EduWear: Smart Textiles as Ways of Relating Computing Technology to Everyday Life

Eva-Sophie Katterfeldt  Nadine Dittert  Heidi Schelhowe
Digital Media in Education (dimeb), University of Bremen, Department of Computer Science
P.O. Box 330440
D-28334 Bremen, Germany
evak@tzi.de  ndittert@tzi.de  schelhowe@tzi.de

ABSTRACT
In this paper, we report on the outcomes of the European project EduWear. The aim of the project was to develop a construction kit with smart textiles and to examine its impact on young people. The construction kit, including a suitable programming environment and a workshop concept, was adopted by children in a number of workshops.

The evaluation of the workshops showed that designing, creating, and programming wearables with a smart textile construction kit allows for creating personal meaningful projects which relate strongly to aspects of young people’s life worlds. Through their construction activities, participants became more self-confident in dealing with technology and were able to draw relations between their own creations and technologies present in their environment. We argue that incorporating such constructionist processes into an appropriate workshop concept is essential for triggering thought processes about the character of digital media beyond the construction process itself.

Categories and Subject Descriptors
K.3.m [Computers and Education]: Miscellaneous – Computer literacy; H.5.2 [Information Interfaces and Presentation]: User Interfaces – Haptic I/O.

General Terms
Human Factors.

Keywords
Construction Kits, Smart Textiles, Education, Children.

1. INTRODUCTION
Understanding ICT and being able to use it competently and confidently are competences that are crucial for active participation in the information society. Based on ideas from Constructionism [12], several construction kits with robotic elements have appeared during the last decade to facilitate access to an understanding of ICT. Such construction kits usually consist of programmable microcontrollers, sensors, and actuator material. Kits like LEGO® Mindstorms® [15] are or have been available on the market and thus have become popular and widely used within schools, at home, or other settings.

Many children and young people have benefitted from working with those kits and learned about robotic technologies and programming [17]. However, most existing construction kits appear rather technical, relate to the world of play, and often stimulate little motivation for people not interested in technology. Learning experiences might be exciting, but relate little to users’ everyday worlds but to the world of play and robots. Thus, those construction kits are likely to attract mainly a male, technology interested target group [21]. As a result, some new kits have been developed. They try to meet the needs of less-technically but rather artistically interested (also female) people and to offer rich learning experiences by combining the kits with state-of-the-art technologies such as “smart textiles”. However, comprehensive evaluation studies about the application of these kits are not known.

To create and implement an educational low-cost smart textile construction kit for wearable and tangible interfaces has been the goal of the European project “EduWear”. The learning objectives were to empower young people through working with this new, but familiar technology to build their own (futuristic) prototypes, and thus to participate actively in information society. This includes the fact that the participants feel more confident in everyday life, perceiving the surrounding wearables not as magic devices, but rather, knowing what is behind them. Six partners from different countries across the European Union took part in this project. From the beginning, the kit was incorporated into the development of a didactically reflected workshop concept. In this two-year project, the “EduWear toolkit” for designing smart textiles and a workshop concept were developed and applied in more than 18 workshops with more than 200 participants in different European countries. These workshops have been evaluated with respect to the concept and the material.

In this paper, we present the EduWear toolkit, the workshops, and the outcomes of the evaluation. We begin by giving background information and referring to related work in the fields of construction kits and smart textiles. In the fourth section, we describe the EduWear project, including its outcomes, the EduWear toolkit and the EduWear workshop concept. In the following section, we report on the settings and the character of the workshops we evaluated in more detail, and name the evaluation methods. We then present the outcomes of the qualitative evaluation supported by quantitative results. In doing so, we focus on the issue of whether and how creating smart...
garments in EduWear workshops allows the participants to draw connections to their life worlds. In the end, we discuss the evaluation results and conclude with implications for future workshop concepts.

2. BACKGROUND

The main ideas of the EduWear project are based on the Constructionist learning approach [18]. Learners are seen as constructors of their own knowledge, and the materials and concepts are supposed to enable young people to construct personally meaningful “objects to think with” and to explore abstract concepts. Resnick et al. [24] argue that providing appropriate material (and learning environments) and so-called “construction kits” allow young people to become expressive using new technologies. Hence, this expressive work with the kits offers them the opportunity to explore basic concepts.

