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Exploring the Computer as a Shapeable Medium by Designing Artefacts for Mixed Reality-Environments in Interdisciplinary Education Processes

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Abstract: Although multimedia computers are becoming widespread in the consumer market, little research has been undertaken into the computer as a shapeable medium based on an understanding of algorithms. Most educational research was focused on the computer simply as a tool or a resource for archiving data. The paper looks at a new interdisciplinary approach introduce the computer as a medium in general education. It discusses the impact of hybrid learning environments to support the development of a broader concept of computational literacy by linking the physical world to digital spaces. Different models for scenarios are introduced. They are linked to sensor technologies and iconic programming tools, as well as software to create three-dimensional worlds and virtual identities (avatars), delivered and experienced through the Internet. The flexible concept of Mixed Reality allows for embedding the computer in a multidimensional education which addresses different human senses. In conclusion the paper looks at skills gained and advances ideas for the development of a sustainable media literacy.

Introduction

The shaping of technology is considered being an active, communicative and participative social process to be put into practice by the individuals involved in the planning and design process of technological systems. Given the fact that information technology has been developed in an environment of mathematical and natural sciences, an innovative approach was introduced to bring together software designers, engineers, social scientists, as well as the users of technological systems to co-operate in multidisciplinary design teams. Technological systems were seen as not to be reduced to the technical dimension. In this context, the social relevance of the constructive shaping process has been highlighted (cp. Corbett, Rasmussen, Rauner, 1991) and new qualification profiles have been developed. Referring to that concept, Mixed-Reality-environments can be seen as facilitators of such shaping and design processes on the level of general education. Why and how those hybrid systems support such constructive procedures of practice in the context of media education on different age levels is discussed in the following.

The conception of the human-centred shaping principle has been introduced in the framework of Computer Integrated Manufacturing Systems (CIM) and vocational education (cp. Rauner, 1988). The shaping process requires for *shaping competence* of the people involved. According to that, the shaping competence of a human being consists of three main dimensions, such as attitudes (interest, motivation, needs, orientations), abilities (knowledge, experience, skills) as well as actions (shaping-oriented communication, co-operation, intervention). From a media education point of view, Mixed-Reality-environments stimulate those dimensions of shaping skills, which are to be addressed in the framework of the design process.

In order to extend the shaping principle and to apply it on the level of general education, we promote the idea of shaping the computer on the programming level as well as on the level of creating high- and low-tech artefacts arranged in the context of arts and rich Mixed-Reality-environments for communication and acting. To open computer science as well as the black box of the computer, the shaping process has to be based on an understanding of computational modelling and algorithms, rather than on an approach to digital media focusing on the acquirement of applying skills. Getting familiar with hard- and software tools is one aspect in the context of media education, rather than the main long term educational goal to aspire to. However, teaching and updating software applying skills is still seen as a main target of media education. Moreover, traditional forms of teaching

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are being projected on media education, rather than being adapted to the characteristics of digital media. Our concept is based on the idea of a human-centred and holistic approach to creating and moulding learning environments with computers and non-digital media, which we introduced from elementary school level on.

The multimedia computer is characterised by bringing together media such as image, video, sound, animation, and simulation under one umbrella. Therefore, the computer allows for addressing the different human senses which is of high importance in the framework of pedagogy. Mixed-Reality-environments support human-centred shaping and design processes. Nonetheless, in education computers are still mainly used simply as tools or as data resources. Only little research has been undertaken into the computer as a shapeable medium based on an understanding of algorithms by self-actingly programming and creating artefacts. The hard- and software tools used allow for experiencing on different age levels, that programming is an active, creative and collaborative process.

