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Pervasive Computing in Schools – Embedding Information Technology into the Ambient Complexities of Physical Group-Learning Environments

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Abstract: In the KiMM (Kids in Media and Motion) Initiative we are following a generalized approach, which places the emphasis of using digital interactive technology with school students in their daily learning environment. Our world is progressively becoming more complex and computer systems are becoming a more integrated part of our environment, though at the same time, getting more invisible. This makes it essential that the learning environment of the student in schools reflect this development. This paper presents five aspects of a pervasive computing learning environment which supports reflection and education in this area.

1 Introduction

Our world is a growing more complex due to the rapidly increasing rate of change in our environment. The socialization of children shifts noticeably from more or less closed and separate environments to more complex interactive systems and situations. Students in schools are still subjected to the same linear approaches of learning that have defined the learning environment their teachers grew up with. In this time and age, it is necessary and possible to incorporate interactive systems using intermeshed network learning methods. Teaching is no longer a just a transfer of information. Student need work in research or design teams, where the teacher adopts the role of team leader. Consequentially adopting digital media is not a matter of explaining technical systems and their functions, but far more exploring technology in its original sense: as in the Greek word *τεχνοω (create, bring out*). The increasing digital augmentation of the learning environment puts the emphasis on new forms of situated learning. Their learning environment has to be more and more the world instead of the classroom. This paper incorporates the ideas of current philosophies on embodiment, environmental economy, cultural geography on infrastructures, psychology of persistent structures, pedagogy of learning as construction, situated learning, or cognitive apprenticeship, and engineering of embedded systems.

2 The KiMM Concept and its Pedagogical Fundament – Erasing the Divide between Me and Us, School and World, Learning and Life

Predominately the majority of research which incorporates digital media within schools is restricted to certain specific fields. In the KiMM (Kids in Media and Motion) Initiative we are following a generalized approach, which places the emphasis of using digital interactive technology with the students collaboratively in their daily learning environment and not exclusively in special projects.

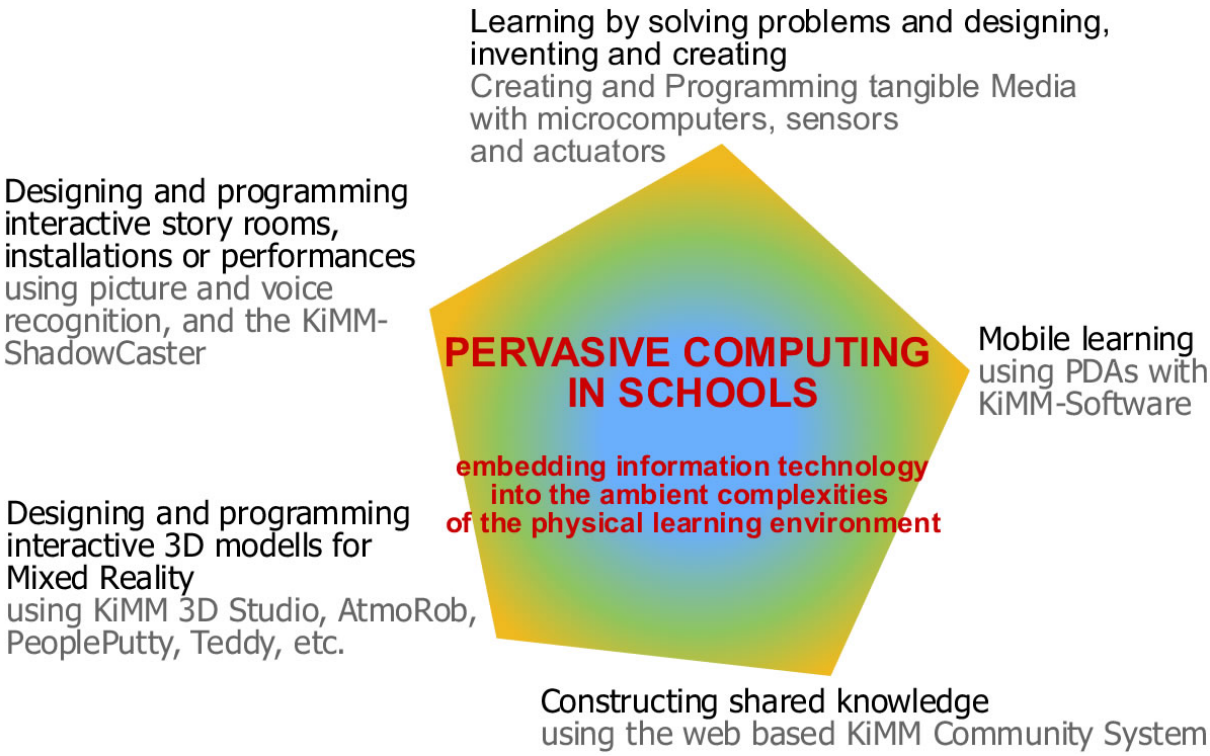
The following five aspects of pervasive computing at school are interwoven in our approach:

1. Learning not performed solely by teaching, but of researching, designing and iconic programming with micro-computers, visual, auditive and haptic presentation systems, as well as sensors and actuators.
2. Learning is done by inventing, designing and programming interactive story rooms, installations or performances.
3. Learning incorporates the creation of 3D mixed-reality environments or performances.
4. Learning takes place with mobile equipment inside and outside of the school.
5. Learning is supported by an interactive community system.

The underlying premise of the above mentioned five aspects is that learning is not only the pursuit of the individual. The KiMM Initiative believes that there exists an intrinsic ability for group learning in the sense of *organismic learning*. This takes into consideration that in the last years scientists have realized that we, like all living organisms, are complex adaptive systems. We operate in environments, such as ecological surroundings, economies and networks of social interactions, political context, etc., which are themselves also complex adaptive systems (Holland, 1995).

3 The Five Aspects of the digitally augmented KiMM Learning Environment

In the last four years we have researched and tested different aspects for expanding digital learning environments in primary and secondary schools in various projects (ArtDeCom, 2004). Since 2004, we are creating and evaluating applications of digital technology within the standard school curriculum on a day-to-day basis within a digitally augmented learning environment (pervasive computing environment). The different software and hardware applications are used only when there is a significant pedagogical advantage to be expected.



3.1 Learning by solving problems and designing, inventing, creating and programming with micro-computers and multi-modal tangible interfaces

This aspect has evolved from the experiences and results of a previous project (ArtDeCom) where we created digital augmented multi-sensory learning spaces in schools (Winkler, Reimann, Herczeg, Höpel, 2003).

11th graders creating the interactive installation “Spring Awakens”
with LEGO MindStorms RIS and VisionCommand

In the KiMM Initiative we are incorporating evaluated digital systems for iconic programming, as well as tangible interfaces for programming sensors and actuators. With the help of tangible interfaces, the students learn to compose and design interactive music, shadow theater, and interactive environments for plants and small animals. We are modelling dynamic, “intelligent” and communicating systems using micro-computers like in the room installation that has been called *“SystemWusel”* (Winkler & Herczeg, 2004).

3.2 Designing and programming interactive story rooms, installations or performances

This aspect explores literary, musical, and dance expression coupled with various new concepts and digital technology alternatives. The ArtDeCom project established the groundwork for creating collaborative and constructive learning installations and performance (Winkler, Kritzenberger, Herczeg, 2002). A new software application, called *“VoiceCommand”* (Glasemann, 2003), assists the elementary school children in their verbal skills in the context of collaborative tasking and performance.

1st graders creating in collaboration the performance “The Clown” with VoiceCommand

Currently, we are focusing on shaping phonological consciousness in students. For example, the students learn about digital storytelling methods and then create a mixed-reality performance or installation in an interactive digital storytelling room.

3.3 Designing and programming interactive 3D-models for mixed-reality

The students create interactive web-based 3D worlds in order to extend their physical learning environment into a mixed-reality learning environment (Winkler, Herczeg, 2004 and Winkler, Herczeg, Reimann, Höpel, 2004). The students use our system *"AtmoRob"* (Bullerdiek, 2004) to connect an interactive 3D web-based world (e.g. Adobe Atmosphere) and an installation or performance in the physical world. They are able to control movement, sound, and light (LEGO RCX) in the physical from the 3D world.