There has been a series of construction kits inviting young people to design and create their own “intelligent” artifacts. Seymour Papert and his research group initiated these so-called “microworlds” which offer the possibility of exploring aspects in fields of interests which could not be explored in real life or school life because of their complexity and/or impracticality.

The learning objectives when working with construction kits are not primarily to “teach” the users abstract concepts such as programming explicitly, but rather to “empower” children for real world activities. Thus, as Papert describes “empowerment of the individual” as the opposite of “learning (…) by being taught” [19], the aim of the EduWear project is to empower learners by offering them new learning experiences with novel materials such as smart textiles and microcontroller technologies. The tutor acts not as an instructor, but more as somebody who supports the children with their ideas and who gives further incentives at the right time.

3. RELATED WORK

3.1 Construction Kits

“Robotic” construction kits which come with programmable bricks have become quite popular, allowing children and young people to explore concepts of programming, microcontroller technology, and robotics (e.g. [9],[15]).

“Construction kit” hereinafter refers to those kits consisting of a programmable microcontroller and a set of sensor and actuator components which can be attached to it. Such a kit comes ideally with an appropriate programming environment to program the microcontroller.

An example of successful marketing of these kinds of kits was the connection of LEGO® with Logo [18]. Programming entered the world of “traditional play”, and the construction kit “Mindstorms Robotics Invention System” was placed on the market in the late 1990s. It enables traditional LEGO bricks to be connected with a programmable brick, and hence “lively” artifacts to be created. The enhanced version of the system, the LEGO® Mindstorms® NXT, appeared in 2006.

Another construction kit is the Handy Cricket system [9]. It too can be programmed using Logo, and sensors and actuators can be connected to it. Instead of connecting it to LEGO bricks, it can be placed in any creative environment.

Kits such as LEGO Mindstorms and the Handy Cricket boards appear rather technical. They have shown to be initially attractive for technically interested young people (esp. boys), and they relate mainly to the world of play [21]. Recent developments in robotic construction kits are therefore aimed at new target groups by becoming more attractive for less-technically, but rather artistically, interested people, including girls. For instance, the Pico Cricket system comes in a rather neutral and less technical-looking design [20]. Buechley et al. [6] have developed the Arduino LilyPad kit. Its components are made for usage with conductive yarn as connectors (instead of cable), thus opening up new possibilities for users to create “intelligent” garments. The purpose of the LilyPad is therefore similar to that of the EduWear construction kit. Since the Arduino LilyPad kit was released during the runtime of the EduWear project, it had an impact on the EduWear toolkit, which we will explain later.

3.2 Smart Textiles

When talking about “smart textiles” in this context, we refer to conductive fabrics and yarns which incorporate or allow microcontroller logic (along with sensors and actuators) to be integrated into garments. Research on these kinds of smart textiles is a rather novel field, and only few products, such as MP3 player control jackets and some applications in the field of medicine or sport, have so far made it to the market. Apart from that, many smart textile applications can be observed in fashion design and arts communities (e.g., cf. [11]).

In educational contexts and IDC, smart textiles are quite novel, too, and thus have not yet made it into regular class rooms and children’s homes. Pioneering work in this field has been performed by Leah Buechley. As preliminary work to the LilyPad construction kit mentioned above, she and her colleagues presented several other “e-textile” projects [5]: An Electronic Sewing Kit for exploring electricity and electronic circuits with fabrics; “Quilt Snaps” which allow creative use of ready-made patches which can be combined and, for example, used to decorate objects; and “Programmable Wearable Displays” which are lights in grid patterns that form low-resolution displays and can be animated, thus providing an entry point into programming. Consequently, Buechley et al. name “electronic”, “software”, and “fabric” craft activities as potential application areas of smart textiles. Due to the ‘soft’ character of the material, the relation to objects or activities from childrens lives (e.g. clothing or accessories), their resulting potential for attracting diverse groups (especially girls), and thus their opportunities for artistic expression, Buechley et al. [5], [6] regard smart textiles as a good medium for a “wonderful way” of introducing electronics.

