Educational Construction of Information Technology as Engagement with the Course of the World

Isabel Zorn

Abstract

One of the specific characteristics of digital media is that they can be constructed, not only by professional developers, but also by lay persons. While a lot of media literacy and computing skills programs have been installed in schools and other educational settings, the educational potential of construction activities with digital media are not yet well explored.

The article will present results from an empirical study that investigates the experiences lay developers make when constructing digital media. Findings indicate that construction activities have the potential to make the learners reflect on their perspectives on technology and on one's own role with technology. As information technology plays a great role in many aspects of life, construction activities also hold a potential for reflection of relations between the Self and its impact on the world.

Introduction

The potentials of information technology for education are currently being widely discussed and celebrated. This has led to the costly development of numerous learning programs, e-learning platforms, computer-blended learning initiatives, web-based trainings etc. Schools have been equipped with computers, but teachers lack convincing concepts of how to integrate them. The benefits of using computers for learning are still not clear in many aspects:

Many education programs are designed to teach merely the use and adaptation to widespread software, e.g. the widely applied European Computer Driving Licence (ECDL), which is offered in many European schools. The objective is to teach basic computing skills to a large part of the population. The content of the courses is mostly learning to use

one software monopolist's office programs (The European Computer Driving Licence Foundation Ltd. 2006). The educational benefits of this learning can be questioned.

In the German speaking context, media competence as a goal (and this included objectives such as raising competence of perceiving and understanding media, using them, and acting accordingly (Baacke & Bundeszentrale für Politische Bildung 1999; Barsch & Erlinger 2002) has been much discussed. Media educators request that learning with and through media needs to focus on encouraging learners to think, to take decisions, to participate in society and to develop critical faculties (e.g. Baacke 1996; Buckingham 2007; Tulodziecki & Herzig 2004). There is also a trend to look more at the educational benefits of using media for reaching more general educational objectives (Marotzki 2004; Wagner 2004), which is also the perspective of this article.

It is generally agreed that learning with digital media (DM) is a necessity in the knowledge society (Hug 2002; International Technology Education Association 2003; Marotzki 2004; Schelhowe 2005; Sörensen 2003). Computing literacy as a pre-condition for active participation in society is broadly accepted as an important educational objective. The German *Gesellschaft für Informatik* (Society for Computing Sciences) suggests that a profound understanding of computing technologies is necessary in order to develop a critical understanding of their effects for individuals and society (Gesellschaft für Informatik 2000).

Concepts for media education need to aim at helping citizens to become capable of acting responsibly in society (*gesellschaftlich handlungsfähige Subjekte*; Groeben & Hurrelmann 2002).

While some people make use of the new opportunities they feel these technologies offer, others feel inferior and overwhelmed by them. The digital divide widens, both in terms of who has access to technology and in terms of how technology is used (Medienpädagogischer Forschungsverbund Südwest 2007).

In order to minimize the divide and to take advantage of the learning opportunities information technologies may provide, many interesting and attractive media education projects are designed with different foci:

One important focus is to use information technology to teach media and / or computing literacy.

Another important field is 'e-learning': Learning programs, e-learning platforms etc. focus on learning about a certain subject (e.g. language vocabulary) with support from a computer program, where the learner simply *uses* the application.

This article relates to a third focus: Information technology is offered for learners to *construct* information technology themselves with the aim of creating challenging scenarios for general education.

The article investigates the educational potential of such constructing activities with information technology. First intermediary results of an ongoing and not yet completed study which I am conducting for my dissertation project will be discussed.

It explores how construction activities are experienced by lay developers. How do they perceive construction? How do they embed the experience into their lives? What can they learn from it? How do they connect their construction experiences and their views on themselves, society, and technology?

First, an overview of the theoretical framework of the study will be given. After an explanation of the methodology, first results will be explored by presenting two case studies. The case studies will be compared, common concepts elaborated and implications for educational perspectives discussed.

Theoretical Framework

Information technology and education

While it is widely agreed that it is experts such as computer scientists or programmers who design the technology for everybody to use, this article focuses on situations, where lay people have been involved in the design of information technologies.

I will argue, that such construction activities offer valuable educational potentials. While ordinary users more and more discover the interesting potentials of digital media in their spare-time; it seems that thereby

they can gain a strong sense of autonomy and authority as learners, which is often denied to them in learning at schools (Levin & Arafeh 2002). Even where computing technologies are used in schools, children complain that it is too limited and restrictive (Facer 2003). 'Engage me or enrage me' is how Prensky (2005) sums up how some children perceive the gap between learning and acting with technologies and learning at schools.

Construction activities with information technology could be a promising educational activity. It may be a way to capitalise on the self-evident potential of digital technology. And it may enable learners to learn about the technologies and to get a more profound understanding of both technology and its impacts on the world. Developing a new construction-oriented relation towards technology could then possibly be a way to develop new relations of oneself and the world around us, too.

The media educator and philosopher Werner Sesink explains how the perceived reality is firstly always a reality to which we have to adapt, because it affects our lives. The personal active design of something new, according to Sesink (2004), partly transforms the world into a self-designed construction, and thereby raises one's perception of agency. Sesink enfolds a relationship between the emancipatory development of technology and the emancipatory motive of education. Through the development of digital media, both influence each other. It is the aspect of construction that is immanent to these media.

