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New Approach to Teach Product Development in the Area of Smart Textiles

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Abstract

This paper deals with the challenges to teach how to develop so called Smart Textiles - these are textile-based products with extended functionalities that will contribute to the next revolution in textile and clothing technology and they have a high market potential. Therefore, it is important to prepare students for this task. So far there are only a few approaches in teaching this interdisciplinary field especially in the area of product development. Accordingly, this project aims for the development, piloting and evaluation of an innovative didactic tool in the field of Smart Textiles for engineering degree programs especially in the field of textiles and clothing. Thus, an application-oriented construction kit is developed that should help to extend the frontiers of knowledge, stimulate creativity, and give students the ability to solve real-world problems. As added benefit it will accelerate the understanding of innovation and interdisciplinary challenges. The project aims to prepare students to think interdisciplinary, broadly, deeply, and last but not least critically. The whole approach is tested in a on scene learning concept as well as in a blended learning concept. Her you get an overview on the didactical approach, the learning tool kit and first experiences.

Keywords: *Smart Textiles, Engineering, Learning tool kit, Didactical approach, E-Textiles.*

1. Introduction

What are Smart Textiles? Why is a new didactic tool needed and how is it created? How can aspects of design thinking and gameful design be integrated in the development? What are the benefits of different teaching-learning approaches and what do learning reflections and participatory observation contribute to optimize those set-up's?

1.1. The textile and clothing industries

The textile and clothing industries are traditional, but at the same time innovative businesses that have to face the challenge of systematically developing new knowledge in order to remain market leaders. This is especially true for Baden-Württemberg, which is the strongest textile location in Germany according to the textile industry association Südwestextil [1, p. 3] and where our university is based. Many companies are already developing and working with high-tech materials and products that will be further used in other industries and will, for example, bring even more safety, sustainability, energy efficiency and comfort into everyday life in the future. One of the most important challenges in the textile and clothing industries will be Smart Textiles – products with extended functionalities [2]

1.2. The interdisciplinary sector of Smart Textiles

Smart Textiles Products will contribute to the next revolution in textile and clothing technology and have a high market potential [3]. These are textile products with an additional benefit - often in combination with electronic components. This can be clothing such as heated gloves, a shirt for monitoring vital parameters or another textile product, such as an anti-theft luggage item or a smart carpet. Although the development of smart textiles has been going on for decades, everyday use is still in its infancy. In the following, Smart Textiles are defined as textile products that interact with their environment and can thus actively support users. The following Figure 1 illustrates the different levels of Smart Textile products. This work focuses on so-called E-textiles, which are textiles with integrated electronic components.

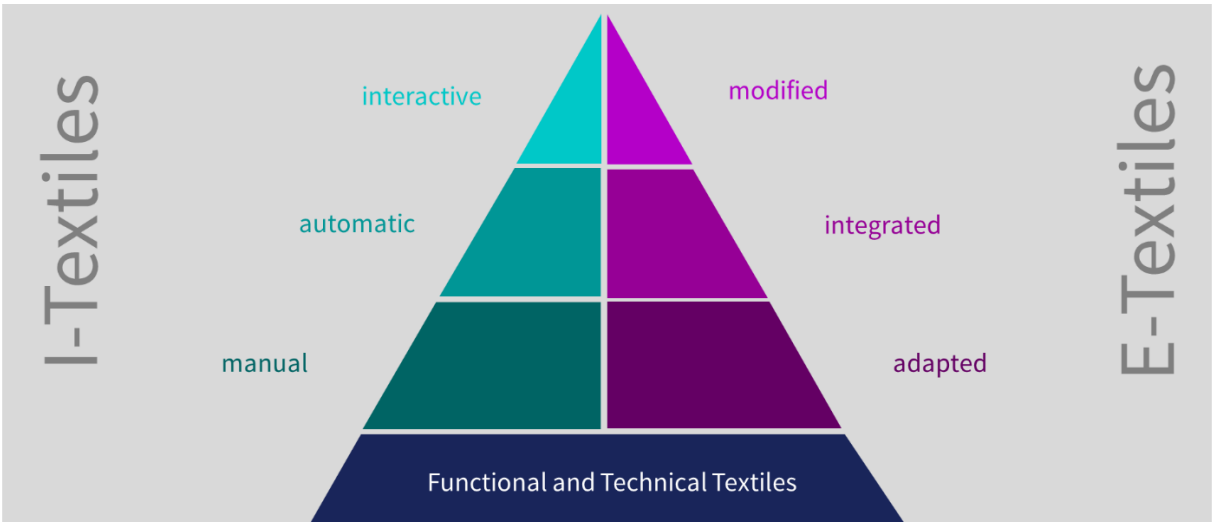

Figure 1: Smart Textiles definition [4]

The area of smart textiles is one of the core competences of future engineers, as this market also addresses the current megatrends of our society, such as digitalization, mobility, health, individualization or silver society [5]. However, there are only a few approaches in teaching this interdisciplinary field especially in the area of product development. Yet what specific competences are needed for product development and how can we foster them?

