

Teaching Teachers to Teach with Body and Space related Technologies: Programmable Clothing in Performative Teaching Processes

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Abstract: The integration of programmable textiles into teaching scenarios allows the necessary support for world-life in the 21st century. Therefore, we are going to discuss theoretically the meaning of this integration. We are going to describe a pilot project, where 10th graders program and create smart textiles, relate to self-produced video clips and an on-stage performance. In the course of the project, active and creative conceptual permeation of commodity (clothes) with digital technology, experimental development and accessibility of new communication and interaction is originated by young people. Furthermore, we are going to discuss how this experience is transformed into teacher education. Evaluation results of the pilot project are used as a basis for the development of teaching modules in teacher education. Lastly, we reflect about the importance of this kind of interdisciplinary (arts/computer science) workshops about wearable media; especially regarding the facilitation of female students at school, in the teaching of preservice students and practicing educators.

Introduction

The teacher training in the 21st century has to take the chance of the opportunities that technology offers today, to reflect and exploit pedagogical processes, because a reassessment of the physical in dealing with digital, interactive media emerges with teenagers. No longer a mere extension of the digital-virtual action space, but the digital enhancement of physical space, emerges in importance (Manovich, 2006). New forms of identity are formed not only in the digital space. Body and spatial interactive media, as an extension of physical space, conquer large areas of the teenager's worlds of experience. The teacher training has to reflect and honour these social changes in modified teaching scenarios, so that the students are prepared adequately for future challenges in the 21st century. One of the main interests of the KiMM initiative¹ in co-operation with the IQSH² concentrates on the design and development, testing and evaluation of digitally enriched interactive learning environments for children and teenagers (K-12). We have worked for more than eight years in this field and transfer a constructivist pedagogical methodology into new, contemporary scenarios of teacher education. We focus on how young people can learn to design and program interactive systems themselves. Using novel interaction tools, they become emerged in an iterative co-design process within their day-to-day classes. We examine which additional pedagogical benefit, if any, emerges through these iterative processes. Furthermore, we study the effects on the joy of learning, especially in regard to science and technology, as well as general effects on identity construction and the critical reflection of novel interactive technology for everyday life. It is important that the learning scenarios are created and evaluated with children

[1] Kids in Media and Motion, Initiative of the University of Luebeck, Germany. <http://kimm.uni-luebeck.de>

[2] Institute of Quality Development at Schools in Schleswig-Holstein (Teacher Education, Germany). <http://www.iqsh.de>

and youngsters in mind and can easily become part of daily practical teaching at schools. This means appropriate use of available technology; i.e., it must be inexpensive and easy to handle. Additionally, the technology and the associated learning scenarios are meant to be directly incorporated into teacher education.

A prerequisite for the design of up-to-date teaching scenarios is a current understanding of structures of learning processes. The science of learning is defined as *mathetics*, according to Seymour Papert (Papert, 1980) and Hartmut von Hentig (von Hentig, 1985). This interpretation relates to the teaching and learning research in any kind of learning, to those involving teachers and also focuses on those learning processes, which take place without teacher's initiation or intention. Particularly, the fact of collective forms of learning is an important constant of human existence, as recent studies by Michael Tomasello show. He developed the theory of *shared intentionality* of humans (Tomasello, 2002). This means the ability to share activities with others by coordinating aims and intentions in a cooperative way. Following this approach, a central function of shared activities is to develop social competence and the ability to put oneself in other's position (joint attention). This entails the ability to communicate, cooperate, and learn with the others, as well as to do so willingly and with a sense of joy. In Tomasello's concept, cooperative learning is not only intended as a directed refinement, but also as a possibility of interpersonal communication. It presents a scientifically grounded enhancement of approaches in learning concepts, which are oriented on a wide range of possible and contemporary forms of sociality and cooperation. Therefore, it also allows for the planning of a model-project with students at school, considering changing societal, cultural and social needs in terms of a new learning culture in the 21st century: *shared intentionality* estimated as a h feature of all learning.