Computer science education could then be an important contribution to general education (*Allgemeinbildung*) as is also suggested by Hubwieser (2000); International Technology Education Association (2003); Klaeren and Sperber (2007).

How can construction activities with information technology be offered in educational scenarios?

Klaeren and Sperber (2007) suggest programming skills as a training of a variety of necessary skills to become prepared for the knowledge society: problem-solving skills, planning projects, organizing and structuring thoughts, paying attention to details, being critical about oneself.

A 'learning-by-designing' approach (Kafai & Harel 1991) is the focus of a learning theory that Seymour Papert called *constructionism* (Papert 1980). The basic idea of constructionism is that by constructing some-

thing, the constructor's inner thinking processes are brought to the outside and are manifested in the technology produced. Information technology for construction activities is then offered as a tool to think with that might evoke a broader kind of learning and reflection than simply learning computing literacy. Some of their projects include robot construction, programming, video game design or digital story telling.

Schelhowe (2007) calls such a constructionis learning-by-designing approach an 'active exploration of digital media' and suggests concepts for encouraging such learning. Schelhowe and her research group design workshops where children and adults actively construct DM and work with up-to-date technology, such as robotics, smart textiles, Web 2.0, etc. The objectives of the workshop design are to raise technological curiosity, to encourage reflection about technology in a technology-driven world, and to interest people in self-determined learning processes and thereby raising their general interest in learning (see Dittert et al. 2008).

My literature review showed that there are not yet any hard facts on what can be learned from constructing. A big German quantitative study on the effects of children's robotic design showed that interest in technology and in pursuing a technological career as well as children's self-efficacy could be raised (Hartmann, Wiesner & Wiesner-Steiner 2007). The focus of this article, however, is to learn more about the more general educational potentials such as the emancipatory potentials mentioned by Sesink, the reflective potential mentioned by Schelhowe, the potentials for challenging thinking processes mentioned by Papert. It analyses how construction activities are perceived not by educators but by the lay developers themselves. The ideas mentioned will serve as first analytical perspectives used in the analysis of the interview data.

Characteristics of information technology and digital media

Digital media, or 'new' media as they are often called, differ significantly from so called traditional media such as newspapers, TV, radio, movies, etc. Digital media such as cell phones, digital video, internet websites, video games, even robots, etc. contain digital content that can be created, referred to and distributed via digital information processing machines, such as computers.

Lev Manovich (2002) describes five principles of 'new media' which summarize the differences between old (analogue) and new (digital) media:

(1) numerical representation,
(2) modularity,
(3) automation,
(4) variability,
(5) transcoding.

In short, the difference is that digital media are constructed from programming code that can be altered, re-used, automated, etc. With some knowledge everyone can alter and construct digital media and implement their own ideas.

Schelhowe (2007) suggests how these properties of digital media can be exploited for educational tasks. DM allow for both active design and passive consumption, and both interweave easily when e.g. consumed content can be altered. Content and technology interact. A content becomes a different content and gets a different meaning depending on the technology that is used to produce or display this content.

Latour (1992) explains how technology acts as an actant. He explains how by the way a technology is present in a situation (such as a bumper on the road) it interacts with the environment (car drivers slow down). Human action and technology's action together constitute a system and interact with each other.

By extending Latour's idea to information technology, we can imagine how it can take action by processing data and giving out results. It can call for action, it can 'refuse' the desired action, it 'answers' questions, it can 'make suggestions', windows pop up unexpectedly, or technology works differently than expected and thereby calls for new action. Seen like this, technology does not only 're-act' to the user / designer's activity but acts by itself and interacts.

In such a perspective, DM can be understood as interaction partners. They react to one's actions, they prove immediately if an idea works or not, they provide feedback, etc.

Referring to Turkle's research (Turkle 1984; 1995) Schelhowe (2007) explains how DM are an evoking learning material. She claims that DM often lead to exploring something new and unknown, raise curiosity and provoke actions in order to overcome problems. As they are closely related to and integrated in the world around us, DM evoke thoughts and reflection. Also, the effects of an action are made visible. An idea put into practice (such as a programmed robot) either works or not, and this is visible to both the developer and the public.

These characteristics could suggest DM as interesting tools for learning-by-constructing: They not only offer material and suitable properties for design and re-design, but they also offer structures that provide feedback to the designer about the results of her / his ideas and actions and they stimulate new thinking and action, which may lead to further learning.

In the study, we will take a look at these interactions, the role technology takes and how technology could provoke new actions by the lay developers.

Methodology

Design of the study

The aim of the study is to develop a theory of educational processes by active IT construction. There still is little knowledge about lay designers' experiences with construction activities. A grounded theory approach (Glaser & Strauss 1967) was followed, where the course of the research is guided by the data gathered. Grounded Theory aims at enabling the researcher to explore an unknown field and learn from the data. It aims at minimizing the bias that we may have from prior assumptions about the field.

In order to explore how construction activities are perceived by lay developers, 30 interviews (episodic interviews, following suggestions by Flick (1996)) were conducted with children (age 10–14) and adults. A 'lay developer' was defined for this study as someone who is not a computer expert, who has little or no design and programming experience, but who learns to design.

The interviewees were involved in various design activities with digital media conducted by the 'Digital Media in Education' research group at the University of Bremen. These projects involved designing and programming robots or designing and setting up a web communication platform (see below). I myself was partly involved in these projects and interviewees knew me from these contexts. The interviews were conducted 4–24 months after the projects started.

