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Learning in our increasing digital World by connecting it to bodily Experience, dealing with Identity, and systemic Thinking

Thomas Winkler, Institute for Multimedia and Interactive Systems, University of Luebeck, Germany
Michael Herczeg, Institute for Multimedia and Interactive Systems, University of Luebeck, Germany
Daniela Reimann, Forum, Muthesius Academy, Kiel, Germany
Ingrid Höpel, Institute of Art History at Christian-Albrechts-University of Kiel, Germany
winkler@imis.uni-luebeck.de

Abstract: Linking physical perception and computer science in education offers new possibilities to comprehend the present world and develop coping skills. We show that a specific exposure to computers in schools can contribute to an understanding of our complex world. It shows how digital, interactive media can increase our perception of our immediate surroundings and also and handling skills. Detailed descriptions are presented of three experiments, which were held at schools, which incorporated a body-based, an Internet-based, and a systemic-based approach to learning. The theoretical background behind the three experiments is explored.

Introduction

This paper exemplifies three experiments at schools where students between the ages of eight to eighteen years learnt new ways of using and understanding digital interactive systems. The first experiment allowed the learner to use their body in a computer and digital picture environment. The second experiment encouraged the learner's identity to emerge and to question their reality utilizing Internet-supported communication. The third experiment concerned systemic thinking and its link to perception. The three experiments link three trends of social changes by well-known theoreticians from the fields of media theory and media pedagogy. First, we refer to the flood of pictures and the lack of physicality when using computers. Secondly, we refer to the creation of simulated reality without reference to physical reality. And thirdly, we refer to simultaneous pattern of perception and understanding.

1. Three experiments at school

1.1 The inclusion of the learner's body (as interface to the virtual world)

In primary schools it is a good idea to interweave interactive systems with physical activity and individual expression of the body. Picture recognition is ideally suited as an interface to register the movement of a body within its environment. Different types of *iconic* software are available on the commercial market, which program *picture-linked sensors* and *physical outputs* (actuators). These software programs utilize a *multiplicity of sensors and actuators* to assure the direct connection of the digital system within a physical space.

In the first experiment, primary school children (a 3rd grade class) incorporated their whole bodies and created the interactive performance "*The World of Dragons*" using digital media. This performance created a transdisciplinary learning experience, which included art, free dance, and computer science. The children developed the story and its choreography themselves (Fig. 1). They designed an interactive stage for the mixed reality performance together with their teachers. The experiment used two main digital media elements. When these two elements were combined with traditional work processes they created a mixed reality.

The first main digital media element used was a video animation created by the pupils (Fig. 3, 5). The pupils created real elements of scenery (Fig. 4), such as self-made trees, a well, dragons, and lava lumps, and then filmed them. The animation used stop-motion technology to show a volcano, its eruption, and a bucket moving in the well (Fig. 5). They projected the animation onto a background on stage during their performance (Fig. 9).
The second main digital media element used was an interactive stage, which linked the actors' movements to image recognition software (Fig. 7). The children defined the position and parameters of various virtual interactive spots on the stage using the image recognition software and a web camera (Fig. 8). The spots were programmed to react to the movements of the children on the stage by creating different sound effects. These were self-made and digitalized sounds effects representing phenomena such as a rattling chain, thunder, volcanic eruptions, and the rustling of trees (Fig. 6). The camera was used as a sensor, which registered both movement (e.g. speed) and color (e.g. orange watering can, yellow lightning,) at the virtual spots on the stage (Fig. 9).