2. Models behind the didactical approaches

This project is situated in the field of constructivist learning theory, which assumes that knowledge cannot be transferred from a teacher to a learner, but that knowledge is individually constructed by each learner. In this process, prior knowledge is actively included and the learner must take responsibility for his or her own learning process. [6, p. 4f]

2.1. Construction Kits

The idea of stimulating users to think and learn via constructive W-questions is also pursued by so-called learning and construction kits. In contrast to the pure transmission of knowledge, complex topics are conveyed in a playful way in these kits. Among other things, motivation, creativity and cognitive abilities are positively influenced. When conducting a market research with regard to modular construction systems, in particular construction kits, which are also used in education in schools and universities, first and foremost well-known brands such as LEGO® Education or Fischertechnik and less well-known brands such as Tinkerbots or littleBits are encountered. What do all these systems have in common? They are construction kits that playfully allow the user to easily construct a variety of different objects using prefabricated elements. These kits use the approach of gamification of learning and promote the joy of learning through their design. At the same time they provide scientific or technical background knowledge. [7] [8] [9] [10] . A special kind of construction kits are so-called experimental kits. The pioneer in this field is the KOSMOS brand, which introduced its first experimental kit to the market in 1922. [11] In a study commissioned by LEGO Education, it was also found that "hands-on learning", i.e. working with the construction kits, significantly boosts learners' confidence in dealing with STEM topics and motivates them to tackle new subjects [12, p. 8 & 27]. All types of construction kits give their users the chance to experiment and to experience learning by doing and trial and error. This is according to Hüther and Quarch" [13, p. 86] the key factor for learning.

2.2. Gameful Design and Design Thinking

The biggest crowd puller in the world is a game, namely soccer. So why is a game so fascinating to us humans? It's often the combination of fun, social interaction, and a way to satisfy oneself and one's curiosity. Focusing on the user's needs leads to increased motivation. Playful elements should enrich the user experience and thus have a positive impact on the learning experience. In addition, the playful approach provides a way to deal with failure in a positive way. [14] But what is the difference between Gamification and Gameful Design? Gameful design, explains Fischer, can be understood as

a design strategy that can help create motivational and participatory learning environments at universities where students can build professional competencies individually or collaboratively. [15, p. 141] Nicholson recaps the principle of gameful design as follows: “Instead of using game design elements to increase external motivation through rewards, designers can use game design elements to increase internal motivation.” [16, p. 3]

The design thinking method is a human-centered problem-solving method in which problems are solved from end-user perspective and therefore the product development process is focused and most of the times accelerated in comparison with other methods. The entire development process of the new kit is therefore based on the clearly structured process and the high user orientation of design thinking and runs through the three phases of the problem and subsequently the solution space in a sequential manner. So, it can be summarized that both the design thinking method and gameful design are focused on the needs of the user.

3. Experiences - the difference between idea, prototype and reality

Whilst teaching smart textiles in the past the Wearic Smart Textiles Kit [17] was used to bring students in contact with this innovative new field of combining textiles and electronics. The Wearic Kit is intended to help people to discover the potential of Smart Textiles. Therefore, the set includes textile-based sensors for pressure and wetness, heating, push-buttons, sewable LEDs, and as core piece an expansion board with an Arduino nano-controller. The board and actors are easily connected by conductive snap fasteners. The following Figure 2 shows the WEARIC Smart Textiles Kit with attached sewed on LEDs, a pressure sensor and a push-button.

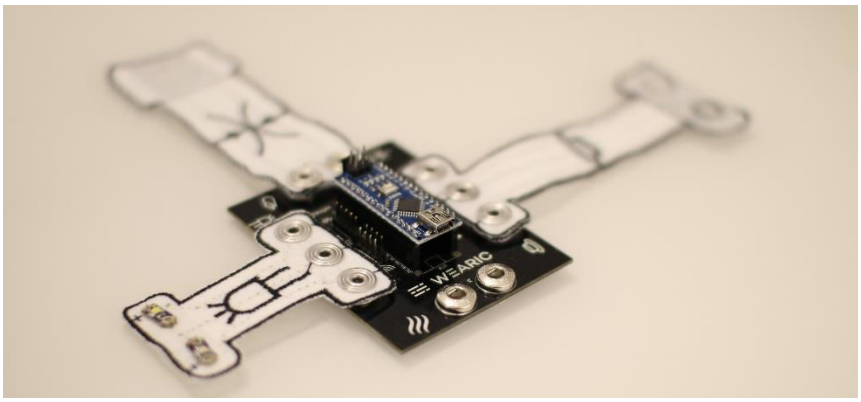

Figure 2: Wearic Smart Textiles Kit

Unfortunately, this kit has a number of disadvantages. The experiences in using the Wearic Kit were initially documented in the form of participant observation. Since the summer semester 2020, my observations have been completed by individual learning reflections of students and evaluated by an content analysis. Students rated working with this kit as a good entry point to the topic of smart textiles, but as soon as they wanted to realize their own products based on their new experiences they found the limits of the system. However, they were subsequently unable to transfer this knowledge to real-life problems such as product development. This goal or the fostering of the competence to act is the focus of the new development.