Media have always influenced our learning, whether as a linguistic or non-linguistic communication media or as media which (pre-)structure the interactions with the object world. In the beginning of the 21st century, the significance of the mediated reality of human life changed fundamentally. These changes must be incorporated into teacher training programs. Communication and interaction (between people and between people and machines) made over the past years a growing in symbiosis with highly complex information processing systems, both in post-geographical (Fassler, 2009), as well as in physical environments. Media have always expanded our body, but now this is done at a very rapid pace. Through the new media, our culture and relation with time and space is changing in a radical way (McLuhan, 1964). The results in the novel, the unprecedented media forms of perceiving and interacting mediated entirely new modes of construction of knowledge (in other words, of learning processes). On this theoretical basis, our relationship to learning, especially that including digital technologies, must consider the following educational criteria (Moegling, 1998) for teacher education:

- counteracting the disembodiment and desensitising structures within the school learning environments, which estrange children and youngsters from themselves and their sense of subjectivity. Teaching methods should be open to combining movement, sensuality, and body experiences in subject-centred and interdisciplinary learning. Intended is a modus for *consideration of physicalness of the learner*, who follows the *phenomenological paradigm* and thus leading to a differentiated ability for critical reflection
- learning must be linked to the *life world* of the students: a well-designed learning environment encourages the students to explore their own life world as a *perceptual experience*, without losing sight of the need to use critical reflection. Learning scenarios are focused on numerous forms of learning: exemplarily, practical, the imaginative and scenic, project-oriented, and the learning which is mediated by empirical research.

New body and space-related computer systems (e.g. programmable textiles) enable new forms of teaching in school and learning environments. It must be understood that while people exist as a physical being, meaning the body is connected with the world and to other people (Merleau-Ponty, 1966), people also perceive their world symbolically (Cassirer, 1955), which means we can only exist as a social being through communication and interaction with others and our environment (vgl. Castoriadis). The microcontroller board *LilyPad Arduino* (figure 9) has been designed and developed by Leah Buechley and SparkFun Electronics³. It is designed for wearables and e-textiles and available since 2007. It can be sewn into fabric and similarly mounted power supplies, sensors and actuators with conductive thread. The *LilyPad* was designed for students to acquire basic information about electronics, programming and textile design. The European project *EduWear* creates and implements an educational low-cost smart textile construction kit for wearable and tangible interfaces. The *LilyPad-Arduino*-based iconic programming environment, called *Amici*⁴ (figure 8), was developed within this project. *Amici* helps by simplifying the students' first

[3] Arduino: <http://www.arduino.cc>

[4] Amici: <http://www.dimeb.de/eduwear>

contact with programming because of its iconic visualisation of the programming code and easy handling of the system components. This facilitates their ability to intuitively design their own interactive digital systems.

Related Work in Arts and Education

Leah Buechley (Buechley, 2006) utilizes LEDs that are sewed into textile surfaces (shirt) via conductive yarn and are driven by the simple microcontroller, *LilyPad*. Depending on the choice of microcontroller and available memory, simple animated patterns and text tickers can be programmed on the fabric. Therefore the shirt is a programmable wearable and acts as a low resolution display (figure 1). Artists like *Barbara Layne* (Layne, 2007) integrate wearable LED-matrices into their fashion. In her *Jacket Antics* project, unique texts and designs scroll through the LED-array on the back of the clothes. If two people wearing the shirts hold hands, the LED-arrays present a third, synchronous message that scrolls from one person's clothing to the other, establishing a new pattern of communication (figure 2). The capacity for interactivity in animated clothing displays extends the narrative qualities of cloth and provides new possibilities for dynamic social interaction (Seymour 08). *Jenny Holzer's* work serves as an example of the role of lettering in contemporary visual arts. Her text designs mainly consist of general public "wisdom" like »AN ELITE IS INEVITABLE« or »GOVERNMENT IS A BURDEN ON THE PEOPLE«. What appears as playful, amusing and sometimes provocative emerges as a form of critique on present life and society. *Jenny Holzer's* textual messages have appeared in numerous artistic works since the 1970s, e.g. as printed posters, on T-shirts (figure 3), but also on electronic display panels and tickers in public space. *Holzer's* work is characterized mainly by its examination of language as a picture. Her early works were classical prints applied to clothing that enabled the wearer to carry the writings to different places.



Figure 1: *Tank Top*. Buechley 2006; **Figure 2:** *Jacket Antics*. Layne 2007; **Figure 3:** *Truism*. Holzer 1984

Our work with students in high schools is inspired by the basic concepts of *Truism* by *Holzer*, and the *Jacket Antics* by *Layne*. The difference of our project is that these afore-mentioned works were not conceived so that high school students could program them, but we need this possibility. For this reason, the students carried out smart textiles projects using *LilyPad-Arduino* microcontroller and the *Amici* iconic programming environment. In contrast to Buechley (Buechley et al., 2008) or EduWear (Katerfeld et al., 2009), our research does not principally focus on teaching students programming skills. Rather artistic work of the students should explore social critical aesthetics and their own identities in onstage performances. It is intended that in a contemporary artistic approach they reflect on societal pattern of communication and interaction in the information society of the 21st century, and not merely create decorative fashion accessories. The evaluation results of this work with the students, forms the bases for developing an instructional model for teaching and learning for the teacher training in arts and interdisciplinary education in a co-design process with high school students.