Berglin [4] has presented “Spookies”, an interactive smart textile toy for children encouraging free play. She sees the potential of smart textiles as a way to “fill the gap between complex computational technology and understanding” [4].

The main potential of smart textiles for education is therefore seen in its “soft”, not initially technical-looking character. However, only little evidence of the benefits of smart textiles for ICT education has been produced so far. EduWear is thus aimed not only at spreading smart textiles for ICT education to a larger group of young people, but also at evaluating the workshops to gain more evidence for some of the potential benefits (e.g. personal meaningfulness) of smart textiles.
3.3 Similar Projects
In some European countries, projects using robotic construction kits in educational settings have spread ICT knowledge and increased interest in technology. This project has now been extended to Europe under the name “Roberta goes EU” [17]. In Ireland, the “Empowering Minds” [7] project has been aiming at supporting creativity in the development of technology since 1998.

These initiatives follow similar goals to the EduWear project, and are also scientifically accompanied, and have didactically founded workshop concepts, too. They use the LEGO Mindstorms kits to do so. We see the advantage of EduWear in employing smart textiles and thus in using material that is more attractive to a wider range of users across Europe.

4. EDUWEAR
The EduWear project started in October 2006 and ended in September 2008. It was funded by the European Commission’s Lifelong Learning program. EduWear was initiated and coordinated by the research group of Digital Media in Education (dimeb) at the University of Bremen, Germany. Five other universities and companies from different countries across the European Union participated, namely St. Patrick’s College in Dublin, Ireland, University of Dundee, UK, the Swedish School of Textile in Borås, Comenius University in Bratislava, Slovakia, and X10D International IT Services in Hungary.

The aim of the EduWear project was to develop a construction kit for smart textiles incorporated in a workshop concept. The EduWear Kit is designed to enable children and young people to create their own “wearables”, and comprises hardware elements to construct them on their own. Furthermore, the kit comes with a visual programming environment which allows young people to program their artifacts. The target age of the EduWear Kit and Workshops is approximately 10 to 14 years.

Each project partner conducted at least three workshops during the project runtime. These workshops were evaluated using questionnaires, and some of the workshops were additionally evaluated with qualitative methods. Based on findings from the workshops, the kit was refined constantly, and several “local” workshop concepts emerged.

4.1 The Kit
The EduWear Kit consists of a physical construction kit, a programming environment, and a didactically reflected workshop concept. The most essential parts of the physical construction kit are a microcontroller board, sensors, actuators, and connectors (see figure 1). Actuators are e.g. LEDs, buzzers or vibrating motors. For sensing input, light sensors, temperature sensors, textile stretch sensors, as well as textile “press” switches, reed switches, and tilt switches, are available. Raw conductive and non-conductive textiles (fabric and yarn) are provided to enable one, for example, to build one’s own textile switch or similar, and mainly to serve as data busses (instead of wire used in common electronic construction kits). During the workshops, other textile materials, existing clothes like t-shirts, shoes, caps, bags, decoration material etc. were added and incorporated into the design processes, based on the thematic focus of the workshop.

Throughout the project, the kit’s parts underwent several iterations of development (e.g. with ready made data busses or sensor “patches”) in its details. When the project started, the Arduino NG and Arduino Diecimila were used as microcontroller devices. We started developing a microcontroller which would be more suitable for textiles purposes than the flat Arduino controllers, but when the Arduino LilyPad was released in October 2007, we stopped further developments and used the LilyPad microcontroller instead.

![Figure 1. Physical components of the EduWear toolkit.](image)

In order to make their textile constructions, i.e. their wearables, “intelligent”, children need to define how the actuator components should react to sensor events. They do so by programming the microcontroller to which the sensors and actuators are connected. Programs need to be written on a computer and uploaded from there to the microcontroller via a USB connection. Since there was no child-appropriate programming environment for Arduino microcontrollers available, an essential part of the EduWear project was the development of the visual programming language “Amici”. Amici builds on the textual programming language “Arduino” [2]. To create a program with Amici, one has to align graphical blocks (see figure 2). Each block represents a programming command or procedure (similar to the graphical programming language “LogoBlocks” [3]).