From these interviews, suitable ones were selected for detailed analysis. The criteria for selection were expressiveness (how well could interviewees express and verbalize their experiences[1]), diversity of interviewee sample regarding their educational and socio-economic background, migration experience, the technology they constructed, and their appreciation of the design experiences. Following the grounded theory demands, it was tried to find minimum and maximum contrasts that would help to create a comprehensive theory. The analysis follows the coding paradigm approach by Strauss and Corbin (1990).

So far, analysis has been started with 8 interviews. This article shows first intermediary results from an ongoing study which is not yet completed. I will argue on the basis of these first analyses and exemplify findings with 2 case studies.

Construction scenarios

The lay developers interviewed for the study were known to me through their participation in construction projects. In the interviews they also talked about additional construction projects. All the children had worked on constructing and programming robots, and all the adults had been involved in designing and administering a web communication platform. Some had additionally set up their own web pages or virtual role play games, some had experience in installing and administering hardware or operating systems or making video films, some had even founded and programmed an online shop or administered a CMS system. All of them were known to me due to their participation in either robotic workshops or in a design project for a web communication platform.

The robotic workshops were geared to boys and girls aged 10–14, who signed up voluntarily. The workshop offered opportunities to invent, construct and program a robot (more see Reichel & Wiesner-Steiner 2006).[2]

The adult interviewees participated in the development of an electronic communication network (a community of practice network), SAN, which was formed by university secretaries and assistants with the mission to support each other in everyday work.

Experiences with digital media cannot be limited to experiences in certain events. DM have become a part of our everyday life and are always at hand. Interviewees reported on many different activities, which they also did or had done in their spare time. Before conducting the interview, it was unknown what other activities they were involved in, besides the robotic or SAN contexts. These experiences are also taken into account, as they form interviewees' perceptions.

Case Studies

While some people are eager to make use of the new opportunities they gain with information technologies, others feel scared and overwhelmed by technology.

Prior positive experience with computers has an influence on the perception of technology and self-efficacy, and on accomplishment (Durndell et al. 2000).

However, I assume that construction activities hold important educational benefits for people both eager and hesitant towards technology.

Therefore two case studies are presented in order to analyse how dfferent people experience construction activities.

Sonea (14) is an example of a computer maniac, while Filou (in her mid-fifties) is an example of those people who are very reluctant to approach technology.

The cases will be contrasted and compared: I will present their views on their construction experiences and analyse how they differ and what they have in common.

Despite their different attitudes towards computing, both also talk about similar experiences with construction activities.

– Both talk about how they bring something new into the world by constructing DM.
– In their construction processes, they access and integrate into new communities.
– They explore new activities and experience themselves in new roles.

These aspects shall be analysed in more detail in order to get a better understanding of the experience of construction activities and its educational potentials.

Case study Sonea: Exploring & expanding identity

Sonea is a 14-year-old girl. She moved from Belarus to Germany with her family at the age of 6. She speaks German without an accent, while her mother and grandmother do not speak German so well. Her parents sent her not to the nearest but to the best school in town, as the family seems to be committed to high educational ideals. However, she does not find like-minded friends at school. Sonea participated in several construction workshops with robots, smart textiles, etc. at the university and even supports workshops as a student tutor. Later, she would also like to work in a technical profession.

Sonea performs many activities on the computer. Her favourite computing activities are focussed on construction: she programs robots and smart textiles and enjoys watching professional robots at the RoboCup tournament, she installs Linux on her personal computer, she engages in virtual role play games (VRPG) on StarGate and even set up her own, she created her own webpage, she is eager to learn about new technologies and uses every opportunity to do so.

Construction activities: Creation, community & collaboration

Sonea enjoys making things work: she tries to find solutions if something does not work until it functions correctly. She actively searches for

help. Earlier it was mostly her father and brother who helped and fixed a problem, but now she notices that sometimes they are wrong and she consults new friends and Linux community members over the internet or asks her new friends at the university. 'Now, I ask people when I don't know something at the computer. I have my computer experts.' {207}[3]

It was her IT construction activities that led her to explore new milieus (Nohl 2002, in a similar case noted this as indication of an educational process) and to join new communities.

A new world of like-minded people has opened to her and she finds role-models and is inspired to new activities, such as installing new software and learning about it, or learning to create and administer her own role play game.

After joining the StarGate role play game and playing for some time and even voluntarily taking on some organisational tasks, Sonea developed her own ideas on what she liked and did not like about the way the game was played. The idea was born to create her own VRPG. Her idea was to fuse several of her favourite TV series and make them into a new game. She needed help to do so, so she asked her virtual friends for help and support. They share tasks which she coordinates.

> Sonea: '*Then one can also appoint others to become administrators*' {233}.
>
> Sonea: '*And one becomes, well, chief of something, and one takes on responsibility for something*' {286}.

In her role play, Sonea sees herself as a chief executive. She decides who can take which role and appoints co-administrators, she decides on the idea and implementation of the game, she decides who can have access, etc. And she also takes on responsibility for the game.

Sonea takes on a new role. She finds ways to implement her own ideas, to materialize them and bring them out into the world. She takes on responsibility.