Mixed-Reality Environments for learning in interdisciplinary education processes

The term of Mixed-Reality stems from computer science and contemporary media art. It refers to hybrid systems linking high- and low-tech artefacts and applications by using a variety of aesthetic materials of digital and non-digital nature, such as images, bodies, technologies, language, sounds and codes. Those art works allow for linking physical reality with the digital spaces by addressing different human senses. The experimental approach towards the different media is characteristic for work methods of most media artists and defined by the term of artistic constellations (Seelinger, 2001). Hybrid media art projects are often coined by a multidimensional and interdisciplinary approach to arts, crossing the borders between disciplines such as arts, design, engineering, science, information and communication technologies, philosophy, literature as well as dramatic narratives and performance. Artists, researchers and scientists are working together at the interface between physical and virtual spaces. However, most collaboration in such interdisciplinary projects is based on the idea of the division of labour, rather than on the idea of a mutual and reciprocal understanding of the other disciplines' approaches. Although the open concept and the variety of different work methods is delivering important impulses for learning only little research has been undertaken testing the concept of Mixed-Reality in media education. Mixed-Reality environments can be perceived as systems of augmented reality. The awareness about virtual reality being an extension rather than a replacement of the physical world as implied in the term of augmented Reality.

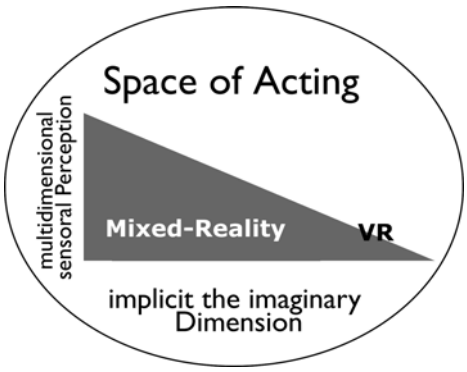

Fig.1: Scheme of Mixed-Reality environments

The computer facilitates the extension of the physical space for communication and acting by adding the digital dimension. Current technologies available on the consumer market, such as sensor technologies, image and gesture recognition software, allow for linking the digital spaces to the physical communication and acting environments of the pupils. Furthermore, those technologies come along with software tools based on iconic programming, that is, visualizing the code to the user.

Pupils are encouraged to self-actingly programming the computer and test the self-made programs in the physical environment. By experiencing the computer as a shapeable medium, they get active, creative designers of digital and non-digital artefacts. We believe a long term media and computer literacy can only be supported on the bases of an understanding of algorithms by using the computer as a medium which can be shaped and manipulated. As the learning processes are based on communication and collaboration, new scenarios of learning are required in the context of computer education.

Special software tools for different age levels have been tested for creating interactive environments as well as three-dimensional worlds and identities delivered through the Internet. Both approaches of models can be combined in the framework of media education scenarios. They support a creative, communicative and collaborative approach to media education. Mixed-Reality-environments keep the link to reality, which we

consider highly important in order to avoid pupils getting lost by immersing in given virtual spaces, which can only be experienced according to the limited functions the program is supporting. To us, the criteria for software selection are based on their support of different interfaces to the physical world, addressing different human senses and allowing for integrating diverse data applications on the technical level.

Two models for scenarios realised in general education

Sensor technologies and iconic programming to instruct micro computers

Sensor technology and iconic sensor programming stems from the field of robotics and automation, closely linked to the complex process of human-machine interaction.

To us, making transparent the invisible inside of computer is a goal to aspire to. The black box of the computer needs to be opened in order to support a long-term understanding of algorithms and informatic thinking and acting. Most software tools of the past did not support such requirements, rather exactly the opposite seemed to be true. Hard- and software tools are designed to be applied, not supposed to be understood on the software design level. They rather tend to confuse the users on the interface level, as well as on the human-machine-interaction level. However, few hard- and software tools are available on the consumer market. We came up with tools, such as sensor technologies (image and gesture recognition) and iconic programming we consider of high use in creative computer education processes. Interestingly enough, only little research has been undertaken in exploring micro computers, robots, robotic toys (actimates) and sensor technologies for learning such as the works by Druin and Hendler (Druin, Hendler, 2000), or the works with tangible interfaces by Ishii, Patten and Griffith who introduced the research field of Tangible Media at MIT (Patten, Griffith, Ishii, 2000).

