In Crawford, C. M. (Ed.) Proceedings of SITE 2006. Chesapeake, VA: AACE. pp. 742-749.

Why and what children learn while creating an interactive, non linear Mixed-Reality-Storytelling-Room

Thomas Winkler, Anke Goldmann, Michael Herczeg
University of Luebeck
Germany
winkler@imis.uni-luebeck.de

Abstract. *The formation of linked thought patterns, the ability of expressing oneself in an artistic and written form, spatial sense and modern media skills based on reflection are effectively promoted if children in schools are taught in such an interdisciplinary way that they creatively enrich their physical environment through multimedia and interactive systems. This paper is divided into three parts: first we shall explain the theoretical foundation of the school project, "Takelwerk," which was planned, accomplished and evaluated within the framework of the KiMM-initiative. Afterwards, we will describe how the children in this project created a visually complex and linguistically abstract network with links to concrete strands in the physical environment through designing and programming an interactive, non linear storytelling room. And finally, we shall present and interpret the results of the evaluation of this project.*

Introduction

Throughout our lives, we experience events from changing perspectives and increasingly use interactive systems. The socialization of school children is drifting from separate, enclosed environments towards networked living spaces of rising complexity. Therefore, the maturity of adolescents only develops through complex education; not through mere accumulation of separate information. Different forms of learning should be integrated for students to adapt to various social environments (ie. through learning within projects and under specific usage of digital media. The KiMM-Initiative researched and tested within the school project "Takelwerk" how an interactive Mixed-Reality learning environment, constructed by sixth graders of a comprehensive school, affected their ability to learn. The communication and interaction among children in relation to real physical situations in common everyday scenarios stands in the center of this constructivistic and multi-sensoral learning experience. Isolating children from reality and life experience is not the intention, but rather encouraging them to learn from situations and scenarios; where the learning space opens the borders of the classroom towards the world. An evaluation, which includes another class as a control group, gives evidence of the success of this objective.

1. Theoretical Foundation

1.1 A non-linear interpretation on experience in association with living space

Teenagers are actually already acquainted with the usage of interactive systems. They play computer games in their spare time; such as diverse ego-shooter (e.g. Counter Strike), racing games (e.g. Need for Speed) or simulation games (e.g. The Sims). This aspect has been considered within the project "Takelwerk" in the usage of the applications "KiMM-Studio" (developed with the authoring system "3D-GameStudio), "AvatarLab" (an easy to use application to build avatars) and "Audacity" (an easy to use application for recording and editing sounds) and thereby allowing a new kind of access into the school environment.

But there are two essential differences with the usage of commercial 3D-games:

1. The children do not only use them, but they themselves turn into the creators of an interactive 3D-game.
2. They build the game world in relation to their real world environment. Through the use of the avatars combined with accessible interactive 3D-rooms, they are then projected back into the physical room, so that the physical and the virtual room are mixed together.

A great potential is being used within the school through the additional input of the children's extracurricular experience with games. Through this means, the strict separation of school and every day life dissolves. The children live already in an environment which contains non-linearity (besides computer games, they use the Internet). They are used to gather in digital 3D-spaces using avatars to act and communicate with each other

(with other real persons or with computer controlled AIs). But this predominantly happens unintentionally without being concerned in using these tools in real life. Today, children take for granted the fact that they can access information from any place via the internet; and in doing so, gain independence from their so-far defined spaces in the physical world. The impact on the children's reality from playing with these commercial applications is problematic: the commercial 3D-applications do contain non-linear structures, but the children are not aware of them. Because of the missing link to the real physical world morally questionable behavior can be practiced. Such can have an effect on their actions in the physical world (Anderson & Bushman, 2001).

1.2 Connecting societal reality with models of abstract thinking through approved conventional and new media

Within the realization of the described project, the connection is made with established, basic cultural techniques in schools. Furthermore, digital media is used where it promises an added value compared to established media. To bridge the usual distance between the multi-sensory tangible and physically accessible space on one hand and the sensorial reduced experience of the virtual 3D-space on the other, these two different spaces become interwoven with the creation of a Mixed-Reality-Storytelling room. Digital media comes into play; the representation through traditional media reaches its limit because the children's imagination, based on their experience with interactive virtual space, exceeds its adequate representability. With a mix between these two spaces (physical and virtual), the children are able to create a physical installation enriched with digital, interactive media. It becomes a multi-layered, sensory experience created by the children themselves. Simultaneously, we reach an abstract level of reflection with the adoption of digital media in the context of a real physical situation, a reflection about historical and social developments, about complex processes and about the beneficial usage of additional forms of expression and presentation. New ways of learning are possible; with bridging the gap between school and real life.