In a robotic workshop, a microcontroller was used with a display showing numbers. Sonea wondered if the display could not also display letters. So she asked more advanced developers and learned that each sign consists of little bars and that the display of each bar is determined by a code, the hexadecimal code. So she learned the hexadecimal code

and determined the code combination for each letter of the alphabet. Thanks to her invention, the display can now also show letters and words.

The technology enables her to make inventions.

The examples about her setting up her own VRPG and about creating code for the microcontroller display show an interesting development. While earlier Sonea depended on her father's or brother's knowledge and decisions, Sonea now learns that technology does not have to stay the way it is or as somebody tells her it is, but that it can be extended or changed or created according to her own ideas.

Constructing space & reflecting power

Sonea is annoyed at her father who often takes over her computer and makes changes, e.g. he formats the computer so that all her data is lost. Inspired by her contacts with more advanced developers, she had the idea to install an additional Linux partition on her computer and set it up. Her father does not understand Linux, which makes the Linux partition her own space. In addition, she has administrative rights for the Windows partition and she decided to take away her father's administration rights, so that now he cannot do much harm to her computer anymore.

> Sonea: (laughs) '*I told my father, if you continue to destroy my computer, then either I delete your account or I withdraw your administration rights. And that is what I did*' (laughing) (…).
>
> Sonea: '*Because usually it is the other way round!*' {368 et seqq}.

This shows that Sonea finds ways to create and protect her space by using the means technology gives her. It also shows that she is aware of the fact that technology gives her a certain power. By using this power she is entitled to do things which she could not do in other life situations, 'normally' things are different, which probably means that normally only her father is entitled to grant rights to her, allow her things or be in charge of something. Technology is a field, where 'normal' hierarchies can be reflected, challenged and changed. The technical structure of the operating system gives her the means to determine roles and rights, withdraw rights and access.

This describes a certain process of emancipation from subordinance. Sonea, who is in the middle of puberty, when emancipation is a big topic in youth development anyway, makes use of the means technology offers her to create her own space and to protect it, and thereby to move away from the world and the control exerted by her father.

What eases her attempt to create and protect her own world is finding new friends and even computer experts on the internet. Several times she refers to how happy she is to find help here from people, e.g. from the Linux community. These people enable her to become more independent from her father's knowledge and to gain more computing skills. This, too, helps her *extend her self-efficacy*.

Case study Filou: Turning technological distance into appreciation

The case of Filou is quite different from that of Sonea. Filou used to have a negative attitude towards technology, it scared her and she did not really want to engage more with technology than absolutely necessary. However, we can find that Filou tells us about her construction activities by partly covering similar aspects to Sonea. She will also talk about the construction of a new product in a collaborative effort and about the relevance this community has for her development. She, too, will point out how by being involved in this construction process, she takes on new responsibilities and explores new roles.

Filou is a woman in her 50s. She works as a secretary at the university and has two teenage sons. Filou was a founding member of an electronic secretary communication network (SAN) at her university and participated in its development.

Technology as a threat

Filou's relationship with information technology is very ambivalent, but it is important to her to assure that she is very 'normal' in this respect {95}. Several times in the interview, she explicitly makes a point that she is '*not a technology-interested person*' {178}. It seems very important to her that I do not misunderstand her involvement in the SAN

project as being motivated by technological interest {i.e. 130, 131, 132, 133, 147 'maybe I AM just not like this', 175}. By contrast, she wants to present herself as being highly sceptical and hesitant towards intensive use of computer technology. In order to illustrate the opposite of her, she tells us in length about her two sons, who are computer maniacs. They spend almost all their spare-time playing online games. To her this is *a foreign world*, which she does not understand, and to which she does not have access. In fact she does not want to access this world at all, because she does not like this kind of activity (this is exemplified by her de-installing a communication software which her son had installed on her office computer so they could be in touch with each other). Even more so, she ponders about the dangers to her sons from such excessive playing and she feels she cannot understand or judge its implications and consequences.

She is plagued by the idea she could be irresponsible by letting her sons play so much, but she feels unclear about what a mother's responsibilities are in this respect {98}. The sons treat her as if she, being a woman, was incapable of understanding computing technology. She feels gender boundaries in this respect, too, and she puts her overall attitude towards computing *in a gendered context with regard to competence and attraction of computing*. Not being interested and not being very competent in computing fits the perceived image of women.

When she comes to talk about her own computing activities she explains that she does not have a computer at home herself—only her boys have.

At work she began to use computers because she was forced to do so by work requirements.

With this information given in the long entry section of the interview, she enfolds a concept of her technology distance and how technology scares her because it confronts her with devaluation, risk of losing competencies, risk of being irresponsible even in her role as mother.

Her relationship towards technology used to be characterised by technology being a threat that comes into her life against her will and her reluctant response in trying to adapt to new situations.

Construction activities: Creation, community & collaboration

In the next part of the interview she starts to differentiate between past and present. In the past she had to learn to use computers in order to get back into her job after maternity leave. She describes related computing activities as sitting dumb in front of computers.

She then describes two other computing activities that differ from this image:

An important activity is her administration role in the secretaries' SAN project. While in the beginning she was afraid of technology ('Oh God, Technology!' {58}) not wanting to have anything to do with it {60}, she now feels competent to use it.