However, it seems that a wide range of educational research misses a link to current prototyped technological developments and therefore does not scrutinize such systems and its' potential for education. The latter is remarkable in terms of the variety of opportunities opening up using those diverse media for new forms of learning. From an education point of view, sensor technologies and icon based programming allow for crossing the barriers of curricula by facilitating subject-crossing and project-oriented learning.

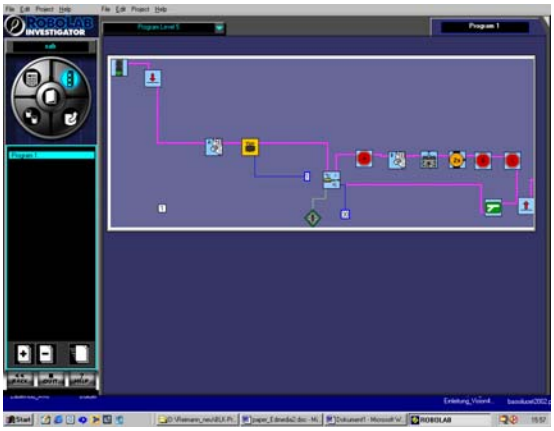

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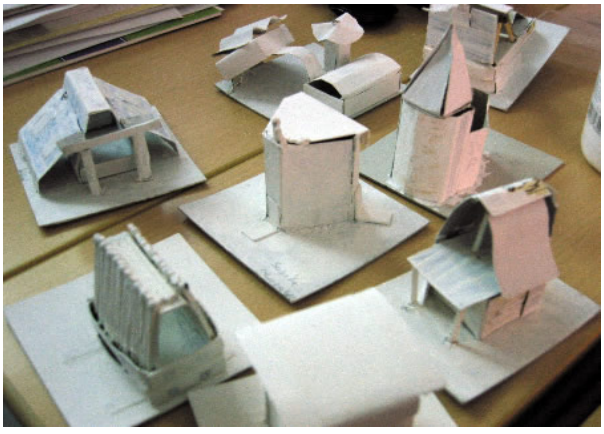
Fig.2: Examples of iconic programming (left) visualizing the line of code (if-then-relation) and the corresponding Mixed-Reality-environments (right) developed by 13 graders and 3rd graders at elementary school

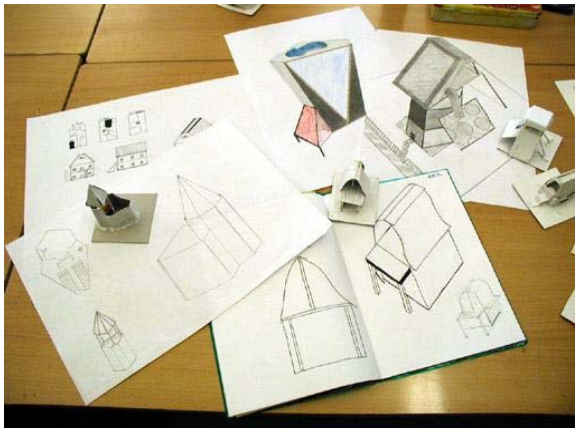
A variety of sensors such as those responding to temperature, haptic click or light have been given to the pupils to experiment with. The pupils themselves have developed environments, installations and stories using event-driven programme features. Controlling motion which allows for moving static objects in physical space, is realised by means of iconic programming. Micro computers and sensors are represented as icons on the desktop which are connected by pieces of physical string to the micro computer shown in figure 2.

