Picking the right interface for engaging physical activity into game based learning

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Abstract: Following Qvortrup (2006) and Bateson (1972), this paper aims to discuss and explore how technology, learning, and movement in synergy makes several levels of learning possible. We will do that by exploring an application for painting developed by engineer students.

In today's technology-driven world, it is easy to forget that we are born movers. To a great extent we have engineered movement out of our lives. (Ratey 2009).

Both bodily and mental acuity increases with activity and declines with inactivity, and so the sedentary character of life in Western societies does not only affect our bodies. It affects our brains as well. (Ratey 2009). However, the most recent results indicate a significant and positive effect of physical activity on children's cognition. (Davis CL, et al. 2011, Kamijo K, et al. 2011). There is a tendency to study brain and body separately.

This dualistic approach is perhaps rooted in a philosophical tradition where knowledge is regarded as a separate phenomenon independent of bodily movement. Contrary to this, though, a growing interest in cognitive studies integrating the body has given rise to new research. (E.g. Aziz-Zadeh & Damasio 2008; Aziz-Zadeh et al. 2006; Binkofski et al. 2004; Buccino et al. 2006; Gibbs 2007; Glenberg et al. 2008; Lutz & Thompson 2003; Pfeifer & Bongard 2007; Rizzolatti & Craighero 2004; Tettamanti et al. 2005).

However, most of these studies lack a connection to the learning processes in an educational setting because they are of a isolated, experimental nature set in a laboratory. An interesting challenge for future research, then, is investigating mind and body as a synergetic catalyst for learning through physical activity in a classroom-setting. Results from this kind of research could have a great impact on the way we think of and organise our educational system.

When using digital learning resources, children should be physically active as part of their learning process. With the paint application, we explore that field. Through bodily activity, children gain new perspectives on and insights into the learning materials. Supported theoretically by Bateson (2000), Schön (1984), Wenger (1998) and Papert (1980), children learn when they are experimenting, constructing, interacting, and physically active.

1. Introduction

This paper aims to explore how technology, learning, and movement in synergy enable learners to achieve all levels of learning following Qvortrup (2007) and Bateson (1974). We describe and analyze a learning resource in the form of a paint application developed by a group of engineer students. Interaction with the application interface is through full bodily movement.

By introducing Luhmann´s theory of communication and Qvortrup's theory of learning (inspired by Bateson), our aim is to show how the paint application is an example of a tool for students to reach all levels of learning. The combination of Luhmann´s and Qvortrup's theories is used as an analytical tool in uncovering the embodied learning potential of the application; revealing a deeper insight into the learning potential of full body interfaces.

This insight applies to all situations of learning. What do you expect from this paper? What do you expect from the authors? When the academic reader lets his eyes wander over the headlines of this paper, he will probably expect the composition of the paper to be consistent with the written scientific tradition. But what if the reader achieves an even greater knowledge or an improved experience if the paper is communicated differently - if the reader's body is used as a cognitive resource via technology?

Expectations afford you an opportunity to prepare for your academic reading. Yet, expectations can also keep the reader rooted in rigid beliefs about reading where the body is given attention only in the event it is a nuisance. Traditionally, scientists assumed that the brain functioned independently from the rest of the body. A dual hegemony has led to a belief that body and senses must be eliminated from the quest for a purely intellectual and objective knowledge. The tendency to study brain and body separately continues. Knowledge is regarded as a separate phenomenon independent of bodily movement.

Nevertheless, the most recent results indicate a significant and positive effect of physical activity on children's cognition. (Davis CL, et al. 2011, Kamijo K, et al. 2011). These studies have investigated the relationship between increased amount of exercise in test subjects and cognition. Children learn when they are experimenting, constructing, interacting and physically active. This is supported theoretically by Bateson (2000), Schön (1984), Wenger (1998) and Papert (1980). So by using digital game based learning resources, children should be physically active as part of the learning process. Through the interactive bodily activity they gain new perspectives on and insight into the learning materials.

Various studies into the influence of physical activity and subsequent cognitive learning have sought to uncover the relationship between physical activity and cognition in children. (Andersen & Froberg 2006; Ericsson 2003; Hillman CH et al. 2009; Sibley & Etnier 2003, Tomporowski et al. 2003, 2008; Trudeau & Shephard 2008). These studies have showed unequivocally in what regard physical activity was enhanced, impaired, or had no effect on cognitive abilities.