Another incident was when she motivated herself to start internet research on a disease. A friend became seriously ill with not very well known symptoms. She researched the net and found out a lot of useful information about the disease. Such information, she said, would usually be only available to professionals and experts such as doctors. Accessing such detailed information in a very short time helped her and the friend's husband to understand better what the friend suffered from.

The SAN network was formed by Filou and other secretaries at a German university with the mission to support each other in everyday work. They asked for support for this project and a cooperation scheme was started with the university's technical administration department and with some researchers of the computer science department. While originally the secretaries' plan was to ask some computer scientists to construct and deliver a platform for them, they started a cooperation and participatory design process.

The group of secretaries, all women in their 40s and 50s with diverse prior computing skills decided about the concept of the electronic network and shared development tasks with one professional developer and two media education researchers with organisational support from the administration department. The platform evolved according to the secretaries' ideas and needs.

Similar to Sonea's experience of constructing a role play game this is a context of *implementing own ideas in collaboration with a team*.

In Filou's narrations we can see a move from feeling alienated from technology and overwhelmed by technological development to taking on a more active attitude and an interest in exploring new possibilities offered by technology. This move is connected with becoming member of a new community, the SAN network, and taking pride in belonging to this group. It is through this membership and contact with like-minded women where she feels understood and supported that she develops new interests and activities. She feels that the community builds on a shared knowledge and (also gender-related) attitude. The group pushes her to become partly involved in construction activities.

Construction, learning & responsibility

Filou feels that by setting up the secretaries' platform she learned a new way of dealing with computers which she can also transfer to daily work. She no longer feels helpless when errors occur and she knows ways to fix problems herself {65}.

The way she talks about computing in the SAN context {i.e. 60} differs strongly from how she talked about computing before. Her attitude is now much more appreciative of computing. *Her interests have expanded and are now driven by what she wants to achieve and not so much by what she is forced to learn*.

In SAN, she even took on some administrator's tasks, which she shares with another secretary. They are responsible for checking and publishing articles that have been entered into the content management system. When some of the tasks and roles required by the CMS needed to be shared and there were not enough volunteers, she took on the job after receiving another training from her peers. She says this is an important task and it means to take on responsibility for the SAN website. She feels this is different and more responsibility than she usually takes on in her job. Being a SAN administrator also means presenting the SAN project to department meetings. She both fears such presentations and enjoys them. The way she talks about her desire to see the project being acknowledged shows how strongly she identifies with their common achievement. While she took on only those tasks that had nothing to do with technology at the beginning of the project, she is now proud to be a platform administrator.

She finds her self-confidence has changed by working on the platform project, and also how other people see her {190, 191}.

Being in the development team means to explore new activities and take on responsibilities. We can see here how *she experiences new roles. These experiences added to raising her self-efficacy and her self-confidence* {191 et seqq.} *and she believes it changed the images of secretaries and women, as their skills, commitment and successes become more visible* {192 et seq.}.

While this experience did not make her enthusiastic about computers, however (again showing her ambivalence), she says she would be very interested to learn about some possible changes on the platform and is interested in reworking the platform {131, 171}. Insofar we can interpret this as *technology construction activities evoking new learning interests*.

Comparison & summary

The case of Sonea shows how she explores her identity and power through construction activities.

The case of Filou shows how someone's distanced relation and standpoint to technology can change in the context of the construction experience.

Both regard their construction experiences as very useful and they embed them into diverse contexts, so that their scope and choices of activities and opportunities are expanded.

Both, in different ways, talk about how they perceive their construction experiences as empowering.

This potential for educational empowerment can be found in three dimensions: creation, exploration, and reflection. They are catalysed by experiencing new worlds, new activities, new relations.

(a) Creation of new products: IT construction as a mediator / gate for bringing something and oneself into the world

Both Filou and Sonea *create something new and put it out into the world*:

Filou participates in creating the SAN platform and another secretary network, which are widely acknowledged. Instead of merely adapting

herself to technology, she creates a technology that adapts her workplace to her needs (more contacts, more information, etc.).

Sonea creates her own role-play, invents a new display mode, sets up a new homepage etc.

The results of their actions are visible and affect other people: *they take action in the world*.

Both tell us about how they perceive the existence of diverse separated worlds. Filou perceives her sons' computing activities as something that happens in 'another (technology-driven) world', which she does not want to access. However, making the experience of taking on new tasks and roles in the secretary network and going to new meetings, *a new world opens up for her*. It is through the creation of a meaningful product or space (SAN platform) that she finds ways to benefit from technology and to take on a creative role in technology-driven contexts.

In Sonea's story we can see how the technology construction both serves as a strong bond between her old world (father, family and Belarus roots), and as a gate to a new world (new friends, new interests, new skills). *Technology construction thus creates gates to connect worlds*.

(b) Exploring new activities: IT construction as a means for exploring activities, and new roles

In both cases, their active immersion in the construction activities enables them to *access new communities, and even form communities of practice* (Wenger 1998). This again extends their computing activities and skills, in both expected and unexpected ways.

By accessing these communities and becoming an acknowledged member, they take on a *new role and extend their identity*: they become administrators, respected managers or (chief) executives, presenters, experts.

In their construction activities, they *take on responsibilities* for their creations and their related actions, and they are respected for doing so. This is partly new to them. Their responsibility is made visible by the technology.

Both make *experiences with additional learning styles*: while Filou was used to taking classes and learned mostly when job requirements forced

her to, she now enjoys learning from her peers and for the reason of extending her project.