Three-dimensional worlds and identities delivered through the Internet

The development software for three-dimensional worlds has become affordable for school kids. From an education point of view, a variety of challenges and opportunities is opening up using such tools in creative and collaborative learning processes. Mixed-Reality-environments enable the pupils to design their own spaces for communication and collaborative experiences to be made in self-created environments. Software tools allow for integrating images, and objects of the physical environment of the pupils, that is, delivering an interface to the physical world. The latter is characteristic for Mixed-Reality-environments. We consider it of increasing importance in the context of embedding the computer in creative and multidimensional education processes, as it links the basic element for the human being – the physical space – with the digital spaces of the computer.

The characteristics of experiences made in virtual worlds differ from those made in the physical environment: The limits and borders of the physical world with their gravity are abrogated in virtuality. The latter can be seen as the medium specific value. The awareness about medium specific values for artistic expression we perceive of increasing importance in the context of media literacy to be developed on the long run. E.g. a perspective drawing can be transferred and therefore navigated as a three-dimensional virtual model (fig. 3). The software comes along with a construction tool mediating different approaches to three-dimensional imagination of the pupils, such as player-, top-, side- and isometric view of construction level. The self-created city can be tested and experienced in the player modus. After the construction phase the collaborative navigation of the city is representing the opening of an online-exhibition. The latter can be projected back to the physical environment using data projectors as an extension of reality.





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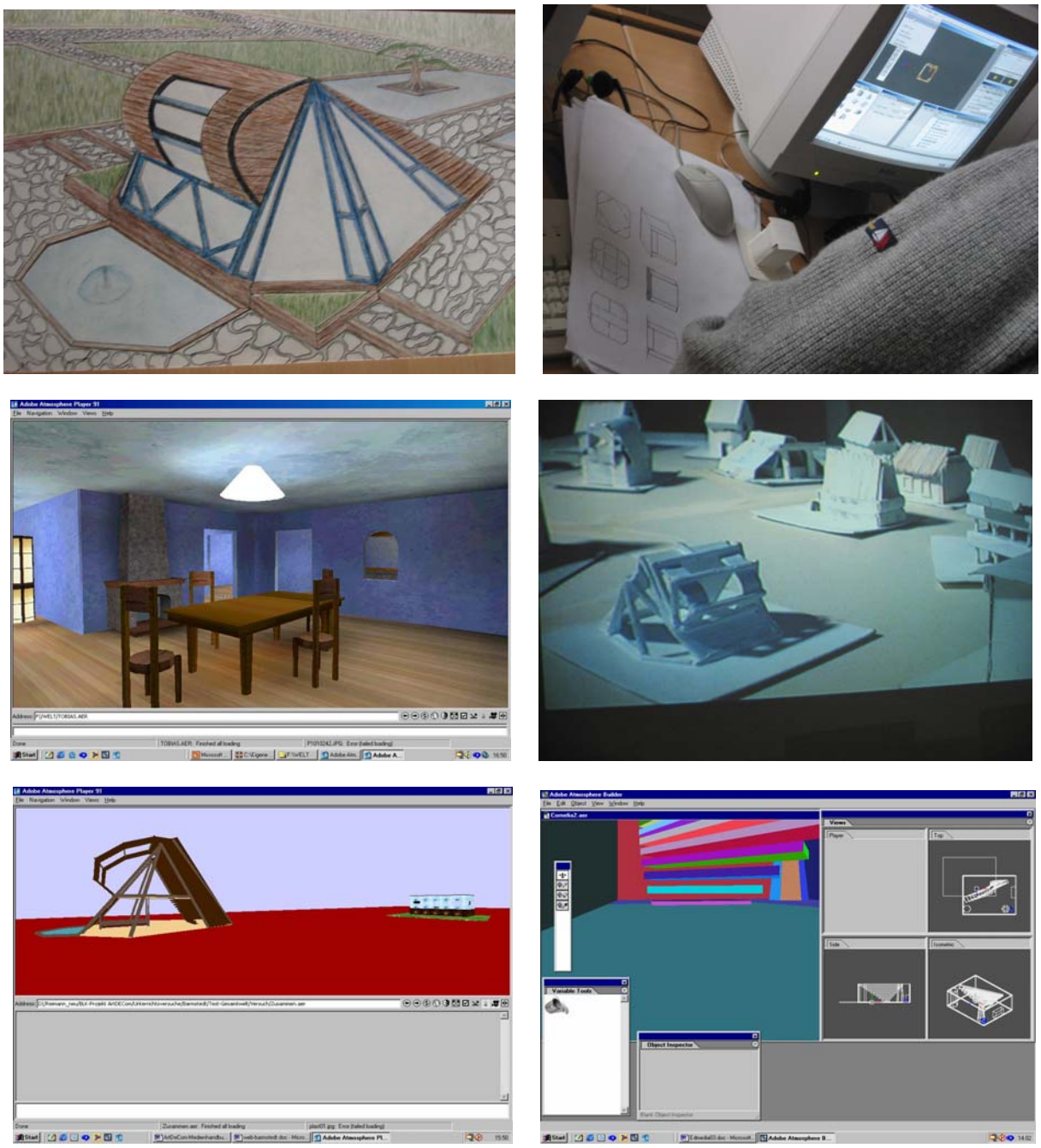