A growing interest into integrating the body in the study of cognition has arisen (E.g. Aziz-Zadeh & Damasio 2008; Aziz-Zadeh et al. 2006; Binkofski et al. 2004; Buccino et al. 2006; Gibbs 2007; Glenberg et al. 2008; Lutz & Thompson 2003; Pfeifer & Bongard 2007; Rizzolatti & Craighero 2004; Tettamanti et al. 2005). These studies have opened new perspectives on the body as a potential learning resource. However, most of these studies are isolated laboratory experiments, lacking connection to the learning processes present in an educational setting.

A great need for research in classroom-based physical activity characterized is needed, specifying meaningful connections between movements and learning objectives. Such research will connect cognitive phenomena with concrete bodily experience, which could optimize the comprehension and memory. A promising challenge for future research is investigating the connection between mind and body as a synergetic catalyst for learning in a classroom-setting. Such research could have a great impact on the way we think of and organize our educational system.

The point of departure in the paper is inspired by theories of embodiment and phenomenology. We cannot exist as reflective individuals with identity and language without the body's perception of the world. Embodied identity and language is what Merleau-Ponty refers to, when he talks about the importance of considering the body as something we are, rather than something we have. Merleau-Ponty's focus on cognition as embedded in the body connects his philosophy to modern cognitive science and the basic idea of the embodiment hypothesis that the body influences our perception of the world significantly. (Merleau-Ponty 1945).

The body allows interaction with the physical world influencing the perception as the individual organizes the world in relation to bodily and pre-conceptual meaning. The embodiment-hypothesis comprehends cognition and consciousness as phenomenons rooted in the body. We can only recognize the world through interacting with it, because thoughts and language cannot be treated separately from the body, senses, movement, nor social interaction or the need for communication. (Lakoff & Johnsson 1999). Our body is the instrument through which we learn and remember.

We will describe and analyze the learning potential of a digital paint application. In using the artifact, the application aim at an embodied learning approach. As such, the interface is designed with the purpose of enabling full-body interaction with the application.

Describing the possibilities of different interfaces is our initially starting point. Afterwards we briefly describe the developed application. By applying essentials of Luhmann's communication theory and Qvortrup's understanding of learning, our aim is to explore the possible ways of learning through the application. We conclude that introducing an application with a full-body interface allows the achievement of all levels of learning.

2. Technology as Facilitator

When using digital learning resources, children should be physically active as part of their learning process. And through interactive movement, they gain new insights into the learning materials. This paper aims to explore how technology can be used as a facilitator in combining knowledge of human movement and learning processes. Children learn when they are experimenting, constructing, interacting and through active participation.

Basically we have three types of technological platforms, which support human movement and embodied learning: *Handheld Interaction, Interactive Wearable's and Interactive Surroundings.* In actual applications, the platforms might be integrated.

First, *Handheld Interaction*: We learn through touch, by using tangible devices such as smartphones, tablets and interactive cubes (Majgaard, 2009). It is customary to distinguish between screen-based interaction on the one hand and the purely physical interaction - as with interactive cubes - on the other (Majgaard, 2012). Screen-based media are chiefly PCs, tablets and smartphones. Screen-based media's classic strength is their presentation of abstract, visual and auditory symbols through for example video clips, interactive simulations and graphics. Screen-based units support intellectual learning processes through user interaction and contribution.

Interactive cubes can provide a more tangible physical form of symbolic knowledge and they support more intuitive and embodied learning. However, there are indications that the two types of media are merging. Traditional screen-based media increasingly engage more physical interaction. And interactive blocks are being equipped with screens (Majgaard, 2012).

Second, *Interactive Wearables*: Wearables, Body Area Networks, and Augmented Reality. Wearables count such things as google glasses, smart phones, GPS watches, heart rate monitors, interactive clothes, accelerometers etc.

Body Area Networks are currently mostly being used as part of fitness training. For instance, you can monitor your pulse as a part of a spinning class. Or you can put touch sensors in your running shoes to measure your walking or running style. A very popular application is the Endomondo running app. You attach a smartphone on your arm and starts Endomondo. The program then tracks you by using GPS while being linked to Google Maps. During the exercise, you get precise feedback on speed and distance, supporting training - as well as being an example of learning where the learner takes responsibility. Another growing field is design of interactive clothes, shoes, and accessories. Children can add interactive modules to their clothes such as programmable light diodes. Through using such interactive units, they acquire deeper knowledge of the technology; as well as being active learners and artistically creative (Melgar, 2012).