![Figure 2. “Block” Program in Amici.](image)
then has to be uploaded to it. Compared to writing programs directly in Arduino, Amici decreases the need to learn the complex syntactic rules of a textual language, and enables the use of complex program structures hidden behind a block.

Furthermore, Amici provides a virtual platform where users can upload and share their project ideas, including a written description, a picture, and the program code of the artifact.

4.2 The EduWear Workshop Concept

The EduWear approach offers a holistic concept, including not only the hardware and a child-appropriate software for programming the microcontroller, but also a didactically reflected workshop concept to bring this somewhat new type of technology to young people.

On the one hand, such a kit and its technology may be too complex to be used successfully at home (compared to more “robust” technologies like LEGO Mindstorms), on the other hand, a workshop can provide social learning experiences (team work) and provide more opportunities and stimulation than using it alone at home.

The basic EduWear workshop concept is related to the “Atelier” or “Studio” style of working [7] [14] and tries to facilitate a learning environment based on Constructionism. This includes encouraging communication, collaboration, and creativity, and to provide for immersive learning experiences but also space for reflection to deal with open-ended “problems”. This does not only mean facilitating an appropriate space, but rather a general setting including the tutors, materials provided, and general “schedule”. The tutors serve as learning partners to guide and support students in exploring things (and eventually expanding their views, also cf. [1]). This kind of setting differs greatly from the traditional school settings children are used to.

The cultural diversity of the participating partners coming from six different nations of different parts of Europe led to refinement of the general concept into different local concepts. The local concepts consider the different target groups and settings and their cultural backgrounds, and thus incorporate the workshops into their “world”. With some groups, for example, it was better to just experiment, while others needed more help in programming, or some went even further and programmed with the textual language. Amici decreases the need to learn the complex syntactic rules of a textual language, and enables the use of complex program structures hidden behind a block.

4.3 Running Workshops

Due to the special impact and potential of a domain like smart textiles, we worked with diverse groups, such as disadvantaged, gifted, both genders, etc., in different settings. About 18 workshops were run by the project partners. Workshops were either held for several days, as one-day events, or on a weekly basis, both integrated in school classes or as holiday courses. A few workshops were also conducted with adult participants.

The basic activity in a workshop was to construct a wearable garment or accessory using the EduWear construction kit. This meant either sewing clothes or—in most cases—taking already existing ones and attaching (sewing) a microcontroller and sensors or switches and actuators, such as LEDs, onto the garment. In order to make the object react “intelligently”, an important part of the workshops was to program the microcontroller.

5. EDUWEAR EVALUATION

5.1 Objectives

Almost all EduWear workshops held in the participating countries were evaluated quantitatively, and some were additionally evaluated with qualitative methods. For the quantitative data collection, standardized questionnaires were given to all partners to be distributed to the participants and tutors before and after each workshop. The questionnaires were then collected and analyzed by the German project partner dimeb.

Since we think that the learning processes taking place in such kind of workshops are hard to measure quantitatively, we also performed a qualitative study in two workshops. The qualitative data was gathered through interviews, by observing the participants and through video documentation during the workshops. This data allowed us to study preliminary issues from the quantitative analysis in more depth.

The evaluation was aimed at finding out whether the project’s objectives were met. We were especially interested in how working with a smart textile construction kit incorporated into the EduWear workshop concept can relate to the participants’ life world and empower them as active designers, increasing their self-confidence in dealing with technology. Subsequently, further objectives were whether smart textiles provide an attractive, personally meaningful entry point for engagement with (wearable computing) technology, whether participants were finally able to relate their experiences back into their life worlds, and whether their perception of digital “intelligent” devices thus changed. Due to the novelty of smart textiles in this context, we kept the evaluation open to further findings and we applied methodologies for hypothesis-testing, as well as hypothesis-generation.