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Fig. 1: Inventing the story

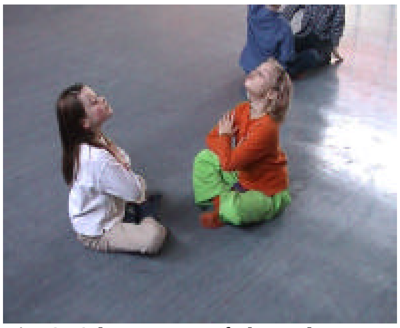

Fig. 2: Advancement of physical expressiveness

Fig. 3: Creating the animations with soft toys

Fig. 4: Creating the physical model of the dragons' world

Fig. 5: Animating of the bucket of the well

Fig. 6: Developing and recording sound effects

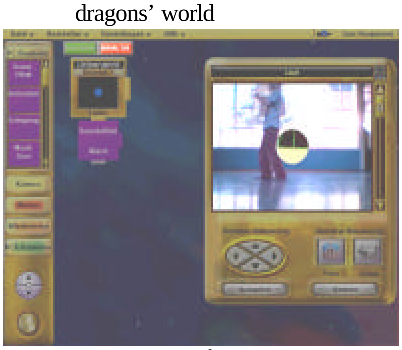

Fig. 7: Recognition of movement and assigning sound effects for each event

Fig. 8: Defining the virtual spots on the stage

Fig. 9: After the orange spot (watering can) initializes the rattling of the wells chain sound effect, a child scoops water in time with the animation

The project culminated with the interactive performance, "The World of Dragons". The children wore dragon costumes, acted out various gestures, and moved to music by Sergej Prokofjew. The music and the background projection, and in particular the iconic software programming, structured the narration and the actors' physical expression. The iconic programming also created an opportunity for the actors to understand abstract modeling.

In this way, their real world became the interface to a virtual and abstract world. Their physical environment was digitally enriched through a software interpretation. The software triggered events, which the actors reacted with. Thus, the discovery and use of virtual space was closely interwoven into the children's immediate environment.

The children acquired practical, artistic, musical, and computer skills in a self-determined, playful, and highly motivated learning environment. In a context such as „The World of Dragons", pupils acquire in very short time duration an intense and competent understanding about how to create digital media (e.g. sound, images, and animation). They learn to understand a computer as a self-shapeable self-programmable media.

1.2 Forming identity and questioning the reality of Internet-supported communication and acting space

The mediated design of reality and our experience within this reality affect more and more our communicative behavior. People reconstruct their traditional cultures, their circumstances, and social being to incorporate the

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influences of the digital world. ArtDeCom provided the artistic and technical scaffolding for a group of 9th graders at an integrated comprehensive school to experiment with interactive 3D spaces and avatars. The purpose of the experiment was to encourage the participants to reflect upon the connection between reality and their own identity. Therefore the students built, in a context of physical space, the interactive environment, "*Real or Unreal – Who cares Anyway?*"

One of the main intentions of the project was to encourage the students to reflect on issues of spaces and current digital forms. Furthermore, they were to analyze the differences and similarities of physical and virtual spaces by converting digitally extended room installations into a 3D-Internet world and then projecting this world back into their physical environment. They experimented with different forms of self-representation in a physical, as well as a digital space.

The first phase of the project showed the participants how to combine physical and virtual space by digitally augmenting self-constructed physical objects and transferring them, as digital models, into virtual space. The students constructed real 3D objects (e.g. a mobile telephone) and made short video clips of them (Fig. 10). This was done with the help of *LEGO-MindStorms Vision Command* hardware and software products. Next, a physical object (i.e. a spider the pupils created) was digitally extended with the help of an instruction microcomputer *RCX*, an acoustic sensor, two small bulbs, and sound effects (e.g. peeping sounds) (Fig. 11). The students then constructed and digitalized (scanned) holograph drawings (Fig. 15).

Fig. 10: Short film about the soft-sculpture, realized with *LEGO-Vision Command*

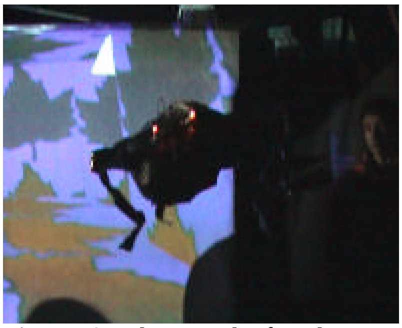

Fig. 11: A real animated soft-sculpture, programmed with *LEGO-MindStorms RIS*

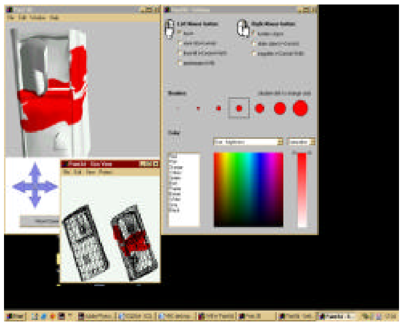

Fig. 12: Coloring with *Alice Paint* a 3D object (a refrigerator) drawn with *Teddy*

