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# Sustainable Teaching through the use of Media Art Technology – Creating Biological Knowledge by Designing a Multimodal Interactive Tangible Media Installation

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**Abstract:** *In this paper the authors explain, that the way of using digital technology in media art can be productive for teaching by means of digital technology. After a short description of the author's research background and the state of art in this field of research, we point out certain parallels between art and education. We exemplify, why media art technology was relevant in an inter-disciplinary collaboration of two teachers of a fifth grade. In linking the subjects diet and digestion in biology with the forms of expression of digital media art, children at school were enabled to reflect their own eating habits in a specific way. But it wasn`t merely the production of media in form of videos and animations which made the difference. Rather it was the building of tangibles by the kids themselves and therefore the relation to the physical reality of life was created. This becomes obvious by the results of an evaluation. The findings are discussed and the conclusion punctuates the pedagogic benefit if teachers learn to teach digital technology in this way more often.*

## Introduction

Tangible and digitally augmented reality has been used successfully for teaching and learning at school for years (i.e Iturrizaga, Falbel, at all, 1999, Price, 2003). The closing of the gap between the world of bits and atoms (Ishii, Ulmer 1997) seldom leads to cost efficient answers. Furthermore these works cover only a small area of the complete curriculum of school. However it's a novelty that teachers teach children in an interdisciplinary approach *how to augment their learning environment digitally*, and learn by *producing tangible media* for an artistic environment. The aim of the teaching project is sustainable learning in the subject biology, as well as artistic expression in the subject art. Simultaneously it involves the acquirement of basic media literacy. But how can creating an interactive artistic environment with self-made tangibles influence learning in positive way? Does it originate from the exposure to primary experiences, from picking up the kids from their world, from recording videos and produce animations, or even from creating an interactive environment using tangibles? Can the artistic strategy be seen as the cause and if yes, which figures in artistic processes support sustainable learning? These questions were the reason to start the teaching project „Your Food is Your Mood".

## Background and brief history

The development, testing, and evaluation of the teaching project "Your Food is Your Mood", originated within the field of KiMM (Kids in Media and Motion) initiative. For more than six years we, at the University of Luebeck, have developed innovative learning technologies and learning scenarios and have transfered them into school education. Initiating learning by using creative wearable-, tangible-, ambient-, mobile- and world media to augment or mix the physical with the digital realm, are proved to be successful for education (Melzer, Hadley, Winkler, Herczeg 2005). The aim of the KiMM initiative is, to establish up-to-date media competence for education. The scientific initiative promotes holistic, project oriented, inter- and transdisciplinary teaching and learning as well as creative and artistic use of digital media. The new interfaces for human computer interaction (HCI) are developed by the scientists of the KiMM team, teachers and pupils together. The development of new software and scenarios for teaching and learning aim at the pedagogic surplus value. However the everyday suitability and the affordability of the new media in school are important. The "open experimental modules", developed within the scope of the KiMM initiative, establishing a creative use of technology in all subjects at school, and nowadays play an increasing role in teacher-training and further education of teachers in northern Germany.

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## Related Work

Already in 1993 Pierre D. Wellner, Wendy Mackay, and Rich Gold wrote in their paper "Computer augmented Environments: Back to the Real World" about the interaction with accustomed physical/tangible environments, and how to augment the digital world. The augmentation of artifacts for digital interaction (e.g. tangible user interfaces) leads back to the primacy of the physical world and the ideal of introducing computing technology unobtrusively. In their paper "Tangible Bits: Toward Seamless Interfaces between People, Bits and Atoms" (1997) Hiroshi Ishii and Brygg Ullmer presented their vision of Human Computer Interaction: "where the user could 'grasp and manipulate' bits of in the centre of users' attention by coupling the bits with everyday physical objects". In the following years many attempts were made at the MIT, Tufts, Maryland and other universities world wide, to close the gap between the world of bits and atoms regarding teaching and learning at school.

Unlike the mere execution of tangible media mentioned above, our more pedagogically driven approach helps teachers to teach pupils to create tangible user interfaces in an artistic process by themselves. This approach borrowed by contemporary art, to have a different look at the world (Eco, 1989) and attain an intensification of perception respectively (Seel, 2005), is genuine pedagogically seen (Parks 1992). The examination of the work of media art plays a primary role for teachers against this background.