1.3 Integrated Thinking and Behaving

The school projects title "Takelwerk" ("Tackling") involves four integration layers:

1. In small groups, the children develop a narrative plot, inspired by their experience on a museum ship. Afterwards, they link the narrative strands. This is supported by using an online community system ("CommSy"), which makes the text fragments easily accessible to each group for their non-linear montage.
2. They then start with translating the narrative strand into pictures. 3D-drawing and the construction of physical 3D-models help to improve visual thinking. A montage of the physical models according to the non-linear narrative structure reaches its limits, initiating, however, thinking about creative solutions to a complex net structure.
3. The next step utilizes the various potential of digital media. Virtual 3D-modells are created based on drawings and the physical room models. These virtual rooms, which can be placed in a random order, form the (digital) space structure for the story. The single narrative strands are interwoven into a dynamic web through scripted interactions. The target-oriented exploration and the creation of flexible docking points for the network (particularly, the function to teleport into the virtual room) allows the so-far unaccounted for gaming experience of the children to be integrated into class.
4. The fourth level of integration is the reintegration of the virtual, interactive 3D-world into the physical space:
    a. A large area projection of the interactive 3D-internet-room in a physical installation on location, including sound and spoken text is used
    b. Through the communication and interaction of several persons who are physically and virtually (as avatars) within the Mixed Reality Installation.

Because of the four coordinated levels of integration in the school project, cognitive structures are expanded and coupled with visual thinking. The children are enabled to construct abstract mental models. This happens through interweaving once-separated classes such as writing, history, drawing and 3D-modelling, into an interdisciplinary project within the physical Reality.

2 Inventing and Shaping

In the following chapter, we will describe the four structure levels of integration, the shape of the organizational structure, and step by step, we will portray how the children implemented the non linear, interactive Mixed-Reality storytelling room. We will also describe the didactic aspects of this project.

2.1 The structure of the non-linear story in space: the content layer

The triggering moment for the content design of the non-linear story is the chosen physical space: the museum ship in the harbor of Luebeck. In writing the multi-perspective story, the children refer to the atmosphere on the ship and its usage. The connection between the real living space and the classroom is established. Based on the different stories, the single strands are connected to form a network of events.

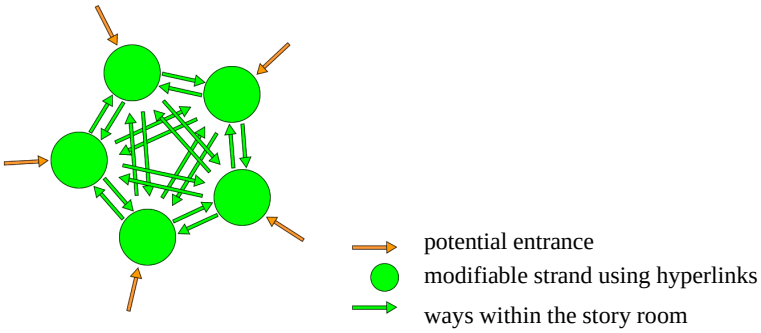


Diagram No. 1: The non-linear, interactive structure of the installation/story space „Takelwerk“

Similar to a mind-map, the children obtain an overview of the design possibilities. Enriched and expanded through the application “KiMM-Studio,” they work out a content core. At the end of each strand (illustrated through a green circle in graphic 1) there is a decision to be made; provoked by the examination of the narrator or the events. This gives direction to where the story will lead (walking through the ship or the installation). To give the children and other visitors of the non-linear storytelling room (either the installation or on the web) a thread to follow, every event is attached to an artifact which is both part of the physical installation and abstracted as a digital 3D-model. These artifacts (keys) initiate one of several solutions to the story at the checkpoints (meeting place on the virtual ship). Another crucial factor is the interaction of the visitor in the storytelling room with avatars of other people (they can participate from different places via the internet and they can communicate through gestures and a chat function). The narration is triggered by the avatars through the decisions which the visitor to the Mixed-Reality-Room makes. This leads to a path through the story. Thus, the sensory experience of the interactions for the project participants and visitor (in person on location or via internet) is deepened and connected to the physical environment.