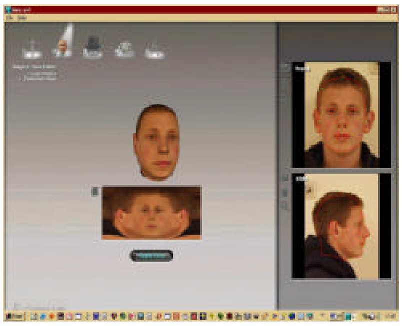

Fig. 13: A student creates himself as an avatar with *AvatarLab*

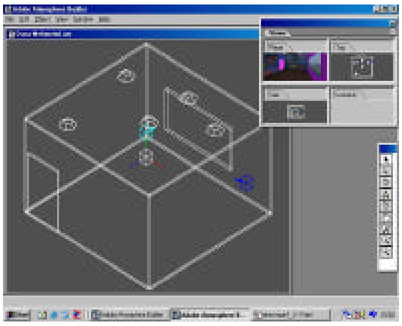

Fig. 14: Creating an 3D Internet space with *Adobe Atmosphere*

Fig. 15: Inserting holograph drawings in *Atmosphere*

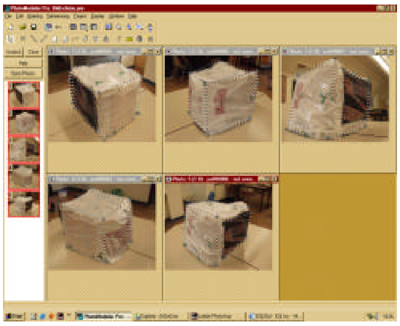

Fig. 16: Digitalizing a soft-sculpture with *PhotoModeler Lite*

Fig. 17: Converting a 3D object from one digital format to another

Fig. 18: A visitor meets Rudolf in the Internet

The next phase of the project required the student to digitally create 3D objects (e.g. a refrigerator). They used the programs *Teddy* and *Chameleon*, as well as *Alice Paint*, to draw and color these 3D objects (Fig. 12). The pupils not only drew 3D objects, they also scanned certain three dimensional objects with the *FotoModeler Lite* software using a photo-optical method (Fig. 16). These digitalized 3D objects were converted with the aid of the program *Viewpoint Builder* (Fig. 17) and integrated into the 3D space that was created using of the program *Adobe Atmosphere* (Fig. 14, 15).

The students then created avatars (Fig. 13). They were either digital 3D representations of the students or completely fictitious 3D figures (e.g. Rudolf the Reindeer) (Fig.18). These figures were animated with the help of the software program *AvatarLab*. A spontaneous rap song that was supposed to be performed online by an avatar inspired the pupils to record more self-created rap songs for the installation.

Fig. 19: Students physically partaking in the projection of a digital world in the Internet

Fig. 20: Soft-sculptures in the installation in front of a Internet space projection

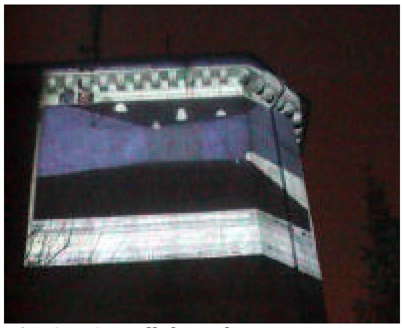

Fig. 21: A stroll through an Internet world, projected on a bunker near the school

The pupils learned in small groups how to creatively operate the software and how to convey their knowledge to their fellow students. Analogue and digital projections mixed real and digitally extended objects in the same installation. The digitalized objects, spaces, and avatars of one's self (i.e. own image) presented the digital world with physical objects within a physical space (Fig. 19, 20, 21). Thus the fusion of digital and physical activity and space challenged the participants and viewers to reflect upon the roles of self-identity and materialism within their immediate environment.