Sonea's construction activities guide her by trying things out for herself, by searching for help when needed, and by asking both peers and more experienced computer experts. She depends less and less on her father's and brother's skills, who would take away her control over the task. *Technology construction activities evoke new activities and perspectives*.

(c) Reflecting new relations: IT construction as a mediator for reflection on relations between the self, the world, and the technology

Subordinance is questioned and reflected, both in terms of subordination to superiors (department, supervisor, teachers) and automatic subordination to men's assumed computing skills (sons, father, brother).

Similarly, by enhancing one's own computing skills through construction activities, *common technology-related gender stereotypes are reflected and partly rejected*. Seeing and acknowledging their own computing skills and interests and their visible successes and also finding other female peers (Filou) or being accepted as an expert (Sonea), they come in touch with common stereotypes and position themselves anew.

Sonea and Filou talk about *gaining access to experts' knowledge and even to experts' communities*. This was something that happened without planning it. While working with the technology, this access was a result of both their intent and the unexpected incidents happening with the technology (e.g. being invited to a VRPG, being called an administrator, finding experts' health information). In this way technology can be understood as an *actant*.

Conclusions

In this analysis, we have come to understand more about

– how construction activities are experienced by lay developers,
– how they embed the experience into their lives,

– how construction is related to interaction (with the product, the community, the acknowledgements) with the world around us,
– how constructing information technology can be an evocative activity,
– and how lay designers connect their construction experiences with their views on themselves, society, and technology.

We can now return to the opening challenge of this article: What are the educational potentials of construction activities?

In the case studies of Sonea and Filou we have come to know two very different approaches to technology and seen how both—each in their own way—have undergone changes in attributing meaning to technology, the self and the environment in which they and technology act.

Although their initial construction ideas were very concrete and confined, it was in the process that they expanded their ideas, their interests, their fields of activity, and their roles. These experiences lead them to reflections about technology and their own roles and the unexpected possibilities they are offered by the technology and by the power they gain when constructing technology.

Construction activities hold the potential to support educational goals in at least three dimensions: creating new worlds, exploring new activities, reflecting relations.

Relating these experiences to education theory, interesting alignments can be found with the ideas by Sesink, Marotzki and Dewey.

Education (*Bildung*), according to Marotzki, happens when the perceptions of relations between Self, Others, and the World are reflected and transformed (Marotzki 1990). Starting from different points of origin, this is what both case studies expressed. Expanding Marotzki's concept, we have seen that the relation with and perception of technology has also been transformed.

Technology can be seen as a threat to personal autonomy and competence. While on a greater scale this may be true, and technology as a carrier of cultural meaning does transport such images (Carstensen 2007), the case studies showed how this notion can change at an individual level, when the benefits of technology become clearer because one feels more in control. In this way, IT construction can become a mediator for

developing new perspectives on the relations between self and technology in a technology-driven world.

The different stages of agency are reflected. A reflection seems to have started about the extent of lay designers' own agency in this interplay of self, world and technology.

Sesink was quoted in the beginning with his idea that technology in the beginning is often seen as something to adapt to, while the active personal design of something new partly transforms the world into a self-designed construction and thereby raises the actor's sense of agency. The analyses have shown exactly this, for both the computer interested Sonea and the computer reluctant Filou.

As we have seen, however, it is not a mere self-designed construction, but a continuous interaction of actorship on the part of the designer and the technology as actant.

Educational theory has long been about the art of teaching. Current research moves more into exploring the art of learning. Holzkamp (1993) expressed how in planning teaching, we can never plan what the subjects will learn, as they follow their own desires and interests. Dewey (1913) argued that one of the most important tasks of a good teacher is to encourage learners in pursuing learning according to their interests and helping them to widen their horizons for more and other interesting topics and connections. This is what the lay designers experienced. However, they did not even mention teachers, probably because they were not aware that there were teaching agents in their construction processes. The learning process evolved more or less by itself, natural consequences of learning, acting and interacting with the technology, colleagues, and communities, and the unexpected new horizons that evolved.

The case studies show how *IT construction can be performed in a community context*. This may broaden the image of IT construction being the activity of the lone computer nerd who spends nights alone in front of his computer, which has transported less attractive images of becoming a computer expert (Weizenbaum 1976).

These educational aspects bring us to an interesting conclusion: The lay designers have not only created technology and new products that act in the world, they have also *constructed their own learning space*.

They have created a situation and space and environment in which their own personal development was stimulated. Their creation of this space includes selecting the topic, searching for help and accessing this help (i.e. people, communities, web pages etc.), learning with and with the support of a community, which is often newly explored. Becoming a member of this community leads them to finding new interesting topics (or speaking with Dewey: horizons) that are worth exploring and learning about, to finding new challenges. They found ways to transfer what had been learned into other fields and to support others in the community with their new knowledge. And they even created structures to create and enjoy successes (i.e. by creating visibility or functioning products).

The study cannot state that such processes are always started in construction activities. Its value lies in having explored that construction activities teach more than construction, more than mere technical skills. It has explored the educational potential of IT construction activities and what it can look like. Taking into consideration the specific characteristics of IT, it is recommended to make full use of its construction potential for educational scenarios. In a more and more technology-influenced world, a profound understanding of technology and its role, as well as of one's own role and opportunities seem to be desired in order to educate people to become critical, active and responsible citizens in the knowledge society.