In the first half of the 90th, artist used tangible user interfaces in media art already. Those allow the user interaction with computers via graspable objects. A possibility to realise cost efficient tangible media with graspable user interfaces consists in barcodes attached to objects and identified by a computer with a barcode reader to control media. One of the best well known media artwork which used barcodes is the interactive environment "Bar Code Hotel" by Perry Hoberman, 1994. Hoberman recycles the ubiquitous symbols (barcodes) found on every consumer product to create a multi-user interface to an unruly virtual environment. The installation makes use of a number of strategies to create a casual, social, multi-person interface. The public simultaneous influences and interactions with computer-generated objects in an oversized three-dimensional projection, scanning and transmitting printed bar code information instantantly into the computer system. The objects, each corresponding to a different user, exist as semi-autonomous agents that are only partially under the control of their human collaborators. Different from Hirosho Ishii and his assistants, who provided non professional users with designed tangibles, Hoberman creates his own tangibles. Due to the fact that these tangibles are abstract, he works without the richness of associative mental models, users already have, due to their own experiences of real world objects.

Our concepts of learning theory regarding the development of specific software to realise tangibles with barcodes, is based on the thoughts of the pedagogical reformers, critical constructivism, the idea of holistic education and discrete learning. Alongside Friedrich Fröbel with his "gifts" for his "kindergarten" inspired Maria Montessori with her graspable learning materials for her "Casa dei Bambini". Both teachers could improve cognitive development in linking thoughts to sensory perception. Furthermore our concepts of the learning theory are based on concepts of pedagogy, regarding critical constructivism in the sense of the psychologist and mathematician Seymour Papert (Papert 1980) and his followers: It is essential for Papert, that kids dominate the computer and not vice versa. Kids should not be trained to be answering machines. Instead they should be enabled to experiment and build new things with computers. This leads them to understand the technical principles, make decisions and take responsibility in the reality of life, interspersed with digital media. The concept of Papert was to boost scientific thoughts and acting by researching independently, linked to the richness of multimodal perception, carried on at the MIT in the late 90th by Mitchel Resnick, Robbie Berg, Michael Eisenberg and others. Our approach regarding the creative, experimental exposure to computers by Papert is expanded by new concepts of holistic and interdisciplinary teaching and learning: For example with the idea of a holistic education, where the idea of interdisciplinary learning, orientation on action, and a felicitous balance of bodily/physical experience and critically rationally competence of acting matters. Priority of the teaching attempt is the competence of acting, oriented on responsibility. In our opinion the following didactic vertices are important for teaching with digital technology: Learning in connections, ethical responsibility, developing autonomous competence to act, work against the disembodiment of the structures and processes at school, phenomenological consideration of physicalness, learning linked to our present world /"Lebenswelt" (Moegling 1998).

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# Teaching interdisciplinary with digital media art technology, the project: "Your food is the mood"

The principal topic within the collaborative teaching attempt of the biology teacher and the art teacher is food and digestion. Thus a banal process, which allows diverse approaches, stands in the center of these interdisciplinary class. Our food is the fuel for our body and important to stay hale. Food has an impact on our physical, intellectual, and mental well-being. Food and drink, seen as a sensual experience and learned to be of high importance for our energy resources as well as for the functioning of our body, are the main theses of the cooperative and process-oriented dealing with the topic.

A central aspect of the teaching unit is the attempt to present the knowledge that was acquired during the course of the biological process, in an interactive environment, in a way, that an interaction between sender, receiver and media is possible. Thus, through a creative usage of the computer, a broader perspective of the object shall be initiated. Pupils will become skilled directors, designers and actors, due to the multi-layered approach to the topic. The interactive environment as a multi-sensual event is realized by pupils, first creating videos about food and the biological process of digestion with regard to its detailed and abstract meaning in and for the human body and second by making it an interactive experience with the support of a phyconic Tangible User Interface (TUI).

By manipulating physical objects (apples, burgers, sneakers,…) on a table with a barcodescanner, four videos are started with the same sound track simultaneously and projected on the four walls of a three-dimensional dice. The viewer individually chooses a phycon and by doing this produces different perspectives in content of the object (visualization of the principal of the networked thinking in structures). By working on the same topic in two different subjects, pupils persistently not only learn how the biological – not visible – processes of digestion work inside the body and which results for our fitness are connected with it, but also to compare this knowledge with their own eating habits.