1.3 Systemic thinking linked to perception

In the third experiment students developed *digital models* of abstract *complex behavior patterns* using *iconic* programming. The premise was to implement and support systemic thinking in a learning environment. An interactive environment, "SystemWusel", was implemented and tested in a teaching project with 13th graders. They developed four objects, or "beings", of different sizes, called "Wusels" were hung in mid-air from a steel girder in an empty lift shaft at the Media Docks. A microcomputer (i.e. RCX) represented the "brain" of every Wusel (Fig. 25). Each Wusel was programmed to interact digitally within its physical surrounding.

The initial challenge for both the students and the teachers was to establish which environmental occurrences or parameters would influence the digital models and integrate these influences in the planning phase (Fig. 26). The movements, optical, and acoustical reactions of the Wusels were generated/caused by the intensity of sounds the visitors made. A sensor found inside of a container on the floor (Fig. 29) captured the intensity of the sounds. A microcomputer (MC1), mounted inside of the container, analyzed and digitalized the input data. This digital data was transmitted to microcomputers (MC 2-5) located in the Wusels, as well as to microcomputers (MC 6-7) mounted to a ceiling structure, which controlled motors moving the Wusels (Fig. 30, 31).

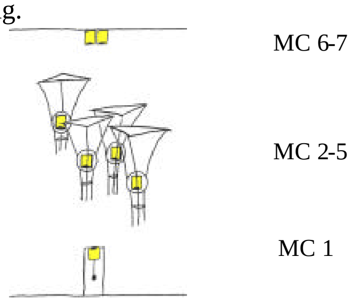

Fig. 22: Microcomputers location in the Wusel system

The system's complex behavioral patterns were influenced by the visitors' movements (e.g. stepping, talking, closing doors) within the Wusels' surrounding (Fig. 23). The Wusels were programmed to adapt both individually and collectively their behavior to their environment. Each Wusel initiated a different behavior depending on the sound level created by the viewer. Collectively though, the four Wusels reacted to a "herding" signal, or a peak sound level, in a manner signifying panic or fear.

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The Wusels were constructed so that their looks reflected their personalities and then they were given different nicknames (e.g. Cheeky, Brave-heart, Chicken Little, or Dumpy) (Fig. 24). Each Wusel interacted differently to the sounds caused by the viewers by demonstrating different types of motion, sound and blinking lights.

Fig. 23: The Wusel system at the staircase

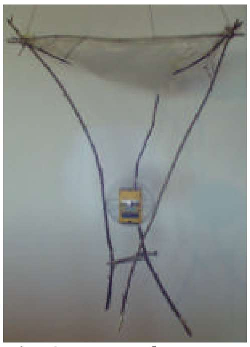

Fig. 24: Brave-heart

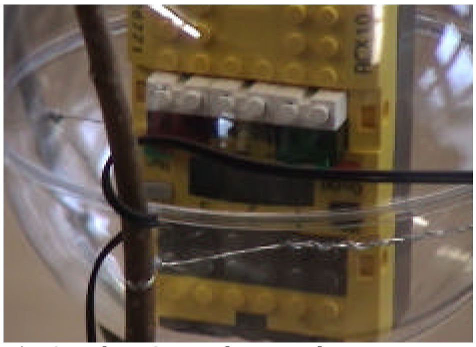

Fig. 25: The RCX inside a Wusel

Fig. 26: Conceiving the interactive installation

Fig. 27: Programming & calculating

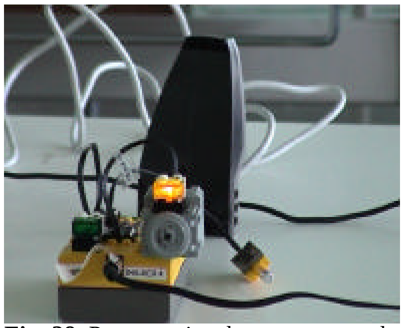

Fig. 28: Programming the program can be directly tested in the real physical world.