Fig.3: Process of designing artefacts: Perspective drawings, architectural models and software interface for the development of a city delivered through the Internet, realised by 9 graders

Representations of identity in digital spaces – avatars in communication and education processes

Most online learning spaces are characterised by a combination of asynchronous and synchronous forms of communication. Synchronous communication traditionally is represented simply as text-based chat, which supports a rather poor level of communication, given the fact that communication is a complex, dynamic phenomenon involving different human senses, gestures, bodies as well as appearances. The introduction of avatars (as well as bots or agents[1]) add a new dimension to online communication. Avatars are digital

[1] Apart from avatars, other forms of continuing basic entities exist, such as embodied conversational agents (e.g. ”Rea” by Justine Cassel). Those agents will be of increasing importance in future education scenarios.

representations of one's identity in cyberspace which can be created self-actingly[2]. They allow for representing oneself in digital space by means of a chosen or constructed appearance and support a more visualized communication delivered through the Internet. Avatars are of increasing importance in the framework of creating and extending communication spaces. The term originally is "derived from the Hindi and refers to the ability of certain gods to take any form at will."(Altstatt, 2001). Furthermore, avatars are defined as "embodiments of a person, a concept or philosophy, as concrete manifestations as of a principle attitude, way of life, or the like." (Vesna, 2001). The concept of Avatars implies a multidimensional approach to the issue of identity formation. Identity represented by an avatar can be anonymous or changed. Different forms of embodiments exist, such as two-dimensional, static ones as well as dynamic avatars which are able to move and communicate by using gestures, voice and the like. The latter we see of importance because they open up a variety of opportunities for collaborative education processes. The identity chosen can be created (or selected) and be developed further self-actingly by using special development tools for creating dynamic avatars[3]. Those allow for integrating scanned objects or photos of real people. The new opportunities are also referring to a variety of contents for education processes, such as the earlier mentioned complex and intercultural topic of identity and identity formation. The worlds and identities created have different interfaces links to the physical space. The software support the integration of photos and scans, sounds and the like which allow for individual creations.