2.2 Organization Structure

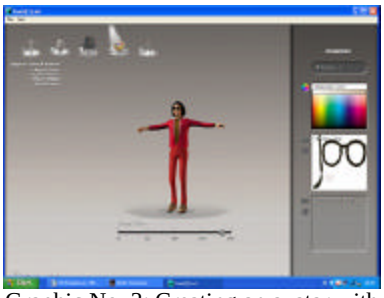
15 boys and 10 girls of a sixth grade class at the comprehensive school in Schlutup, Luebeck constructed an interactive, non-linear storytelling room in a cross disciplinary class of Art, German, Math and Computer Science. It took place every Friday during one term within the scope of the KiMM-Initiative. The lessons were meant to support and improve their linguistic, technical and artistic skills, as well as systemic thinking and acting. The children independently created a digitally enriched learning environment; in which they combined communication, objects, and actions. A visit to the Luebeck harbor and the replica of a medieval trading vessel (the museum ship “Lisa von Luebeck”) was utilized to make up a non-linear story based around this ship using traditional techniques (writing, drawing, photography, hand craft). The constriction of the narrative plots, which shall remain individual and uninfluenced from each other within the later network, were the result of dealing with the sensory experience of the museum space. The children convert their perception of this unusual environment into first story drafts. The result is the accumulation of many narrative plots. These plots were then revised in five work groups and linked together (see graphic no.1). A first visualization of this structure and the possibilities for connecting them was aided through a network of red string. After selecting the story cores, the five groups organized their work, emphasizing both design and the media expansion of the narrative strands. Here the main focus was on teamwork, both within each group and between the 5 groups. The net structure of the non-linear storytelling room mirrored the organizational structure; for it is only in this manner that connecting the five chosen individual strands can succeed.

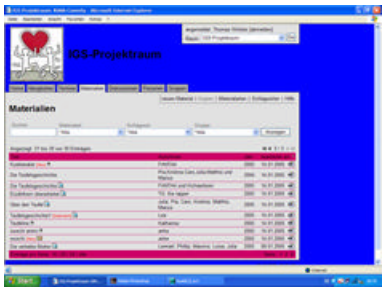
2.3 The Procedure / coordinating the constructive steps towards networking

The children learned the structure of non-linear narratives while rewriting the single pieces of a former linear story in such a way that each could fit together in random order. They created a preliminary net structure in the classroom with a red thread (graphic No.2), which represented the possible connections. Afterwards, characters of the story were drawn and build as avatars with the help of several digital applications (graphic No.3). A further connection was made with saving the single story plots, sketches and other project dates in the internet based community system “KiMM-CommSy” (graphic No.4) so that they could be accessed and modified from anywhere at

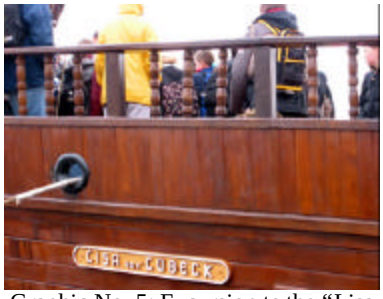
anytime; be it in the classroom or at home. The catalyst for the content of the non-linear story is the experience of space (the ship), of whose atmosphere and usage the children refer to while writing a story (graphic No. 5). Ultimately, we aim to connect real living space with the later realization of a digital illusion of space within a Mixed-Reality installation. Another connection occurs, when the first room sketches (graphic No. 6) are built as physical 3D-models. These models are then used to combine the single narrative strands in different ways (graphic No. 7). Their conversion into digital models with the application "KiMM-Studio" will then enhance the connectivity even more. The use of behavior scripts allows the visitor's avatar to teleport within the virtual space (graphic No. 9). When the visitor passes through certain locations, sounds and spoken text passages, which were previously recorded and edited with the application "Audacity" (graphic No. 8), are played. The Mixed-Reality installation, a combination of digital, narrative and artistic elements, finally connects the real physical space with the virtual 3D-space (graphic No. 10).