5.2 Methodology

For the workshop participants, two different sets of questionnaires were employed: One for finding out about the motivation, expectations, prior experiences, and attitudes towards technology and clothing before the workshops; and a similar one after the workshop to find out issues as whether their expectations were fulfilled, how their concepts and their self-confidence towards technology, programming, and smart textiles had changed.

The questionnaires were filled in on paper and later digitized for analyzing the data. We collected data from 167 workshop participants. Out of these, 23 were adults and were therefore not included in the analysis because the questions differed slightly and because adults are not among the target group. From the remaining 144 children and youngsters (aged 10 to 16), 132 indicated their gender, so that we have explicit data from 66 boys and from 66 girls.

In general, the questionnaires seemed to be appropriate, but we found that, especially for some younger children and children from disadvantaged backgrounds or with learning difficulties, the questionnaires were too complex. Furthermore, at the end of the workshops, some seemed to be in a hurry preferring to finish their projects instead of spending time with the questionnaire, meaning many questions were not answered, and therefore leading to missing data in the post-course data collection. We thus consider...
the results from the quantitative analysis as supplements to the qualitative findings, but do not value them individually.

For the qualitative evaluation, participants were observed and interviewed during the workshop. Their work and their final results were video recorded. This allowed for involvement, which we can regard as “micro-ethnographics” where the evaluator “dives into” the group and participates in certain aspects. This can allow for a deeper understanding of the learning process and group dynamics, as well as create an atmosphere of acceptance and openness among the participants.

The key questions and main objectives had been established in a pre-start workshop at the very beginning of the EduWear project. The main focus was then on interaction among people, and among people and technology.

As interview techniques, group discussions, short role plays and mental scenarios (e.g. asking some children to think of programming an artifact different from the one they are currently working on) to find out about transfer processes and changing mental models were applied.

The recorded interviews were transcribed using “open coding” [8] and then grouped and analyzed in the context of certain categories with regard to the objectives of this study. All people who participated in the evaluation did so voluntarily. The questionnaires were filled out anonymously. Parents had signed an agreement before the workshops that their children were allowed to take part in research and that pictures and video could be taken for that purpose. In the following text, we have substituted all personal names. Participants’ quotations marked with [translation] have been translated from the German language.

5.3 Settings (Qualitative Evaluation)

Two workshops were studied with qualitative methods. The first workshop took place during school holidays in May 2008. It was a five-day full-day workshop taking place at the university lab of the German project partner. The workshop had been advertised as “Smart Fashion—tomorrow’s intelligent clothing made out of yesterday’s garment” in public newspapers and via an email newsletter to previous workshop participants. Participation was therefore not bound to any obligation as a school class, for example. In total, 15 children and young people aged between 10 and 14 participated, of whom 13 were female and two were male. The majority had no programming experience; textile experience varied from little needle-craft experience to using sewing machines regularly. Three female tutors guided the workshop: One was a research assistant in Digital Media working fulltime in the workshop. One Digital Media student and one fashion design student were present part-time. This workshop explicitly followed (as the German local concept) a “five-stages” approach: The construction activity itself was incorporated into a creative process of fantasies, getting to know the materials, creating ideas, and a presentation at the end (cf. [10]).

The second workshop took place in Ireland at the end of May 2008 at the participating university’s research lab. It was a three-day workshop where nine students and their teacher came in each morning to work for three hours. Six of the students were female, and three were male, all aged 12 or 13. The school the participants came from is located in a socially disadvantaged area. There was no specific workshop theme. Students had no experience with smart textiles but a little experience from home in sewing, and they had worked with LEGO Mindstorms a few years before (and thus had programming experience). The schedule of the workshop was more free (compared to the other workshop described above) emphasizing the “Atelier” style approach.

5.4 Evaluation Results

5.4.1 Personal Meaningfulness and Relevance

As stated above, we regard “personal meaningfulness” of the participant’s projects as a prerequisite for deep engagement in the construction process, and thus for feeling empowered and for “learning”, respectively. Furthermore, we think that working with smart textiles and thus clothes can make the construction of technology meaningful to a wider audience, rather than only addressing robotics or technology, since these materials relate more to the constructors’ life worlds.