Concept and Realisation of the Pilot Project *Digital Fashion*

Today medial supported learning means learning in mixed reality environments. Out of the spirit of the 21st century is the understanding of media as an enhancement of the body, concerning the sensual aspects and also the social cooperation. Digital media enhance both body and soul. Insofar they are systematically linked to the structures of physical space; they allow new forms of thinking and, as such, ethically responsible acting. The digital information systems are not only linked to the real world, they also link us with the world, insofar options for an ob-

ject identification exist and/or such identifications for a localization of objects in the room. Digital systems are connected to us in multi-modal or multi-code forms. Together, with them or also with other people, they allow us to learn without negating our physical existence or disconnecting us from physical experiences in context to actual life realities. We argue that the basis of such learning is not only technology fortification of possible life scenarios, but also the sensual experience within designing learning scenarios with new media in terms of Experience Design.

Nowadays, teenagers increasingly develop an understanding of the world by using language in unique ways. More and more, they use linguistically flexible association chains to communicate socially (e.g., leet speak). They post comments in chat rooms or discussion forums in virtual environments not tied to physical space. In contrast to the traditionally finalized usage of language that emphasizes the process of writing, the written word has become more democratic and exists in the form of a process-orientated social dialogue. In contrast to *Holzer*, written words become more like a liquid. Teenagers of the 21st century are offered the opportunity to reassess their physicality when interacting with digital interactive media. Not only the mere extension of digital and virtual spaces, but also the digital enrichment of physical space is becoming a more and more important aspect in communication and social interaction. The reflection of the surface of the body as an inter-active interface is based on what we wear on our bodies; clothes and jewellery are a form of expression of our personality. Teenagers who practice flexible and non-linear identity constructions recognize the creative potential of wearables as self-programmable interactive interfaces that can be used to extend their possibilities of expressing their bodies as parts of an outward-orientated identity.

In cooperation with KiMM and IQSH, the pilot project, *Digital Fashion*, the design and, implementation of 10th graders work is evaluated with the goal of developing an instructional model for the education of teachers. The project intentions are for teenagers to experimentally develop and utilize new communication and social interaction to create active conceptual and creative implementation/integration of digital technology commodities (e.g. clothes). The challenge of the scholars is to make clothes more intelligent and to also give them an individual touch in a process of personal brainstorming; for example, by adding lettering in form of a display on a T-shirt (figure 6). The work contains normal static functionality processes and, eventually, becomes the driving power for an onstage performance (figure 10-12).

Main aspects of the examination with this topic are the following:

- understanding clothes as an expression of cultural codes, but also as an expression of rapid convertibility of short-lived trends and of exploring, perceiving and comprehending these forms of expression
- setting up complex forms of possible identities and communication. Identity appears as an activity that takes place in the tension between school, friends, clothes, communication, travel, computers, leisure, music and career aspirations. This is a explorative process in interpersonal orientation
- creating programmable clothing and video sequences (figure 7-9) that have valid context to the real world of young people
- getting acquainted with an easy-to-use, beginner friendly microcontroller (*LilyPad*), which is specifically developed for the design of wearable computing
- developing an aesthetic point of view complying to technology-oriented forms of suturing the LEDs (it is important to ensure the power supply to electrical resistance on the instructions of conductive yarns and transistors) (figure 9)
- constructing several LED-pads with 5x5-matrix arrays to represent letters, words and semantic units as well as some pictograms (figure 7)
- programming the LED-matrix (with the iconic programming environment *Amici*) (figure 8)
- initiating a mixed reality stage performance that consist of self-created digitally augmented T-shirts and digital videos (figur 10-12)
- acquiring narratives, which in the context of a on-stage performance process is interactively visualized by T-shirts and videos (figure 4)

The function of the body surface as interface is in the main focus of the interdisciplinary pilot project between the circular arts and computer science subjects. With the design of intelligent T-shirts, the students explore not only regularities in the dynamic behavior of interactive processes (between people and computer systems) but they also learn to understand their life-world via physical simulation in the context of manual model-building. The performance occurs between the displayed textual content on the T-shirts and self-created video clips.