Graphic No. 2: Physical net, made with a red thread

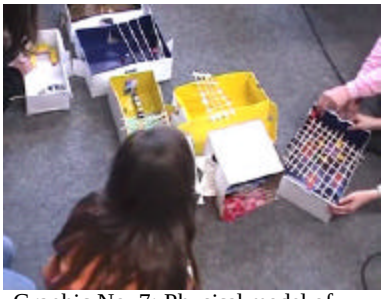

Graphic No. 3: Creating an avatar with "AvatarLab"



Graphic No. 4: Saving files with "KiMM-CommSy"


Graphic No. 5: Excursion to the "Lisa von Luebeck"


Graphic No. 6: Drawings of the projected space


Graphic No. 7: Physical model of the story room


Graphic No. 8: Recording speech for the digital 3D space


Graphic No. 9: Digital 3D space created with "KiMM-Studio"


Graphic No. 10: Mixed reality installation

2.4 Didactic Aspects

Cooperative work both within each group and between the several groups is required and encouraged, because the principle of integration not only dominates the structure of the digital storytelling space but is also an organic work form throughout the project.

The examination of the space phenomenon takes place on different levels of perception:

- While walking through the museum ship, one experiences space with all senses
- Learning to draw room sketches based on the vanishing point principle (illusion of space)
- Gaining a tactile perpective through building the rooms out of cardboard boxes (creation of physical space)

- Creating interactive, digital 3D-models (animated avatars) and walkable digital 3D-space (ground plan, body plan, sheer plan, perspective view, rendered model (with KiMM-Studio))
- Applying and experiencing interactivity within the digital space
- Building a Mixed-Reality installation (creating, experiencing and reflecting digitally enriched physical space)

3 Evaluation

The purpose of the project "Takelwerk" is not merely the use of digital technology. Rather, the pedagogical approach is more important. This approach demands a specific evaluation process which acquires the positive and negative influences caused by the specific use of mixed-reality applications. We assume that the school project as a pedagogical element affects four different target dimensions in regards to cognition, individual and social behaviour, and the emotional behaviour of both the students and teachers. Within the KiMM initiative, we developed an evaluation framework for the multiplicity of the different projects at school (Melzer, Hadley, Herczeg, 2005).

3.1 The List of questions

To evaluate "Takelwerk", we recorded the effects of a specific hybrid of classical media as well as of digital media by questioning a target group (students from 6c). In addition, we compared the results with the outcome of a questionnaire from a comparison group (students from 6b). At the same time, the students of the comparison group 6b were instructed with same curriculum in the subjects of „German" (analysis and composition), "mathematics" (geometry) and "art" (drawing and tactile examination of space). In the comparison group (6b), the use of media (script writing, drawing, sculpting, working with a 3D-Modelling program at the computer, internet researching with search engines in the www) took place in a traditional way without the use of the applications AvatarLab, 3D-KiMM-Studio, Audacity, and in the individual subjects. We also interviewed the teachers of the target group.

The list of questions for the target group (15 girls and 10 boys) as well as the comparison group (13 girls and 10 boys) consisted of four domains with 62 questions:

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

The list of questions for the teacher consisted of the following target dimensions:

- Students' 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 students' teamwork) and one's own experiences (i.e., satisfaction, emotional stress)

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) were separated for girls and boys. In the target group, as well as in the comparison group, the average (*M*) and the standard deviation (*SD*) 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.

3.2 The main results of the inquiry of the students

Results from the set of questions "Students´ behaviour and experiences" (questions=Q 1-18):
Q 2: The students of the target group 6c assume that they have "*definitely better success in the subjects German, math and art*" (which were instructed in an interdisciplinary manner in the target group) "*as in the other subjects at school*" (*M* 4.32, *SD* 1.18). It becomes apparent that the answer in comparison group 6b differs (*M* 1.91, *SD* 1.41), see diagram No. 11.

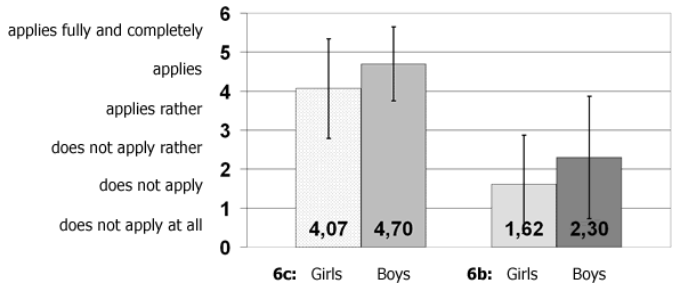


Diagram No. 11: Q 2

Q 14: While all students, with the exception of one, from target group 6c "*look forward to the next lesson in the subjects German, math and art*" (which were instructed interdisciplinary in the target) (*M* 4.39, *SD* 0,97), a lot less in the comparison group 6b felt the same (*M* 1.96, *SD* 1.63).