The project ideas developed and implemented during the workshops were associated with sport, school, or leisure time activities (e.g. thief-proof bag, signalling glove, sports shoes that measure steps, ventilation shirt or caps, etc.) or envisioning other target groups such as elderly or handicapped people as potential wearers (e.g. jacket for blind people, police cap). The design and decoration of the project reflected its personal significance in almost all cases. For instance, Pete, a football fan, designed a football shirt. He had often made sketches for football shirts in the past, but in this workshop, he did not only have the chance to realize his ideas, but even to make an interactive shirt.

In the “Smart Fashion” workshop, a group of girls created a “thief-proof-handbag”: To implement it, they sewed a handbag out of an old pair of jeans with a buzzer inside and alarm LEDs attached and a conductive piece of fabric on the strap. As a counterpart, they created a t-shirt with a piece of conductive fabric attached to its shoulder. Whenever the strap of the bag was removed from the shoulder, the alarm set off. To de-/activate the alarm mode, a switch was placed in the bag. To realize the project, they cut up and re-designed old clothes they had been very fond of, constantly coming up with new ideas to decorate their smart garment (see figure 3).

![Figure 3. Thief-proof “sexy bag”](image)

Also the title of their project “sexy bag” was closely associated with their lives as a reference to a pop song:

Natalie: With the sequins, we thought we’d put them here, and then we were looking for something funny that we could create our motto with, which is “sexy bag”, so we changed...
the original “ck” into a “g” and took this as our motto. [translation]

During the interview, the girls mentioned several times that their motivation for their project had been to design something “cool” and functional at the same time.

Another group created a “massage shirt” with vibrating motors on each shoulder. When asked about her motivation, Helena had a clear vision of how the shirt could be integrated into her (or other peoples’) daily life:

For example, if you have a stressful day at work, or we sometimes have class until quarter past two, and then just put that [T-shirt] on and sit down somewhere for half an hour or an hour, and read something or just relax. [translation]

The project ideas indicate that working with smart textiles allows for constructing “realistic”, personally meaningful objects which relate to fun or play and joyful use and at the same time to everyday activities and “real world” problems. Thus, they might be perceived by the participants as having significance in the world.

Since the Dublin workshop group had worked with LEGO Mindstorms some years before, it was possible to ask the participants for a comparison with the EduWear Kit (though we have to bear in mind that the latter was much more present in their minds at that moment). All participants stated that they had liked working with LEGO Mindstorms, but that working with smart textiles was more interesting. They gave reasons that hint at the special nature of the (smart) textile material:

Evie: You get to design something for yourself.

Amy: I have to wear clothes everyday obviously. With LEGO, having flashing lights on them would be weird. You can only play with LEGO indoors. If it gets wet, it might break. With your clothes, it’s a bit different.

This indicates that the young people associate LEGO Mindstorms mainly with the world of play and as something which can only be used within limited settings. Furthermore, it offers very little possibility for personal design. Whereas (smart) textiles and clothing have a higher relevance in life not only relating to play, but also to school, work, and other situations in everyday life. Equipping textiles with smart features thus opens up a wider range of possibilities for personal meaningful projects.

5.4.2 Attitude Towards Technology

We observed that the workshop activities—designing and sewing, as well as working with electric circuits and programming—became more familiar and less inconvenient during the workshop.

At the end, most children were amazed at what they had achieved:

Miriam: At the beginning, I didn’t think that you could make a whole blouse intelligent in four days. Or that you could connect it properly at all. Well I thought that was like, wow. [translation]

Amy: I thought it was complicated. When she [the tutor] was just showing us things, I was like: I’ll never be able to do that, because of everything she showed us, (…), and I didn’t think I’d be able to do that, because it looked fairly hard to do. (…) And it’s so easy. I thought it was gonna be real hard, but it’s really straightforward and simple.