Figure 4: Design of the performance; **Figure 5:** Video shooting; **Figure 6:** Enjoying the rehearsals



Figure 7: Creating LED-matrixes; **Figure 8:** Programming the matrix; **Figure 9:** Shirt with LED-matrix & *LilyPad*



Figure 10, 11, 12: Rehearsal and performance in front of video clips

Through the playful, spontaneous, self-determined, local and temporary interaction of students with each other and the self-made video clips, there is a creative production of chains of associations at the moment of performance. Here occur the meaning and aesthetic sensation, as an expression of communication and swarm behavior in the process with the others (*shared intentionality*). Through physical and spatial forms of digital augmentation of clothing - using wearables - the possibilities of interaction and communication are reflected and expanded by young people in a very thorough and yet realistic manner. In doing so, they experience performance processes, not something fixed or fully planned, but as elastic and disposable transformation processes. This allows them an open scope and space to shape their own identity construction.

Evaluation of Digital Fashion

The pilot project took place in the 10th grade arts class with 16 female and 12 male students at a secondary school (average age 16.25 years). Concerning the answers to the questions a scale was used from 0 = *does not apply at all* to 5 = *applies fully and completely*. The *mean* (arithmetic average), the *standard deviation* (measure of the statistical dispersion), and the *median* (relative frequency, not influenced by extremes) were calculated. Some of the questions of the pre-evaluation could only be answered with *No* or *Yes*. These answers are pointed out by percentages. Some of the questions were formulated in a negative way, therefore the original phrase is marked in brackets.

The pre-evaluation questionnaire consists of 45 questions. The majority of questions (the first 36) establish the usage of media and previous experience in use of digital devices in specific contexts. They provide data for comparative evaluations regarding other media projects at school. Only 9 questions focus specifically on the project *Digital Fashion*. The questionnaire shows that, all but one male student make conscious decisions about their choice

of clothing. Only 28% of the teenagers say they spend *a lot of money* on clothes. All but one female student say that they do not think that their choice of clothes is influenced by their behaviour of friends. Less than half of the teenagers believe that their choice of clothes is influenced by the fashion trends. Only half of the male students believe there is a correlation between body image and clothes, whereas the female students were considerably more. The majority of the students are conscious that clothes are an expression of their personality (identity). The answers of some of the male students concluded, that there is no awareness regarding this phenomenon. Furthermore, the male students are not conscious about the role of clothes in communication processes. It is interesting, that before starting the pilot project, 47% of the female students, in contrast to 7% of the male students, believe that within wearable media somebody is able to express feelings by means of actors, such as light, etc. 73% of the female students, in contrast to 22% of the male students, want to figure out the possibilities of electronic media in order to communicate with others.

Except for the first four questions, all of the post-evaluation corresponds to the pilot project *Digital Fashion*. Opposite to the conclusion of the male students who stayed undecided, the activity leads the female students to personal satisfaction. The experience to express the results in the framework of an onstage performance to the public, was new for the students. In contrast to the male students, the female students are proud of the presentation of the onstage performance, and because of their hands-on doing, it is easier for them to remember the content of the project: Only half of the male students believe in this. While the students predominantly hold that art education, based on programmable wearables, is interesting that particularly female students express this meaning more significantly. Working papers, structuring the self-oriented design of the LED-matrix are reviewed quite clearly by the female students. The teacher of the pilot project pointed out that the male students did not deeply reflect on the content of the paper and thus had more ambivalent statements. Thus the transfer into to the needs of practice often is not goal-oriented. Female students, but not male students, feel in particular motivated by the use of programmable shirts in education. First of all, female students agree that the pilot project develops self-oriented learning processes. In contrast to the female students, the male students are using much less the space to place their own ideas of design. (The teacher believes that this is based on the absence of willingness on the part of the male students.) Practically every one of the students were satisfied working together with others by creating the LED-matrix. However, it was frustrating for them to optimize the functionality of the LED-matrix, again and again during the working process. Even if the average is not significant at first sight, there is a considerable difference between the sexes concerning the following: The female students are highly motivated and they are getting involved on the arts project in their spare time, beyond the lessons at school. On the contrary, the male students were not willing to invest engagement over and above the regular art lessons. Also, we figured out a gender-related difference between the female and male students: the female students take much more pleasure in *collective* problem solving operations while designing the LED-matrix. Whereas, on the average the students believe that they know how to program the LED-matrix, the male students assume that they can design a complex program to visualize lettering. Doing so, they are less likely to go back to the instruction of the working paper (showing the structure and the programming of the LEDs in the LED-matrix) to act independently, as the females do. Very noticeable is the extreme standard deviation of the answer regarding the question on the part of the female students: it shows that the female students are much more self-critical in estimating their skills adopting the programming. The female students' motivation to accomplish the project is related to act independently in designing the onstage performance, i.e. they enjoy the integration of LED-T-shirts as well as the video clips, but above all, by the use of the combination of both. The students feel that the project work is one of the most beautiful experiences in arts education so far. They believe that they learned a lot about choreography for creating a performance and storyboards for the video clips. While all the wearers of the digitally augmented shirts find it interesting to be a part of the performance, the male students feel uncertain in wearing the shirt, unlike the female students. This is validated by means of the female students, who would like to wear the LED-T-shirt in a disco, too.