These results point to the manifold educational potentials that IT construction activities hold. These potentials go far beyond a media literacy concept that aims only at acquiring computing skills.

The educational benefits of such construction activities may go far beyond the benefits of learning to adapt to office software (more research would be needed on the educational benefits of acquiring these skills), especially if learners report expansive learning in their construction activities as opposed to defensive learning when being bored and feeling pressured to learn office software (on expansive and defensive learning see Holzkamp 1993).

The case studies also suggest for educators to expand ideas on how information technology can be used in educational contexts.

Taking on an educational perspective, the case studies showed that *construction activities not only offer an increase in computing skills, but also offer*

opportunities for attaining more general educational objectives. This result should encourage educators to make use of the full benefit information technology offers, namely by not just 'using' it but to explore its specific potential to be designed, re-designed and used for learners' constructing own ideas.

This result suggests two things for the design of educational scenarios. One is to design settings for constructionist learning that allow for a broad range of experiences, to encourage learners to work in teams and to form and join communities and exchange knowledge. Such scenarios may appeal not only to the traditionally envisioned groups of computing kids, but also to new groups.

The second is to incorporate knowledge and skills that are increasingly acquired by learners in private activities with computers. As shown, it may be worthwhile getting to know how and what they learn when they actively work on realizing own ideas using computing technology. Then educators could be catalysts to reflect, extend and transfer such skills and knowledge, thereby inspiring more personal development for the learners.

Notes

1 This was an issue especially with some of the younger children. However, when possible, I tried to include experiences from people who did not have good verbalization skills, as such experiences are also important to be considered.

2 More about such workshops see http://dimeb.informatik.uni-bremen.de/content/blogcategory/80/198/.

3 Numbers indicate the paragraph numbers of the transcribed interview.

References

Baacke, Dieter (1996), 'Medienkompetenz als Netzwerk—Reichweite und Fokussierung eines Begriffs, der Konjunktur hat', *medien praktisch* (2): 410.

Baacke, Dieter and Bundeszentrale für Politische Bildung (1999), *Handbuch Medien: Medienkompetenz: Modelle und Projekte*, Bonn: Bundeszentrale für Politische Bildung,

Barsch, Achim and Hans Dieter Erlinger (2002), *Medienpädagogik: eine Einführung*, Stuttgart: Klett-Cotta.

Buckingham, David (2007), 'Media education goes digital: an introduction', *Learning, Media and Technology* 32: 111–119, www.informaworld.com/10.1080/17 439880 701343006.

Dewey, John (1913), *Interest and Effort in Education*, Boston: Houghton Mifflin Co.

Dittert, Nadine, K. Dittmann, T. Grüter, A. Kümmel, A. Osterloh, M. Reichel, H. Schelhowe, G. Volkmann, and I. Zorn (2008), 'Understanding Digital Media by constructing intelligent artefacts', *ED-MEDIA World Conference on Educational Multimedia, Hypermedia & Telecommunications*, Wien: 2348–2358.

Durndell, Alan, Z. Haag, D. Asenova, and H. Laithwaite (2000), 'Computer self efficacy and gender', *Proceedings of the IFIP TC9/WG9.1 Seventh International Conference on Woman, Work and Computerization: Charting a Course to the Future*, Deventer: Kluwer, 78–85.

Facer, Keri (2003), *Screenplay: Children and Computing in the Home*, London / New York: Routledge / Falmer.

Flick, Uwe (1996), *Psychologie des technisierten Alltags: soziale Konstruktion und Repräsentation technischen Wandels in verschiedenen kulturellen Kontexten*, Opladen: Westdeutscher Verlag.

Gesellschaft für Informatik (2000), 'Informatische Bildung und Medienerziehung. Empfehlung der Gesellschaft für Informatik e.V. erarbeitet von einem Arbeitskreis des Fachausschusses "Informatische Bildung in Schulen"', *Informatik-Spektrum* (2): 122–126.

Glaser, Barney G. and Anselm L. Strauss (1967), *The Discovery of Grounded Theory; Strategies for Qualitative Research*, Chicago: Aldine Pub. Co.

Groeben, Norbert and Bettina Hurrelmann (Eds.) (2002), *Medienkompetenz: Voraussetzungen, Dimensionen, Funktionen*, *Lesesozialisation und Medien*, Weinheim: Juventa.

Hartmann, Susann, Heike Wiesner, and Andreas Wiesner-Steiner (2007), 'Robotics and gender: The use of robotics for the empowerment of girls in the classroom', in Zorn, Isabel, Susanne Maass, Els Rommes, Carola Schirmer, and Heidi Schelhowe (Eds.), *GenderDesignsIT—Construction and De-Construction of Information Society Technology*, Wiesbaden: VS-Verlag, 175–188.

Holzkamp, Klaus (1993), *Lernen: subjektwissenschaftliche Grundlegung*, Frankfurt am Main: Campus.

Hubwieser, Peter (2000), *Didaktik der Informatik: Grundlagen, Konzepte, Beispiele*, Berlin: Springer.

Hug, Theo (2002), 'Medienpädagogik. Begriffe, Konzeptionen, Perspektiven', in Rusch, G. (Eds.), *Einführung in die Medienwissenschaft*: Westdeutscher Verlag, 189–207.