8th grader using 3D-Software (KiMM-Studio) to create interactive mixed-reality installations

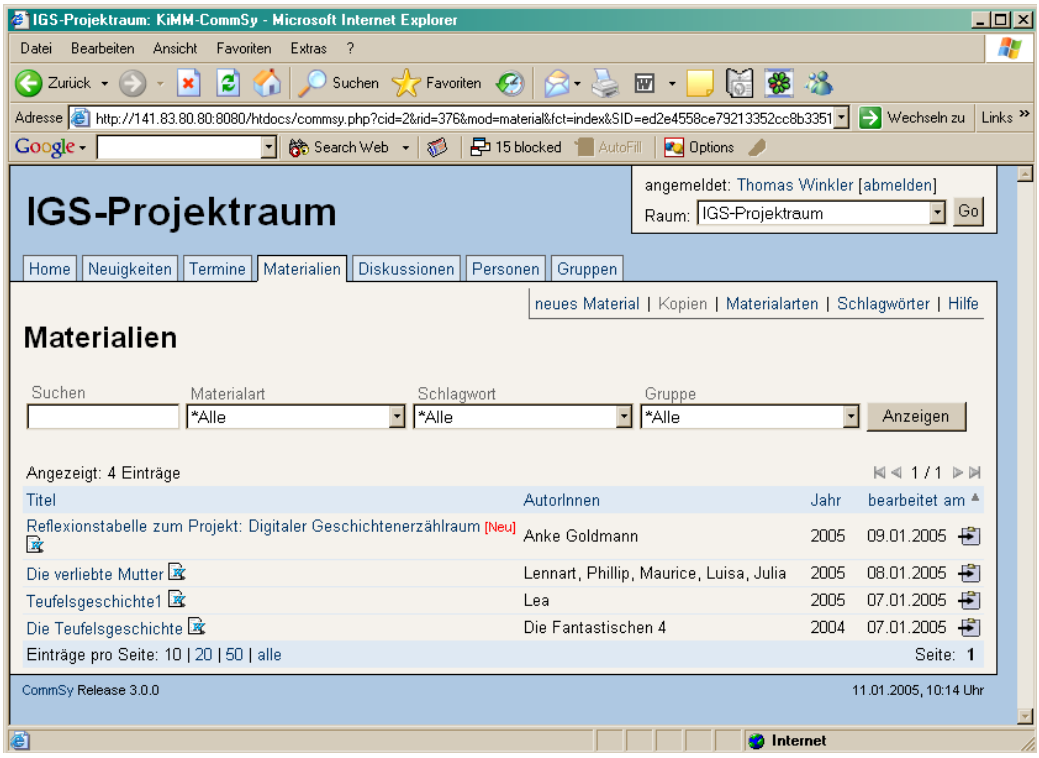
3.4 Mobile learning using PDAs and data-gathering devices

The KiMM Initiative uses mobile digital equipment to extend the students' learning environment outside of the school. For example, the students are using digital cameras, PDAs, and micro-computers with sensors during their field trips to access previously entered information, and to calculate and record their findings during the excursions. They are sent out in exploration teams and they collaborate in all aspects of task distribution, collecting data, evaluating and presenting their material. This presentation material is presented on self-created posters, projected on a screen, or placed in a communication platform, our *"KiMM-CommSy"* system.

5th grader using a PDA for Mobile Learning in the middle-aged town of Luebeck

3.5 Constructing shared knowledge, creating, emerging and working geographically independent with a Web-based Community System

The KiMM Initiative uses modified CSCW software, called *"CommSy"* developed by the University of Hamburg, Germany. Teachers, researchers, university students and the school students participating in the initiative use this platform for a large variety of services, like communication, planning and archives.



A shared web based workspace at KiMM-CommSy,
here for example used by 6th graders, creating a nonlinear story room.

By this teachers have direct access to learning modules, the collaborative work is independent of the location, and the availability of up-to-date project information and programs for the students is ensured. The students can work independent of place and specific computers as well as collaboratively.

4 Conclusions and Future Work

All five aspects of the extended digital learning environments aim on liberating the teachers and the students as much as possible from the typical desktop computer and workplace where they are facing a wall and sitting with their backs to each other. For this purpose we use highly mobile and pervasive digital technology: e.g. laptops with WLAN, PDA, and tangible user interface. Students design, construct and program tightly coupled physical-digital artifacts and installations incorporating themselves. The learning contents are highly interdisciplinary and teachers and students are working in teams using direct and mediated synchronous and asynchronous communication via a community platform.