Fig. 29: The container of the sound sensor and microprocessor (MC 1)

Fig. 30: The construction which supports the hanging Wusels

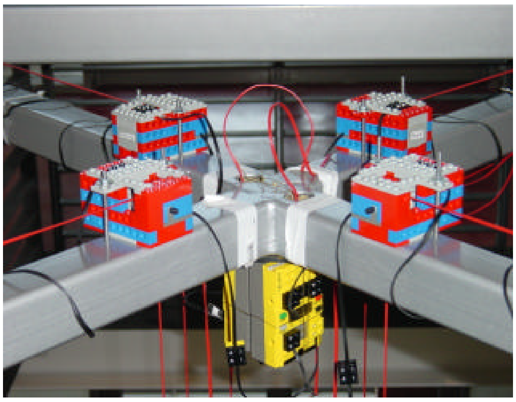

Fig. 31: Motors with rotation sensors and two microprocessors (MC 6-7)

The behavior of the Wusels emulated certain human or animal behavior. Their activity was calm, curious, excited, or fearful. When there were no viewers or when the viewers were not making any noise, the Wusels were barely active (i.e. calmly) – they beeped and blinked occasionally. Low intensity sounds made them become curious. They beeped and blinked more rapidly and they started to move at different speeds from the first floor towards the ground floor respective to the character traits. When it got louder, they became excited and started to bounce up and down. When it got too loud, they became scared and rapidly climbed up to the second floor.

Sounds of middle intensity (e.g. curious or excited) caused different behaviors in each individual Wusel. The Wusels expressed these *secondary forms of behavior* by reacting differently to the same input. In the *higher-ranking form of behavior* (e.g. fearful) they all adopted simultaneously the same type of behavior: just like in herds in nature. "Chicken little" was the most fearful of all.

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Each of the four Wusels was moved by two motors, which were mounted on a metal structure suspended from the ceiling on the top floor of the staircase (Fig. 30). Two RCXs (MC 6-7) received infrared data signals from the RCX (MC 1) on the ground floor (Fig. 29). All the functions of the motors and the Wusels were programmed with the software '*RoboLab*' (Fig. 27).

This software product presents visualizing fragments of code on the pc screen (iconic programming) (Fig. 32). The program developed by the students on the pc was transferred to a microcomputer (e.g. MC 1) via an infra-red-connection. Each microcomputer communicated with other microcomputers in the system. The students were successfully able to implement artistic concepts, model construction, and a complex system design into an interactive environment.

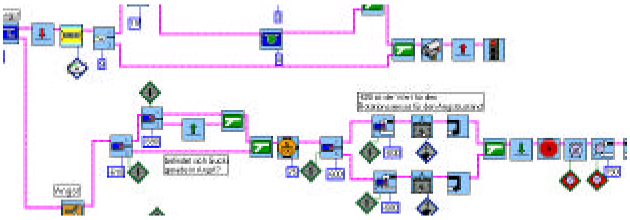

Fig. 32: Fragment of the *RoboLab* program (e.g. Cheeky's motion control)

The Wusels were suspended on Kevlar leashes and they had a 10V power supply. Each of the four Kevlar leashes was manipulated by the two micro-motors on the ceiling structure. At the other end of each leash there was a counter weight to assist the motors in moving the Wusels (Fig. 30).

The Wusels expressed their individuality not only through their context-adapted behavior, but also through material being (Fig. 23, 24, 25, 30, 31). The students used both natural and industrial materials. They used, for example, willow branches and hemp ropes, as well as plastic films, transparent plastic globes, and red Kevlar leashes to visualize the intertwining of nature and technology. *Sytemic* thinking and action enabled the students to successfully complete a project of this complexity.