4. Plans – the new concept

The new concept is structured in the following phases, where these phases are already completed:

- Survey of the requirements for quality teaching in the field of product development for smart textiles incl. research in relation to other teaching programs and construction kits Implementation of a face-to-face course with the Wearic kit and the evaluation tool of participant observation
- Implementation of an online course with the Wearic kit and the evaluation tool of individual learning reflection
- Evaluation of the participant observations and learning reflections
- Development of the new kit (Flex-STEx) using methods from design thinking and considering gameful design aspects

The following steps are planned for the next year

- Piloting of the kit with a student working group
- Revision and duplication of the construction kit
- Implementation of the new kit in a face-to-face course as well as in a blended learning course in order to evaluate the integration into the teaching-learning arrangement.

4.1. The Flex-STEx Kit

The new kit is called the Flexible Smart Textiles Experience Kit, abbreviated Flex-STEx. The Flex-STEx should enable my students to make their own experiences with the construction kit and, after an initial introduction, also to develop their own ideas and implement them directly in prototypes. The construction of a product prototype should thus be facilitated and it should be possible to make mistakes when working with the construction kit in order to learn from these and avoid this when realizing the products. At the moment the new kit is being optimized - it is now mounted on a textile carrier and uses a Lilypad Arduino as controller and some components ae enlarging the Flex-STEx kit.

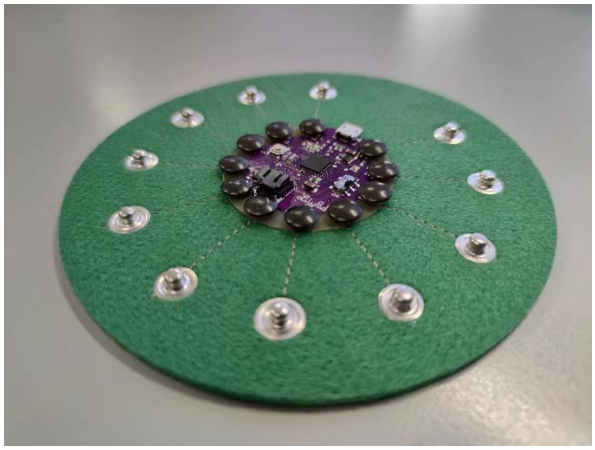

Figure 3: Flex-STEx Prototype

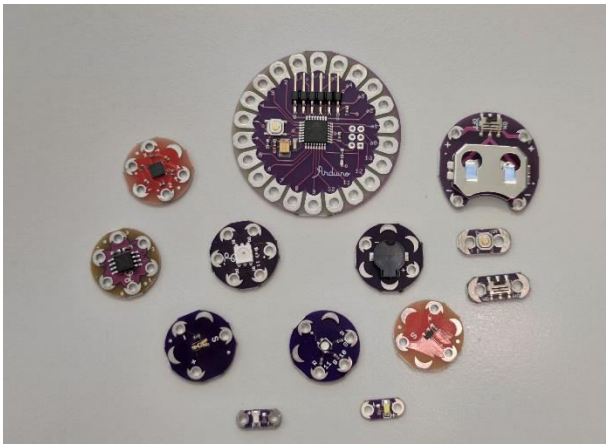

Figure 4: Lilypad Components to enlarge the Flex-STEx Kit

The next steps include on the one hand the optimization of the prototype and on the other hand the implementation in a student working group. If necessary, this phase will be followed by iterative improvement of the prototype before it is subsequently multiplied. The theoretical and practical exploration of the Flex-STEx learning kit will take place didactically and methodologically in parallel in a face-to-face course and in a blended learning course from the summer semester of 2021. These two methodological approaches are chosen in order to do equal attention to the existing teaching concept of the course as well as future planning with digitized teaching and to be able to compare the extent to which the kit is suitable for use in both teaching-learning arrangements.

5. Conclusion

In the field of smart textiles, interdisciplinary cooperation between specialists from the textile and clothing industry, as well as information technology and electrical engineering, is one of the most important key factors. Therefore, students have to be prepared to work in this way. The Flex-STEx application-oriented construction kit is intended to help to extend the frontiers of knowledge, stimulate creativity, and give students the ability to solve real-world problems. As added benefit it will accelerate the understanding of innovation and interdisciplinary challenges. A content-analytical evaluation of the data resulting from the work with two student groups each in presence and after the blended learning approach with the two construction kits will be carried out. Finally, by comparing these results, experiences and learning reflections, it can be determined whether the students have acquired professional competence through the innovations in the interdisciplinary field of smart textiles and are subsequently able to develop products independently or to optimize existing products in a targeted manner. Students will be ready to contribute to the development of new products and face the challenges of structural change along their working life if they are teached in the proposed concept.

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