Transfer into Teacher Education

A multiplicity of workshops focusing an interdisciplinary approach was accomplished within teacher education and further teacher education regarding all subjects and different kinds of schools.⁵ Therefore a module for

[5] In the land *Schleswig-Holstein* in northern Germany.

teacher education was derived from the results of the evaluation of the pilot project *Digital Fashion*. This teaching module structures workshops regarding the use of *wearable media* in pedagogical processes, concerning the special field “Learning with Digital Media” within teacher education. The scaffolding of the teaching module is developed out of an understanding of *wearable media* in an onstage performance context. The content includes comprehensive material on innovative pedagogical processes in schools. Thereby, the usage of body and space related media is directed to the additional qualities, which arise by the use of this media in teaching process. They enable the design and realization of the wearables in multi-modal und multi-code learning environments. This encourages a transformation process in the realm of human communication and interaction.

A survey was conducted of the participants in each of the three workshops. The results indicate that the previous experiences, both on the part of their ongoing university studies (pre-teachers) or their work life (teacher in service) are marginal regarding the inclusion of digital, interactive multimedia into teaching and learning scenarios. Particularly, applications beyond the traditional desktop PC with keyboard, mouse and screen are not well-known. Also, in the field of media art and media theory, exceeding the traditional comprehension of media competence (i.e. regarding movies and TV), there is little knowledge or understanding of meaningful usage of media in schools.



Figure 13, 14, 15: Design of prototypes of “intelligent”, computer based clothing and accessory

For this reason, the structure of the workshops is geared to locate the subject in the context of media theory by means of selected examples of media arts and media design. Secondly, hands-on content served to offer a comprehensive and practical utilization of digital technologies (i.e. basics of iconic programming). Supplementary to this, the teachers learn in tutorials how to develop their own design ideas, in order to derive meaningful learning scenarios (figure 13-15). The teachers found that rapid prototyping and experimenting is vital not only for developing basic programming skills but for creating design ideas, imbedded in the design of teaching and learning scenarios in the context of performances to realise in day-to-day teaching at school.

Conclusions and Further Work

As we briefly mentioned at the beginning of the paper, digital media of the 21st century, body and space related media are more than just practical tools. They have the opportunity to create a new learning culture that encourages key competences such as the ability to explore meaningful expressions of sensuality, communication, self-motivated action, and problem-solving in context to teamwork and real life situations. The artistic examination undertaken through the use of smart textiles woven into a *performance in front of self-made video clips* creates an important differential experience for the students. This experience allows them to critically and constructively reflect upon themselves within a digitally augmented reality. The results of our evaluation of the pilot projects *Digital Fashion* conclusively supported the characteristic mentioned by Tomasello concerning the learning culture of the 21st century (*shared intentionality*). More significantly, the evaluation results showed that the engagement of female students was high when they were presented with the opportunity to work with such creative and constructive digital technologies (programming wearable by digital lettering as a form of individual expression and mixing this with an onstage performance).

For this reason, focal points and objectives should be newly shaped and implemented in the education of *arts teachers*. State-of-the-art teaching scenarios must be forward-thinking and integrate the potential usages of digital media into *teaching modules*. They offer the possibility to reflect upon the fact that our bodies and our possibilities of communication are forever extendable. Finally, we believe that the teaching modules make it possible for

teachers to capture the interest of high school students, since they enter the world of the Digital Natives and offer them an environment where they can critically explore their world. The high request of workshops about wearable media demonstrate the importance of the interdisciplinary (arts and computer science) offering for the teaching of pre-teacher and teacher in service.

The ongoing research includes interactive writing on the T-shirts with mobile phones (Winkler at all. 09), as well as a multiplicity of body-sensing technologies.⁶ Through textile sensors the physical and emotional state can be captured through the ever-changing properties of the epidermis. Also, through the connection to the web, complex social interaction will be allowed (cloud computing).

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[6] i.e. in the ongoing project *MoMo* (Mobile Monitoring), IMIS, University of Luebeck, Germany.