The results of our studies indicate a high level of motivation, not only on the part of the students, but also from the teachers and the patents of the students. Creating and using pervasive computing environment only makes sense when a significant pedagogical advantage is guaranteed. An extensive qualitative and quantitative evaluation is ongoing.

References

ArtDeCom, Theory and Practice of Arts, Design and Computer Science in Education, http://artdecom.mesh.de, Jan., 14th 2005

Bullerdiek, S., *AtmoRob*, http://www.kimm.uni-luebeck.de/forschung/atmorob.html, , Jan., 14th 2005

CommSy, http://www.commsy.de/, , Jan., 14th 2005

Chawla, S., Renesch, J., *Learning organizations: Developing cultures for tomorrow's workplace*. Portland, OR: Productivity Press., 1995

Glasemann, M., *VoiceCommand*, 2003, http://www.kimm.uni-luebeck.de/forschung/voice_command.html, Jan., 14th 2005

Gleich, M., *Web of Life: Die Kunst vernetzt zu leben*, Hoffmann und Campe, 2002

Holland, J. H., *Emergence: From Chaos to Order*, Cambridge, Massachusetts, 1998

Holland, J. H., *Hidden order. How Adaptation builds Complexity*. Cambridge, Massachusetts, 1995

KiMM, Kids in Media and Motion, http://www.kimm.uni-luebeck.de, , Jan., 14th 2005

Milgram, P., Kishino, F., *A Taxonomy of Mixed Reality Visual Displays*, IEICE Transactions on Information Systems, Vol E77-D, No.12 December 1994

McCullough, M., *Digital Ground – Architecture; Pervasive Computing, and Environmental Knowing*, The MIT Press 2004

Lucia, T., Specht, M., Stefaner, M., *Design of an Interface for the Technology Supported Collaborative Learning – The RAFT Approach*, ICEC 2004, p 522-525

Pape, B. at all, Software *Requirements for Project-Based Learning – CommSy as an Exemplary Approach*, Proceedings of the 35th Hawaii International Conference on System Sciences, 2002

Thoourburn, D., Jenkins, H., *Rethinking Media Change – The Aesthetics of Transition*, MIT Press 2003

Visser, J., Jain, M., Anzalone, S., Naidoo, G., *Multilingualism in a Pervasive Learning Environment*, World Conference of the International Council for Distance Education on "The new learning environment: A global perspective", 1997

Winkler, T., Herczeg, M., Reimann, D., Hoepel, I., *Creating digital augmented multisensual learning spaces - Transdisciplinary education at school between aesthetic creating and building concepts in computer science,* Berichte des German Chapters of the ACM, Mensch & Computer, Stuttgart, 2003

Winkler, T., Herczeg, M., *Avatars - can they help developing personality among students in school? Consequences of connecting the physical world with interactive 3D-Worlds to hybrid experience and acting spaces to promote sophisticated social behavior*, IEEE XPlore / Proceedings of the ITHET, Istanbul, Turkey 2004.

Winkler, T., Herczeg, M., Reimann, D., Hoepel, I., *Learning in our increasing digital world by connecting it to bodily experience , dealing with identity and systemic thinking,* Proceedings of the Site Conference, Atlanta, GA, USA, 2004.

Winkler, T., Kritzenberger, H, Herczeg, M., *Mixed Reality Environments as Collaborative and Constructive Learning Spaces for Elementary School Children,* Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications, Vol. 2002, Issue. 1, 2002, pp. 1034-1039.

Winkler, T., Kritzenberger, H., Herczeg, M., *Collaborative and Constructive Learning of Elementary School Children in Experiental Learning Spaces along the Vituality Continuum,* Vom interaktiven Werkzeug zu kooperativen Arbeits- und Lernwelten, Berichte des German Chapters of the ACM, Mensch & Computer 2002, Vol. 56, pp. 115-124.

Winkler, T., Herczeg, M., *SystemWusel*, 2004, http://netzspannung.org/learning/artdecom/real-irreal/index.xsp?lang=de, Jan., 14th 2005