Particularly those with no prior programming experience seemed to come into the workshop thinking that “programming is difficult” and that they would not be able to create and program their artifact successfully over the course of the workshop. Although a little overwhelmed when first confronted with the new smart materials, the assessment of their own abilities and the time needed to conceive and realize a given project became more realistic after working with the material for some time. At the end of the workshops, extreme attitudes about the complexity of the material and technology were mostly levelled out.

Laura: Well, at first, I imagined it to be a lot easier, but I didn’t know that there were conductive fabrics and yarn and such. I thought you use cables or something. And then I realized that it is much more difficult. Then I thought that it is even harder than it really is. It is just right, so that you can make it when you do it right. [translation]

It seems that the changing of attitudes during the workshop does not necessarily have anything to do with acquiring specific skills. We assume that it is more likely due to an increase in self-confidence regarding technology, programming, and handicraft.

Results from the quantitative evaluation support this observation, showing an increase in self-confidence regarding technology and programming and a greater openness to technical subjects and professions:

For instance, concerning the statements “If I wanted to, I could program my own computer game”, the ratio reversed from disagreement into agreement for both boys and girls during the workshop: Before the workshop, two thirds of the girls disagreed, whereas after the workshop a slight majority agreed. For the boys, a slight majority disagreed in the beginning, but afterwards there were almost 2:5 as many agreeing as disagreeing.

The perception of both genders of whether high technology seems magical to them shifted towards disagreement: While before the workshop, the majority of female participants agreed to the statement “To me, most high technology seems like ‘magic’”, afterwards, the number of agreeing and disagreeing girls was balanced. For the boys, the slight majority agreeing before became more distinct after the workshop. We attribute this to their interaction with the EduWear material by which the participants realized that technology is not a “black box” (i.e. intransparent) after all, but can be studied and understood like any other domain.

From these findings we derive that, by creating wearables, the notion that even high technology can be accessed and understood became more common. The respondents regard themselves not only as mere users of ready-made, static technology, but feel that they are able to participate in design processes of innovative technology.

5.4.3 Drawing Relations to Everyday Life

At a group discussion towards the end of the “Smart Fashion” workshop, participants related what they had seen and used in the course to technologies of everyday life. Michael, for instance, compared the microcontroller board and power supply used in the workshop to the hardware elements he had seen in the computer club at school:

Michael: We opened up a computer and looked what’s in it.
Interviewer: Is it similar, when you look at the LilyPad?

Michael: No. Kind of. (...) The battery pack. (...) It’s like that in the computer, but it’s longer.

Some also made connections between the wearable they had created during the workshop and things they had seen before:

Natalie: There are these beepers for grandmas. [translation]
Laura: There are these shoes, when you take a step they light up, I think they’re based on a similar principle, the pressure switch. [translation]

These comments show that the participants were able to identify and classify technical devices in their environment after having worked with the EduWear material. By drawing analogies between ready-made, on-the-market products and their own artifacts, they incorporated their own creations into a larger context. They seemed to understand the underlying principles of the sensors and actuators used for their projects to a certain extent and realized that even professionally designed “high technology” utilizes similar components.

5.4.4 Perception of Digital Devices’ Autonomy

During interviews, the young people were asked whether and why they regarded their products as “intelligent”. Some regarded making LEDs light up with an electric circuit alone as making their garment “intelligent”, and they accounted “user-friendliness” or the way that technology was integrated into clothing for it.

Miriam: Well, I think this is pretty useful, because otherwise you’d always have to carry a torch light on you. And turn it different ways to see everything. And with this, you just press things together and that’s it. [translation]

Others connected “intelligence” only to programmed artifacts. When asked about their conception of “intelligent” or whether their artifact had this attribute, we noticed that many interviewees thought about it for a long time and reconsidered their answers repeatedly:

Jessica: Erm, well somehow something technological... technology...something like that has to be included, and well, like, I don’t know, be able to do something. Like, talk or...er, flash, something like that.

Interviewer: If you had done it like you had planned originally, do you think it would have already been intelligent, or only because it is doing it automatically now?