In the course of the artistic dealing they work for possibilities of an asthetic visualization of specific and abstract parts of installation on different levels of perception. They learn to find concepts together, write storyboards, realize filming and make sound files.

**The concept in the intersection of the subjects Biology and Art**

Starting factor for the design in content is the idea to teach the topic of food and digestion, which is obligatory on biology at school, within the subjects biology and art in one and the same project. This learning situation is supposed to show how digital media can influence the learning of pupils sustainably, and how this new knowledge in the context of physical and digital reality can lead to changes in thought and action. First studies about the pupils` own eating habits are made, in which the pupils write down their own food record and fill in comparing tables. Next they experiment with digital technologies (camera) in connection with specific processes of eating. By doing this puils learn about the meaning of angle, perspective and plot axes and how to use this for the presentation of the meaning of food and its components (connection of cognitive and affective dimensions of biological processes). There are two ways of looking at the topic of digestion: on the one hand building and functioning of the digestion system are visualized by a relief plastic made of everyday objects, on the other hand it's shown in an absract way, by using colour codes for the food elements in red, green and yellow.

The multi-perspective work and structuring in storyboards is focused on four levels: the sensul experience of eating, the analysis of biological and chemical processes, the effects of food on the body, tables and interviews with experts outside the school. Analogous to these levels, video- and sound clips of 30 seconds will be produced. As carrier of the different perspectives and aspects concerning the topic, physical objects motivate on a table in the middle of a dice one can walk through, for the viewer to deal with multi-perspectively and interactively in space and context.

**Didactic aspects**

The combination of the subjects biology and art supports the principle of thought in networked and not-linear structures, the dealing with own productions and those of others and kooperative work within the learning

groups because of the possible diverse approaches to the topic. The possibility for developing individual and differentiated ways of learning supports the sustainable consolidation of thought and action as learning in contexts. Through researching, presenting and designing the sensually perceptible world in special tasks, pupils learn a critical and competent way of using media. They get to learn about cause and effect between food, body and well-being, and can express their knowledge in the concept of the dice with the help of back-projection of the self-made video clips on the four walls. The production of the multi-perspective is experienced by presenting physical objects on tables which shows the diversity of the topic.

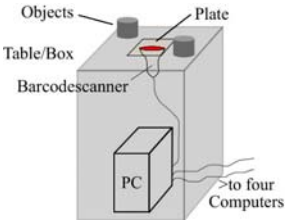


Figure 1: Draft for the scan box

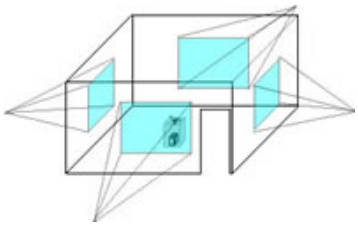

Figure 2: Draft for the installation

Figure 3: The Installation

**Technical description**

The application, which controls the installation, was developed in Java, using the Java-QuickTime library to operate the media players. The USB-connection with the bar code scanner is recognized as a human interface device (HID). An event handler catches the barcode input and reads out a string. This string is send to each of the four computers, which are running the projections. Using a configuration table the string is assigned to another string, representing a path to a video on that specific computer. This path is handed over to the player, which will start running that video. The configuration table can be modified, so that new assignments to other videos can be prepared, to be used in another installation. In this case all four tables assign the same string to different videos. The software is free for download and a used multidirectional barcode scanner is available for about $ 50.

## Evaluation

Within the KiMM initiative, we developed an evaluation framework for the multiplicity of the different projects at school (Melzer, Hadley, Herczeg, 2005). To evaluate „Your Food is your Mood“, we recorded the effects of the teaching attempt within the teachers, pupils, and parents.

The list of 32 questions for teachers consisted of the following target dimensions:

- Pupils' performance, behaviour, and experiences
- Media (e.g., usage, applicability)
- Expectation and comprehension (concerning the KiMM concept) and Judgment of KiMM support
- Evaluating one's own behaviour (e.g. treatment of pupils' teamwork) and one's own experiences (i.e., satisfaction, emotional stress)

The list of 30 questions for pupils consisted of four domains regarding:

- Pupils´ behavior and experiences
- Communication/social interaction by pupils grouped around tables in teams
- Media diagnostics
- Evaluating the behavior of the teacher during class

The list of 15 questions for parents consisted primarily of the domains regarding:

- Changes seen in pupils´ behaviour
- Sustainability of the learned facts
- The use of digital media at school

The answers to the several questions were carried out by an assignment with a scale from 1 = "does not apply at all" to 6 = "applies fully and completely." The answers collected (from 1 to 6) regarding pupils and parents were separated for girls and boys. For pupils and parents the average (*M*), the standard deviation (*SD*) and the

median (*MD*) was calculated. A presentation of all findings from the questionnaire would be clearly beyond the scope of this paper, therefore only the main findings will be reported.