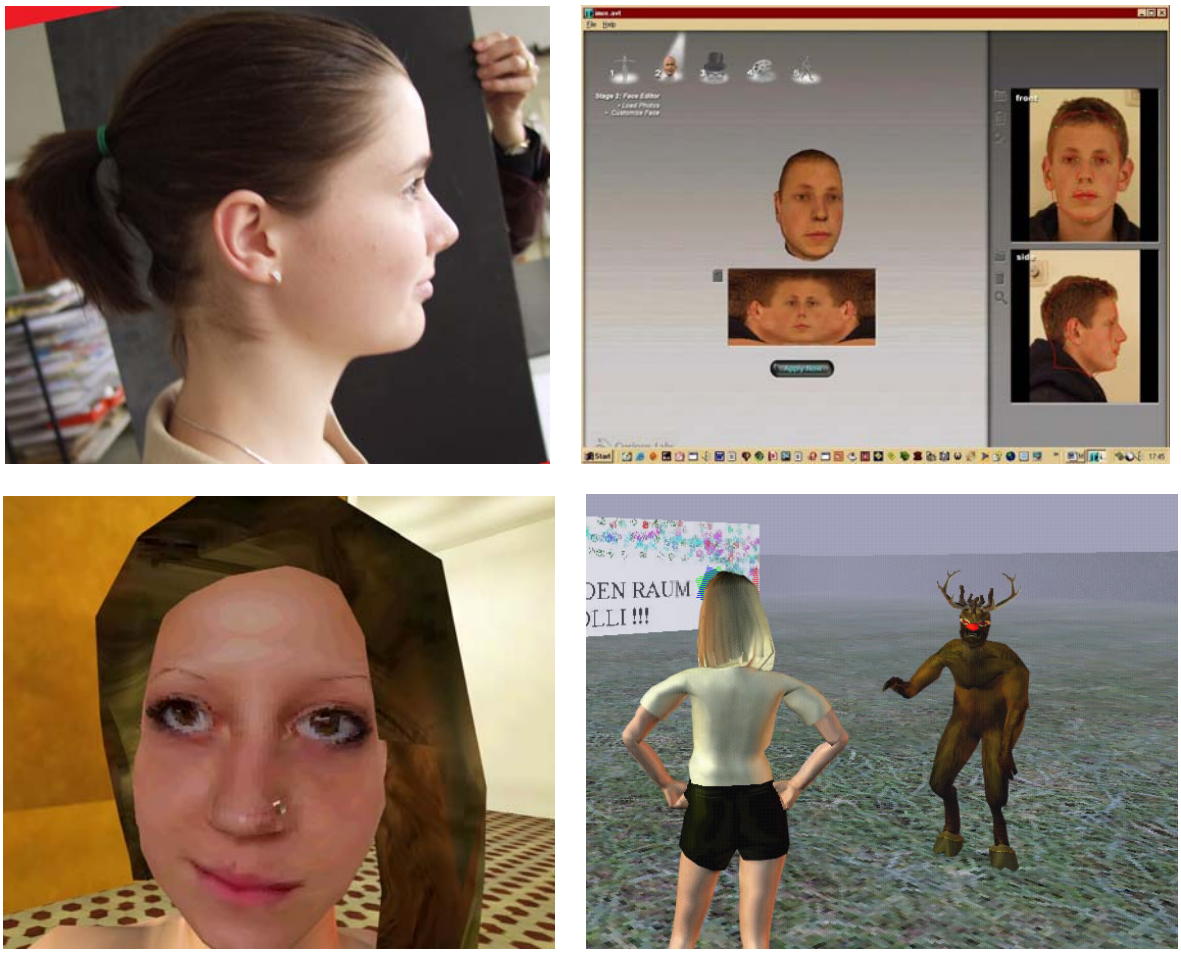

Fig.4: Self-created dynamic avatars simulating human communication using hand gestures and body stance in self-constructed 3D-Internet worlds

Learning processes and educational goals exploring the computer as a shapeable medium

[1] It is still common practice to select an avatar from a variety of collections available in the Internet, rather than create one's own representation.
[3] e.g. by using Java script language

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The learning processes are characterised by a variety of phases. The pupils collaboratively develop concepts, manage time, experience team work and presentations. They become familiar with hard- and software by experimenting with it and create physical objects and models, such as drawings or low-tech artefacts. Last not least they test the program developed or navigate the spaces created. We have investigated a wide range of approaches opening up for learning by experimenting with different technologies. The educational goals given below are related to media education, pedagogy as well as to knowledge creation linked to the disciplines of arts, design and computer science.

