections on technology through the usage of robots, and in general, AI-enabled systems. ’Play partners’ could be leveraged in the development of primary skills, new language acquisition, and technology literacy. Other applications include the design of spatial structures or ‘memory palaces’ in virtual environments to facilitate knowledge management, associative learning, and information recollection. An embodied approach can also be applied in creating contextual sensory environments that humanise remote collaboration for adults in the workplace, and non-remote gamified collaboration in classrooms by synergising virtual reality, micro-sensors, and haptic and tactile feedback into a uniform experience.

Before any form of practical exploration, there has to be a theoretical deconstruction of certain concepts. Some of which can be posed as questions which I would be interested in discussing and exchanging ideas on in this workshop:

- How can we observe how children offload/extend their cognitive functions to their digital and non-digital environment and abstract such behaviours in designing for other age ranges?
- How can we demonstrate how embodied cognition influences child-learning in contrast to disembodied cognition and reverse learning by using the body and its environment to influence the mind?
- How can we extract the understanding of children exploiting external scaffolding, physical activity, and embodied knowledge and use it to simulate and design social agents and multi-modal interactive environments which aid child learning/development trajectory and abilities?
- How can we leverage embodied cognition to design robots that could stimulate children's critical reflection on its usage?

When designing educational technology using intelligent agents, AI or robots, understanding their implications on children is extremely important. For instance, thorough consideration needs to be placed on the ethical and social impact of such technologies in an educational environment and therefore, monitoring to what extent these are allowed to influence children's behaviour. By understanding how sensorimotor information, beyond the traditional engagement of your eyes and ears, affects children's cognitive development, there lies the potential for a redefinition of what it means to learn.

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