**The main results of the inquiry**

Teachers:

- The pupils can recognize contexts more easily after the teaching unit. (*M* 6)
- The lessons were seen as hard and exhausting, but they were successful anyway.(*M* 6)
- The ideas for the project were explicitely creative and diverse. (*M* 6)
- The pupils have tried different approaches in team work. (*M* 6)
- The pupils had no problems working with digital media. (*M* 5)
- The used digital media was very useful to reach the goal. (*M* 6)
- Contentment with the project motivates to implementation in everyday school life. (*M* 6)
- It can be seen as positive that the artistic use of digital media changes the perspective from which pupils see their own thought and action. (*M* 6)

Pupils:

- There is an average of 3,11% computers in the household of pupils.
- 74,07 % of the class own a computer
- Every 6th child doesn't work with a computer at home at all. 1/6 only rarely, 1/5 between rarely and often, the other children (majority) mostly: *M* 4,4 (compare: 3,5 = middle between 1-6) / *SD* 1,84 / *MD* 4,5
- Only little more than half of the class like biology lessons: *M* 3,82 / *SD* 1,66 / *MD* 4
- Except of one child they all like art lessons: *M* 4,68 / *SD* 1,39 / *MD* 5
- Because of the project, 5 out of 6 children can use their knowledge from biology lessons and compare it with their own eating habits: *M* 3,75 / *SD* 1,67 / *MD* 4
- The production of films doesn't have any influence on pupils remebering content from biology lessons so far: *M* 3.32 / *SD* 1.52 / *MD* 3
- Compared to other subjects pupils were able to work more independent: planning, experimenting, etc.: *M* 4,0 / *SD* 1.66 / *MD* 4,5
- Except of a few pupuils, all agreed that the teachers liked to work with digital media: *M* 5,07 / *SD* 1,21 / *MD* 6

Parents:

- After finishing the project I think that my child has experienced the topic of food and digestion comprehensively and closely related to reality . *M* 4,65 / *SD* 1,12 / *MD* 5
- I think that because of the connection of two subjects it was easier for my child to understand the content of the biology lessons. *M* 4,35 / *SD* 1,08 / *MD* 5
- I think that my child is better in understanding why a correct or wrong way of eating can influence body, well-being and effectiveness because of the way in which the content of food and digestion was taught.. *M* 5 / *SD* 0,96 / *MD* 5
- I think it's positive that my child got used to digital media. *M* 5,5 / *SD* 0,80 / *MD* 6
- The presentation of the results fromthe project gave my child a good feeling and appreciation. *M* 4,55 / *SD* 1,31 / *MD* 5

## Conclusion

The results from the evaluation confirm that the only functional use of media (producing videos etc.) doesn't change the pupils' learning sustainably. The pedagogic value arises because constructing the digitally produced media opens the view towards the object and therefore makes it possible to reflect one`s own physical world of living. These tangible objects used in the installation (apple, sausage, sneaker,...) are associatively extending the content of videos and animation. The Graspable User Interface gives personal multi-modal experiences by handling the well-known objects and therefore support a deeper understanding of the content of the self-produced media. The answers as listed above prove this. In the artistic environment of "Your food is your mood" the computer (the box with keyboard and screen) disappears (Paradiso 2005). It is invisible to the user in the

exhibition. But the children themself dominate the computer: they say which objects as defined by physical icons (phycons) let the medially changed aspects of the topic to be experienced. Because of the individual and reliable working and learning with digital, interactive media in an artistic way, there's not only a high motivation for the pupils and a better understanding of abstract information, but one can identify a sustainable reference to one`s own existence and actions (for example eating habits) with pupils. Even more teachers feel releafed and there's more contentment with their job, if they motivate their pupils to work independently, and find solutions with the help of digital, interactive media in artistic contexts.

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"Bar Code Hotel" at the website of Perry Hobermann: http://www.perryhoberman.com/ (Dec. 8th ´06)