International Technology Education Association. (2003), *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*, Reston, VA: International Technology Education Association.

Kafai, Yasmin B. and Idit Harel (1991), 'Learning through design and teaching', in Harel, I. and S. Papert (Eds.), *Constructionism*, Norwood, NJ: Ablex Publishing Corporation: 85–110.

Klaeren, Herbert and Michael Sperber (2007), *Die Macht der Abstraktion: Einführung in die Programmierung*, Wiesbaden: Teubner, 1. Aufl.

Latour, Bruno (1992), 'Where are the missing masses? The sociology of a few mundane artifacts', in Bijker, W. E. and J. Law (Eds.), *ShapingTechnology / Building Society: Studies in Sociotechnical Change*, Cambridge, MA: MIT Press, 225–258.

Levin, Doug and Sousan Arafeh (2002), *The Digital Disconnect: The Widening Gap between Internet-Savvy Students and their Schools*, Washington DC: Pew Internet and American Life Project, www.pewinternet.org/pdfs/PIP_Schools_Internet_ Report. pdf.

Marotzki, Wilfried (2004), 'Von der Medienkompetenz zur Medienbildung', in Brödel, R. and J. Kreimeyer (Eds.), *Lebensbegleitendes Lernen als Kompetenzentwicklung: Analysen – Konzeptionen – Handlungsfelder*, Bielefeld: wbw Bertelsmann, 63–74.

Marotzki, Winfried (1990), *Entwurf einer strukturalen Bildungstheorie: biographietheoretische Auslegung von Bildungsprozessen in hochkomplexen Gesellschaften*, Weinheim: Dt. Studien-Verlag.

Medienpädagogischer Forschungsverbund Südwest (2007), *JIM-Studie: Jugend, Information, (Multi-) Media; Basisuntersuchung zum Medienumgang 12- bis 19jähriger*, Baden-Baden: MPFS, www.mpfs.de/fileadmin/JIM-pdf07/JIM-Studie2007. pdf.

Nohl, Arnd-Michael (2002), 'Personale und soziotechnische Bildungsprozesse im Internet', *ZBBS Zeitschrift* 3 (2): 215–240.

Papert, Seymour (1980), *Mindstorms: Children, Computers, and Powerful Ideas*, New York: Basic Books.

Prensky, Marc (2005), '"Engage me or enrage me"—What today's learners demand', *EDUCAUSE Review* 40 (5): 60–65.

Reichel, Milena and Andreas Wiesner-Steiner (2006), 'Gender inscriptions in robotic courses', *1st International Conference on Digital Media and Learning 2006 (ICDML 2006)*, Bangkok, Thailand: Tana Press.

Schelhowe, Heidi (2005), 'Medienpädagogik und Informatik. Zur Notwendigkeit einer Neubestimmung der Rolle Digitaler Medien in Bildungsprozessen', *Medien-Pädagogik* (2), www.medienpaed.com/05-2/schelhowe05-2.pdf [2008-07-12].

Schelhowe, Heidi (2007), *Technologie, Imagination und Lernen: Grundlagen für Bildungsprozesse mit Digitalen Medien*, Münster: Waxmann.

Sesink, Werner (2004), *In-formatio: die Einbildung des Computers: Beiträge zur Theorie der Bildung in der Informationsgesellschaft*, Münster: LIT.

Sörensen, Brigitte Holm (2003), 'If spare time didn't exist—a future perspective on children's off-school virtual learning processes', *merz Zeitschrift für Medienpädagogik* 47 (5): 28–38.

Strauss, Anselm L. and Juliet M. Corbin (1990), *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*, Newbury Park, Calif.: Sage.

The European Computer Driving Licence Foundation Ltd. (2006), *European Computer Driving Licence Syllabus Version 4.0*, Dublin, Ireland: The European Computer Driving Licence Foundation Ltd., www.ecdl.com/files/products/20060331035737_ECDLV4SWG110159.pdf.

Tulodziecki, Gerhard and Bardo Herzig (2004), *Mediendidaktik: Medien in Lehr- und Lernprozessen*, Stuttgart: Klett-Cotta.

Turkle, Sherry (1984), *The Second Self: Computers and the Human Spirit*, New York: Simon & Schuster.

Turkle, Sherry (1995), *Life on the Screen: Identity in the Age of the Internet*, New York: Simon & Schuster.

Wagner, Wolf-Rüdiger (2004), *Medienkompetenz revisited: Medien als Werkzeuge der Weltaneignung: ein pädagogisches Programm*, München: kopaed.

Weizenbaum, Joseph (1976), *Computer Power and Human Reason: From Judgment to Calculation*, San Francisco: Freeman.

Wenger, Etienne (1998), *Communities of Practice: Learning, Meaning, and Identity*, Cambridge, UK / New York: Cambridge University Press.

Zorn, Isabel, Susanne Maass, Els Rommes, Carola Schirmer, and Heidi Schelhowe (Eds.) (2007), *GenderDesignsIT—Construction and Deconstruction of Information Society Technology, Studien Interdisziplinäre Geschlechterforschung*, Wiesbaden: Verlag für Sozialwissenschaften.

Zorn, Isabel (2005), 'Do culture and technology interact?: Overcoming technological barriers to intercultural communication in virtual communities', *SIGGROUP Bull.* 25 (2): 8–13.