2. Theoretical background of the three experiments at school

It has been recognized for a fairly long time now that the use of digital media is usually marked by the following three moments:

2.1 An increasing flood of pictures and the lack of physicality while using computers

Nowadays, computers are able to create a simulated reality, which has *no reference in the physical world* (Virilio, 1984). The limited use of the body (discarnatism) alters the relationship we have with our physical world, as well as with other human beings (von Henting, 2002, p.255). The borders of physical reality as we have experienced up to now begin to dissolve. *The way we interact with computers and digital networks* contributes greatly in this process.

Computers and digital networks gain in importance in how we play, learn, and communicate with other, but, in many sense, we have left our bodies behind. We increasingly communicate and handle using symbolic and abstract information in our daily life. The question is whether this form of communication is suitable for us as human beings. *The basis of our existence is and will remain the physical world*. The rapidly expanding, interactive *image and sound worlds of multimedia* shifts the handling process into a space beyond the bodily existence that we are accustomed to.

Ultimately, for us, human beings, existence is directly and intuitively linked to "*here and now*": to our physical surrounding. There is no world for us without the body. On the other hand, we can experience only through mediators the world we live in. We need to simulate the reality through our brains just like we need the reality itself (von Foerster, 1985). ArtDeCom's goal was to create a learning environment where teachers and school children could experiment with art, technology, and mixed media to learn and build informatic models as an integral part of their physical world.

2.2 Creating simulated reality without reference to physical reality

The new digital networks bestow such an *abundance of data* that many people feel they are being clobbered over the head with it. Other people, often young people, are fascinated and are drawn into the new virtual worlds and digital realities. The digital media deprives us of self-determined handling options. They offer us the possibility of understanding technological advancements in network, digital pictures and realities, but they do not offer us a learning platform to understand the consequences of these developments.

The wide range of technological advancements, such as, cell phones, multi-player Internet games, etc, influences the social behavior of children and teenagers. Not only parents, but also many teachers, feel that they are inadequately prepared to compete or to instruct the children about how to intelligently use these digital influences.

This lack of clarity within our schools occurs, in part, because the academics today have contradictory theories about how we should assess the influence of new media. For example, *von Henting* calls attention to the fact that the new “interactivity” of the network and of the computer games only educates the spectator mentality (von Henting, 2002, p.97). He is a strong advocate that children need to explore with their seven senses and not with a keyboard within their learning environment. *Florian Rötzer* (Rötzer, 1997, p.149), on the other hand, theorizes, in reference to *Gerard Schulze*, that interactive computer games are part of a new emerging *ludic culture*. His theory stipulates, for example, that computer games have become a *paradigm for processes of human interaction*, not only with media, but also with system elements and complex systems (von Foerster, 1985). These influences change not only society, or cultural techniques of perception, memory, interactivity, but also change us, as individuals and our respective identity (de Kerckhove, 1991, p.73). Projects such as ArtDeCom create a learning environment where teachers were able to teach school children how to develop artistic and technological skills using new forms of computers and Internet-supported communication in mixed realities.

2.3 Thinking in simultaneous models of perception and comprehension

The world, which we acknowledge, in which *simultaneous interactions* in economy and society take place, is strongly influenced by digital systems. It is important to implement systemic thinking within our school system instead of thinking in terms of causalities and sequential patterns as they are still taught nowadays. In our rapidly changing society *thinking in simultaneous models of perception and comprehension* (Fassler, 1999) is required in order to be able to manage current and future type of problems.

Conclusion

Linking physical perception and computer science in education offers new possibilities to comprehend the present world and develop coping skills. We created a learning environment where the students and teachers could discover the direct connection between digital systems within a physical space.

Digitalized objects, spaces, and avatars presented projected in a digital world as well as in a physical space define new forms of thinking. The fusion of digital and physical activity and space can teach us how to reflect upon the roles of individual identity and materialism within our immediate environment.

In order to develop network thinking (in terms of Vester, 2002) in our schools, requires that knowledge is self-generated, cooperative and project-oriented. Only in this way can the level of symbolic thinking and handling increase. This is why we promote differentiating between reasoning patterns and understanding patterns in the project-oriented and physically-consolidated learning environment. This way it is possible for school children to understand their globally networked surroundings.

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