Third, *Interactive Surroundings*: Sensor Networks and Gesture-based interfaces. This technology can be integrated in the environment, as part of a room or furniture or some other object. Some of the technologies are not in direct physical contact with the body and requires a more controlled and limited environment. Examples are Microsoft Kinect and Camera tracking and hands-free speech recognition. One of the most popular Kinect applications is *Dance Central* – combining game, play and human movement.

In the following we will present an example, which illustrates Interactive Surroundings. Further, we will discuss it's learning potential in relation to Qvortrup's (2006), Bateson´s (2000) and Luhmann`s (2006) ideas of learning.

3. Illustrative Example: the Painting app

The paint app prototype was developed by students at the engineering programme Learning and Experience Technology at University of Southern Denmark. The goals of the developed prototype were to enrich social interaction and motoric skills among children with special needs and children without a handicap (Christensen et al, 2013).

The prototype was a motion sensing input device for Windows PCs similar to Microsoft's Kinect, based on the Asus Xtion Pro platform see figure 1(a). An infrared camera enabled users to control and interact with the computer without the need to touch a game controller, using only body and hand gestures (Melgar, 2012). The technology is an example of interactive surroundings – and as such it competes with Wii Remote and Eye Toy.

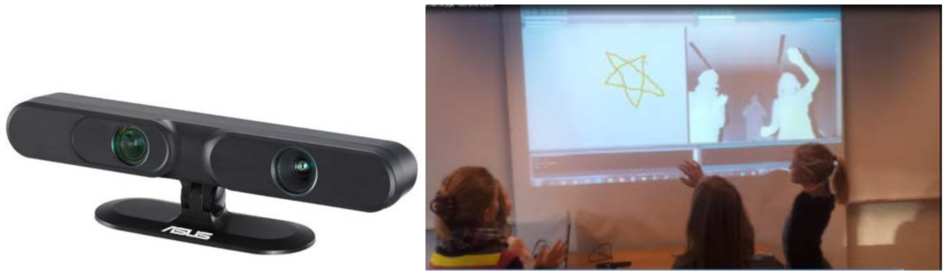

Figure 1: (a) Asus Xtion Pro. (b) Testing the painting prototype (the star is subsequently made more colourful)

The graphical user interface of the prototype was divided into parts; see figure 1(b). The left side showed the user's painting and the right side showed a 3D image of the user. The setup simulated a colour pencil in the user's hand and enables switching between 10 different colours, deleting everything on the screen, and switching between five different pencils.

The students tested the prototype against a group of four school children from the third grade. The feedback was useful. Besides some minor usability issues, the system was unexpectedly very playful to use. The children also had a lot of creative design ideas e.g. painting using feet instead of hands – and even sang and danced while they waited for their turn.
If further developed, the application holds promising possibilities for full-body interaction, participatory interaction, and creative interaction.

What are children learning by using the painting application? In the next section, we will reflect upon that question.

4. The Paint application as a learning resource

Applying a synthesis of Luhmann's, Qvortrup´s (2006), and Bateson's (1972) theories, affords us a better understanding of the synergy between movement, learning and technology. Central to Luhmann theory is the notion of a system. According to Luhmann, systems are emergent, interdependent, arranged and simultaneously bound to the surroundings in a non-hierarchical manner. Autopoiesis is the expression of the system's capability of automatically recreating itself through exchanging entity with the surrounding environment (Kneer & Nassehi, 1997). A person is considered partly as a psychological system (a conscious or mental system) and partly as a number of other systems and subsystems of the different systems. These systems, the mental system viewed from the phenomenological perspective, the bodies movement system, and the neurological system are interrelated through the communicative processes of 'structural coupling' (Luhmann, 2006).

In some interpretations of Luhmann's concept of system, a technological concept with hardware and software can be seen as a system that transports and converts (mediates and remediates) information. We understand the painting application as such a system that converts movement actions into visual information. The application reflects visually the children's movements. In that sense, we treat the learning process as an integration and development of systems.