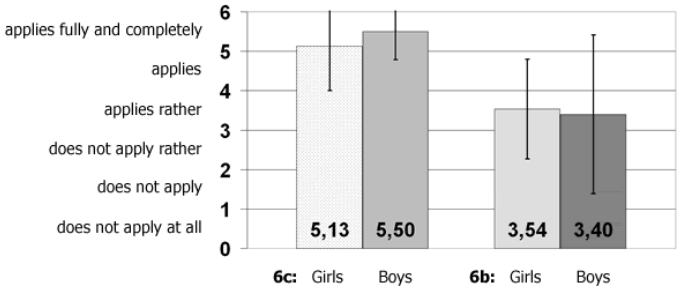


Diagram No. 12: Q 14

Q 7: Compared to the students of the comparison group, more students of the target group 6c agree that they, "*have a lot of ideas in class*" (*M* 4.56, *SD* 1.29 : *M* 3.91, *SD* 1.47).
Q 8: that they "*have many extraordinary and unique ideas to contribute*" (*M* 4.44, *SD* 1,08 : *M* 3.26, *SD* 1.35).
Q 11: that "*the class was fun and was entirely engaging*" (*M* 4.76, *SD* 1.01 : *M* 3.74, *SD* 1.05).
Q 15: that the "*have more success than failure in class*" (*M* 4.52, *SD* 1.15 : *M* 3.30, *SD* 1.36).
Q 17: that they "*were happy with the classes in which they used digital media*" (*M* 5.2, *SD* 0.67 : *M* 3.91, *SD* 1.20).
All other answers in the complex: "students´ behaviour and experiences" do not demonstrate any differences, because the form of the teaching methods in 6c and in 6b was very similar.

As expected, the answers in the second complex „Communication/social interaction by students grouped around tables in teams" (Q 19-38) demonstrated no noteworthy differences between the target group and the comparison group. (Over all: *M* 3.45, *SD* 1.37 : *M* 3.32, *SD* 1.51). In both groups, the students work in well organized teams grouped around tables. But with the results it can be assumed, that the increased use of digital media has no negative influence on communication and social interaction.

Results from the set of questions out of the third complex "media diagnostics" (Q 39-52):
Q 43: The answer shows clearly the motivating effect of the use of KiMM specific applications. While clearly more than the half of the students of the target group 6c affirm, that "*their classmates appreciate what they construct/produce/do*" (*M* 3,64, *SD* 1.77), only 16 from 23 students of the comparison group 6b felt that this "does not apply at all" (*M* 1,61, *SD* 1.23).

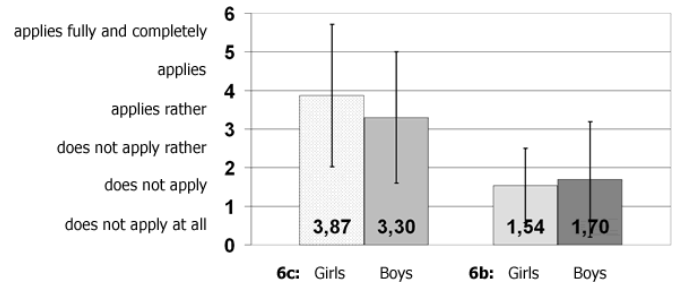


Diagram No. 13: Q 43

Q 39 to 42 and 46 to 47 were given only to the target group.
Q 39: The answers show clearly that the students, "*could manage and deal with the specific applications* (AvatarLab, KiMM Studio, Audacity) *introduced by the KiMM initiative very well and easily"* (*M* 4.56, *SD* 1.15),
Q 40: that "*it was clear to them, what they need the applications and devices for and how they functioned*" (*M* 4.56, *SD* 1.19),
Q 41: that they "*could generally effectively use the applications/devices and could use them for their work* (*M* 5, *SD* 1.19).