- Promoting interest in the act of self-actingly programming and creating is initiating an awareness about programming and creating being an active and creative process.
- Supporting an awareness about the characteristics of digital media, such as the issue of manipulation of digital artefacts.
- Supporting team based learning and encouraging collaborative relationships.
- Allowing for linking the digital space of the computer with the physical environments of the pupils, addressing the hactic dimension. The pupils are firstly programming self-actingly the computer and afterwards they test the programme in real world. Apart from testing the programmes, different events, such as sounds and media projections and the like can be programmed to happen in the real environment. Or the created artefacts are brought back into the physical world using data projections. The latter can be seen as a broader process of shaping the environment.
- Supporting designing skills and the awareness about the aesthetic dimension of real and digital objects.
- Software tools supporting the visualization of the program hidden inside of the black box, behind the screen the computer. It allows for making transparent informatic thinking and design models.
- The hard- and software tools which facilitate the production and combination of diverse media, such as sounds, videos, stop-motion-animations as well as programming image recognition software at elementary school level.
- Facilitating multimedia-storytelling and developing aesthetic objects which involve the pupils in the learning process.
- Promoting a holistic view on the world as a shapeable environment.

Conclusion

The interdisciplinary approach linking creativity and shaping skills to media education based on the mediation of informatic models in Mixed-Reality was proved being fruitful at the different age levels applied. In semi-structured qualitative interviews, the interviewees highlighted the importance of project orientation in the context multimedia and arts. The combination of algorithmic machine and aesthetics processes have been perceived positively by both pupils and teachers. It was highlighted that the mixed reality context can be seen as an excellent means to get the pupils involved in the learning content. Interviewees have underpinned our hypotheses, that the linking of diverse media, material as well as ideas was perceived as creativity stimulating processes.

On the long run, the updating of technical skills can not be perceived as the main educational goal. We believe in the necessity of a broader concept of media literacy which would be embedded in terms of constantly accompanying the students through their lifelong education careers. The skills gained by the pupils consist of a wide range of experiences and competences on the level of knowledge creation, as well as on the social level of communication and collaboration and self-consciousness.

Self-actingly programming to instruct micro computers or to develop three-dimensional artefacts of different nature, as well as skills linked to informatic and aesthetic thinking and acting have been acquired by the pupils applying an experimental approach to media. Furthermore, the pupils reach awareness about the characteristics and the nature of digital media, such as the issue of data manipulation and modularity. The latter we perceive as being an important element in the framework of computer literacy. Last not least the pupils have experienced that programming is a creative and interactive process by creating aesthetical objects. Apart from that, communication skills had to be developed in order to link team based arrangements to the overall common project, such as an exhibition, a Mixed-Reality-performance. Time management and presentation skills as well as self confidence have been supported. They experienced the atmosphere required to support creative thinking and acting in the framework of co-operation by developing relationships and the fun and satisfaction linked to it. The experience of creative work processes by designing concepts, moulding objects and arranging environments we see as an essential means to manage one's own human existence and the needs and requirements linked to it. The overall concept of shaping and designing therefore delivers important impulses. Realising individual ideas by creating objects, stories and environments using diverse materials, is an excellent means to motivate the pupils and get them emotionally involved in the learning process. They have been an active part in the process of

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testing new dimensions of media education. At the learning environment level, which is part of the school conditions it requires for embedding the computer in the framework of Mixed-Reality-arrangements with an open studio character. It indicates to get away from the concept of centralized computer classrooms based on an inflexible infrastructure on the basis of immobile equipment such as single work place systems. Furthermore, traditional forms of teaching including the roles of learners and teachers need to be re-thought and re-defined towards more flexible team based learning arrangements with facilitators initiating creative and collaborative learning practices in Mixed-Reality projects and environments which are shaped by the people themselves.

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LEGO ® Mindstroms
Adobe Atmosphere (beta)
Avatar Lab, Curious Labs

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