According to Luhmann, the integration and development is promoted by *disruptions*. Disruptions are the result of information bytes making a difference – communicating and thus resulting in learning.

When the user is doing the virtual painting, disruptions caused by the palm movements are remediated into visual information that are grasped by the eye. This forces the user to learn how to paint virtually without the kinesthetic feedback that a normal paintbrush affords. Through this, information causing these disruptions is translated from one system’s coding to the other system's coding through structural coupling.
The structural couplings indicated by physical movement become a visual line on the applications’ screen – a sign of change indicative of the occurrence of learning.

According to Qvortrup (2006), the form of communication is divided in levels and thus types of learning processes – evident in his categories of knowledge and learning. *Learning-1* is the learning of facts and skills – in Qvortrup's vocabulary; this corresponds to acquiring qualifications. In the present context, such qualifications amount to getting familiar with the app: *What can you do? How do you do it? etc.* In addition, the user at *level-1 learning* learns the basic use of the line, by changing the line thickness or color. In the interaction we have seen, the child learns how to use a virtual paintbrush as a cultural artifact, skillfully expressing herself in a language of painting.
In the perspective of the theory of learning and communication, the learning process can fundamentally be described as a change in behavior. Two aspects of learning are evident: 1) Learning *about something* – in this context about using a virtual brush and 2) Learning *to learn*.

While you learned the concrete subject matter, you also learned a way to learn. The learner is situated in the learning process. This is called *learning-2* learning. According to Qvortrup, in a broader interpretation this is also a reflective approach to the learners’ own actions.
Through the right side of the interface, the user's interaction is mirrored back to her. The application offers a reflecting tool to the user on what normally is tacit and invisible for the child – it’s own movements. Within the communicative act of expressing herself through painting, lies an opportunity for learning a conscious awareness of her own body.

Through repetition, this learning form becomes a habit. Consciously changing learning habits to create new learning skills or knowledge is what Qvortrup calls *learning-3* learning.
Through the two sides of the interface, the application is the mediating unit between the child's artistic expression and her own body as a motor system. Displaying the child's own movements alongside the child's learned creation enables *level 3-learning.*

Learning-3 has many dimensions. It constitutes the creation of new knowledge, of improvisation, of creatively expressing oneself artistically, and when the children proposed redesigns of the application. The children create new knowledge.
The children contribute simultaneously with at least two forms of learning at level 3 learning. When using the application, the children create images and simultaneously involve themselves as co-designers.

The critical question might be whether this multi-dimensional learning agenda occurring in the child create an overload of possible structural couplings of the child as an creating, reflecting and skillful acting entity in the child's desire for communication with the environment. All at the same time, the child simultaneously learns to manage a virtual tool, a new form of cultural skill, and creative expression through a virtual painting medium – and at the same time have the ability to relate reflective to his own body and thus a narcissistic self-reflection.

Will this possible overload of information and structural couplings create a stress that affects the focused communicative act of expressing one self or will it open for opportunities for further parallel learning? Future research will need to emphasise these perspectives.

In testing the interface, we also saw that from the very beginning, the children tried other ways of using the application by experimenting with using their feet. At the same time, they involved themselves as co-developers by making suggestions for improvements and new features. Future research needs to emphasise the possibility of children initiating learning processes inspired by their play and their communities of practices (Karoff, 2009, 2013).

5. Conclusion

In this article, we introduced aspects of bodily movement, technology, and learning. We introduced three types of technology implementing learning through full body movement. The types of technology are Handheld Interaction, Interactive Wearable's and Interactive Surroundings. In order to unfold our views on movement, technology, and learning, we introduced the illustrative example: The Painting App. Children used their hands for painting virtual drawings on the wall – a technology categorised as interactive surroundings.

We introduced the learning perspective, inspired by Luhmann (2006), Bateson (2000) and Qvortrup (2007). We used Luhmann's ideas of disruption for learning. We discussed our illustrative example in light of Qvortrup's learning levels. We found enriched learning potentials at all three learning levels. The next step in our research will be to develop and explore these technologies in a bigger study. We find the perspectives for combining full body movement, technology, and learning very promising. This future study will require cross-disciplinary research. We would like to develop prototypes in all of all the three categories. Most research has been done in the area of handheld interaction. Interactive Wearable's and Interactive Surroundings are upcoming technologies and could be the foundation for future interesting studies.

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