Results from the set of questions of the fourth complex "Evaluating the behavior of the teacher during classes" (Q 56-62):
Q 56: Predominantly the students of the target group attest that in the classroom it was "*sometimes disruptive, but the teacher always mastered the situation*" (*M* 4.36, *SD* 0.86 : *M* 3.86, *SD* 1.30).
Q 57: The students noticed that "*during classes the teacher is stressed*" (*M* 4.36, *SD* 1.18 : *M* 3.39, *SD* 1.30)
Q 58: On the other hand, the students assume that "*the teacher handles the applications and devices very well and can use them properly*" (*M* 4.90, *SD* 0.97 : *M* 4.3, *SD* 1.48).
Q 59: Additionally, not many felt "that it was less stressful for the teacher when she didn't use the computer in the lessons" (*M* 3.44, *SD* 1.04 : *M* 2.86, *SD* 1.25).
Q 60: Almost all of the students of target group 6c assume that "*the instructor enjoys teaching*". In the comparison group, clearly less of the students think so. (*M* 4.92, *SD* 0.95 : *M* 3.91, *SD* 1.12).
Q 61: Here also was a clear difference: "*My teacher looks forward to the next class*" (M 5, SD 0.86 : M 3.52, 1.50).
Q 62: And again: "*I believe that my teacher would like to use computer and other digital applications in teaching other subjects at school"* (*M* 4.92, *SD* 0.75 : *M* 2.69, *SD* 1.71).

3.2 Results of the inquiry of the teacher

The inquiry consisted of 73 questions. Here are some of the main findings:
Clearly the evaluation of the students is reflected in the estimation of the teacher. Here some answers of specific questions for the teacher which where not given to the students. The answers were also evaluated with a scale from 1 to 6 (from "does not apply at all" to "applies fully and completely".
Q 12: "*After the project, the students were better at thinking in group work* "(6),
Q 62: "*The use of digital media comprised significant additional effort*"(5),
Q 63: "*The objective of the class was achieved easily and more effectively using digital technology instead of using traditional instruments*" (6).
Q 73: "*I would like to use the devices and technology of the KiMM initiative in other interdisciplinary projects in combination with other subjects*" (5).

Conclusion

The project "Takelwerk" endeavors to create a sensorial perceptive accessible realization of the structure of the procedure and a sustainable comprehension of the structure of a non-linear, interactive story room as well. Complex structures of the reality of life (including the experiences with digital, interactive media and digital networks), which exist predominantly unnoticed by 6th graders, are comprehendible and graspable by the interconnection of building abstract models and work processes of visualizing and materializing during classes. Connecting comprehension and application (abstract proceeding in direct combination with the physical experience of events) allows thus the first bridge to be laid towards the ever increasing demand for higher competency in better decision making of our youth of today. By connecting the learning space to the living and experience space of the students, the interdisciplinary project "Takelwerk" boosts motivation and creativity and in turn, sustainable learning.

The results of the project (the independent creation of a complex mixed reality space) and the findings of the inquiries show that this way of instructing students is not only very efficient in improving their learning of subjects at school, but helps to build their ability in systemic thinking.

In Crawford, C. M. (Ed.) Proceedings of SITE 2006. Chesapeake, VA: AACE. pp. 742-749.

Literatur

Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behaviour: A meta-analytic review of the scientific literature. *Psychological Science, 12,* pp. 353-359.

Fuchs, T. & Wößmann, L., (2004). Computers and Student Learning: Bivariate and Multivariate Evidence on the Availability and Use of Computers at Home and at School. *CESifo Working Paper 1321*

Melzer, A., Hadlay, L., Herczeg, M., (2005). Evaluation of a Mixed-Reality and High Interaction Media Project in the Classroom: Strategies and Methods. *Proceedings of ED-MEDIA. Norfolk, USA,* pp. 3984-3991

Robertson, J. & Good, J., (2004). Children's narrative development through computer game authoring. *Proceedings of the 2004 conference on Interaction design and children: building a community, Maryland, USA,* pp. 57-64

Winkler, T. & Herczeg, M., (2004). Pervasive Computing in Schools - Embedding Information Technology into the Ambient Complexities of Phsical Group-Learning Enviroments. *Proceedings of the SITE Conference 2005, Norfolk, USA,* pp 2889-2894.

Winkler, T. & Herczeg, M., (2004). 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 behaviour. *Proceedings of the IEEE XPlore / ITHET, Istanbul, Turkey*