Jessica: I think it would already be intelligent like that, but this makes it even more intelligent [laughs]. [translation]

We found that, during interviews or group discussions, thought processes were often initiated and the participants started to reflect on the different kinds of features of their artifacts, e.g. on what is meant by saying that a shirt is “able” to do something and why or why not these features can be considered “intelligent”. This then also led to making distinctions between automation processes, operation modes, human and artificial intelligence.

6. Discussion

From our evaluation, we conclude that working with smart textiles allows for creating personal meaningful projects which have relevance for the participants since they relate to aspects of their life worlds.

By creating their personal meaningful objects (and thus implementing state-of-the-art prototypes), participants became more self-confident in dealing with technology.

Participants were able to draw relations between the objects they created and other wearable technology they had encountered in their everyday life. We attribute this to the high personal and realistic relevance of the material and objects created.

Drawing such relations and thinking explicitly about the character of digital media did, in most cases, not seem to happen automatically. In the context of discussions with their peers, tutors, and interviewers, thought processes about e.g. the artificial “intelligence” of digital artifacts were initiated. This stresses the importance of incorporating working with construction kits into a pedagogically conceptualized workshop setting where thought processes are triggered, e.g. by discussion rounds or confronting the participants to already existing wearable technologies as research objects or “real” commodities. Then, the constructions can also become objects-to-think-with beyond the actual construction process, and thus contribute to an understanding of digital media we regard as essential in the 21st century.

However, some weaknesses in this evaluation need to be kept in mind: We were only able to gather qualitative data from very few workshops compared to the overall number of workshops. Although the observations made are largely supported by the quantitative results, a more comprehensive qualitative evaluation at least within all participating countries (considering their local concepts) would have led to more reliable results. The quantitative data gathered was also incomplete.

There is some evidence that the EduWear toolkit and workshop settings contribute considerably to the positive results. But we cannot exclude that other factors may also have contributed to the results, such as the motivation and prior experience of the tutors, the individual backgrounds of the participants, and their reasons for being at the workshops (e.g. whether school or leisure, compulsory or not). Individual occurrences at the workshops as specific material, individual technical problems, and social factors might also have influenced the children’s perception. A comparative evaluation study could provide more reliable results of the advantages of smart textiles compared to robots, playthings, etc.

The evaluation has shown that the participants (especially the girls) gained more self-confidence regarding technology through the workshop. However, whether this experience really has a long-lasting effect in their lives and whether it may even result in taking up a profession in ICT would have to be subject to a longitudinal study incorporating biographical research methods.

7. CONCLUSIONS, FUTURE WORK

In this paper, we have presented the EduWear project and its outcome. We have described the results based on a qualitative evaluation of two workshops, supported by quantitative data gathered in all workshops. From our evaluation, we conclude that the EduWear workshops proved successful in relating technology and programming to young people’s life worlds, and we thus suppose that construction kits with smart textiles, such as the EduWear tool kit, are suitable for attracting a wider target group. Our evaluation study has shown that, within the scope of the EduWear workshops:
- Working with smart textiles allows for creating personal meaningful projects which relate strongly to aspects of life worlds.
- Participants become more self-confident in dealing with technology through their construction activities.
- Participants are able to draw relations between their own creations and already existing wearable technology.
- For deeper consideration of the autonomous character of digital artifacts and to reflect on the current experiences with the novel material and practices (like programming), it is essential to trigger thought processes e.g. in discussion rounds. Thus, incorporating a construction kit into a workshop concept, which gives appropriate occasions like the EduWear approach, is needed.

From this, we deduce that there is a possibility for “empowering” young people by providing the opportunity to construct wearable technologies as if they were developers of future products, as well as by making wearable computing devices more transparent to them.

For future work, we want to put effort into “multiplier workshops” to train tutors to hold EduWear workshops in other regions. We have also gained initial experience with inter-generational workshops, where elderly people and youngsters work and learn together. Other attempts aim towards integrating the EduWear approach into school curricula. The primary objective of these activities is for EduWear workshops to be provided area-wide so that more young people can participate.

We also plan to put further efforts into improving the Amici programming environment and community platform, as well as the composition and selection of the physical parts of the toolkit.

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9. REFERENCES
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