Collection of requirements for teaching in the area of Smart Textiles

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Abstract. The textile and clothing industries are facing new challenges. Smart Textiles are a huge topic with a high market potential, however there are only few approaches in teaching this interdisciplinary field. Moreover, individuals are expected to continuously adapt to the new requirements by following the concept of lifelong learning. We propose a new concept that will integrate a smart textiles kit. This application-oriented construction kit 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 blended learning concept aims to prepare students to think interdisciplinary, broadly, deeply, and last but not least critically. Students will be ready to contribute to the development of new products and face the challenges of structural change along their working life.

1. Introduction

1.1. Lifelong learning for personal development and innovation

Globalization contributes to the fact that our societies are increasingly changing, especially in the world of education and work. Each individual is expected to continuously adapt to new circumstances. This only works through further education in the form of lifelong learning. Lifelong learning is understood as the personal willingness to actively participate in shaping the future. It helps each individual to be better prepared for the challenges of the job market and to face changed conditions in all areas of life. Furthermore, lifelong learning counts as one of the success factors for personal development and can decisively improve the quality of life. Lifelong learning is therefore becoming increasingly important and is regarded as a key issue in education policy in innovative regions. The state of Baden-Württemberg in Germany, where Albstadt-Sigmaringen University is located, is particularly worth mentioning here as the state occupied the top position in the European Union in the Innovation Index 2018 and continues to be the region with the highest innovative capacity [1-2].

1.2. The special position of the textile and clothing industries

The textile and clothing industries in particular, a traditional branch of industry that is constantly reinventing itself and is thus regarded as very innovative, must face the challenge of systematically developing new knowledge. Especially so in Baden-Württemberg, which is Germany's strongest textile location according to the Southwest Textile Industry Association [3]. In addition, many companies benefit from the increasing demand for high-tech materials that are subsequently processed in other industries, however this requires up-to-date know-how. With smart materials, today's companies are
already developing products that will, for example, bring even more safety, sustainability, energy efficiency, and comfort into everyday life in the future.

1.3. The interdisciplinary field of Smart Textiles

One of the most important fields of activity in the Textile and Clothing Sector will be Smart Textiles – products with extended functionalities. These will contribute to the next revolution in textile and clothing technology. Although the development of smart textiles has been going on for decades, everyday use is still in its infancy and there are numerous definitions with different emphasis. In the following, Smart Textiles are defined as textile products that interact with their environment and can thus actively support users. Often there is also the distinction between I-textiles, so-called intelligent textiles, and E-textiles, which are textiles with integrated electronic components. The following Figure 1 illustrates the different levels of Smart Textile products.

![Figure 1. Smart Textiles definition](image)

1.4. Market development of Smart Textiles and the need for new educational concepts.

The Smart Textiles segment is a fast-growing market with very good forecasts [4], picking up on current megatrends [5]. It is therefore of immense importance to prepare future technical specialists and management personnel competently for the challenges in this topic area. Overall, one of the biggest challenges for textile companies is the search for skilled employees, especially against the background of some companies wanting to relocate their production back to Europe [6]. In the field of Smart Textiles, interdisciplinary cooperation between specialists from the textile and clothing industry as well as computer science and electrical engineering is required, especially in research and development. Therefore, the transfer of competences must be interdisciplinary for a heterogenic target group, not only for current students, but also for participants from industry. Lifelong learning is a key competence in professional life and significantly contributes to a company’s success [7]. To cater for participants from industry, the learning contents will be communicated via a blended learning module that includes both e-learning and classroom teaching suitable for the heterogenic target group. In this way, a tip from the manual "New Media and Mobile Learning" will be realized and a successful introduction into a new topic area will be guaranteed [8]. In order to strengthen the application-oriented competence of participants, a learning kit for hands-on exercises is to be provided.
2. Models behind the didactical approaches

Our didactical approach will include the areas of research-based learning, problem-oriented learning in projects, learning group coaching, and gameful experience in learning and edutainment. The gameful experience or gameful design puts the user’s needs first while making education more engaging and fun. This is in contrast to gamification, which stands for the use of game thinking and game mechanics in non-game contexts to engage the users in solving problems, that motivation helps a successful learning process is also proven by the so-called ARCS model of motivational design. ARCS stands for Attention, Relevance, Confidence, and Satisfaction and has the goal to stimulate the curiosity to learn and to focus on the learners’ needs [9]. In the following, less known didactical approaches are shortly explained and the last paragraph deals with the fact, that the learning module will be designed for a blended learning approach.

2.1. Learning group coaching

Learning group coaching was developed in the engineering sciences at the Heilbronn University of Applied Sciences and takes place in 3 phases. The aim is to strengthen the ability for independent further education as well as cooperation and organisational competence. During self-learning in phase 1, the students independently work out a learning text created by the lecturer especially for this purpose and note down any uncertainties and questions. When learning in a team in phase 2, the students discuss the questions that were raised in the first phase with each other. Work on the remaining open questions happens in phase 3, the actual learning group coaching, together with the lecturer [10].

2.2. Gameful design

The biggest crowd puller in the world is a game, soccer. So why is a game so fascinating for us humans? It is often the combination of having fun, social interaction, and a possibility to satisfy yourself and your curiosity. The focus on the user’s needs leads to increased motivation. The implementation with consideration of playful approaches generates positive emotions, strengthens the social networks, communicates the usefulness, and makes success directly perceptible. According to Ehrenberg [11], the following characteristics are important for creating good games:

1. Player autonomy, competence and social inclusion
2. Balanced addressing of intrinsic and extrinsic motivation for user retention
3. Endogenous values in the game, i.e. something happens in the game that makes sense there.
4. the playful elements have to be connected sensibly with the purpose of application, if this is not the case, ludonarrative dissonance arises and with it a lack of meaningfulness and in turn a lack of motivation.

Playful elements should therefore enrich the user experience and thus have a positive effect on the learning experience. Moreover, a game offers the possibility to handle a failure in a positive way. [11]

2.3. Blended learning

As for Smart Textiles interdisciplinary teamwork is a key factor for success, it is mandatory that the educational module considers the social interaction between users with different backgrounds. Moreover, the module must be realised in a way that directly combines further education and training with the job requirements, a blended learning concept. Hands-on work on products and the direct interaction with other players is extremely important and cannot be provided by e-learning or distance learning alone. The concept of blended learning combines the advantages of classic presence learning scenarios with the advantages of online based learning. It describes a flexible teaching-learning setting that can deal with a very heterogenic target group comprising diverse teachers and learners. At the beginning of the course, a face-to-face event is useful so that the lecturers and participants get to know each other personally and the organizational process can be explained. The e-learning phase offers participants the advantage that any content can be learned and repeated individually at their own pace and at any location – therefore it is helpful if the content is multimedia and caters for different types of learners. [12]
3. Experience with different didactical approaches
Digitalisation and numerous changes in societies brought new challenges to lecturers and students. This sometimes leads to a fight for attention and a challenge to focus on learning. Some students have developed a so called “consumer” attitude and hope that they don’t have to engage in the learning process. This problem seems to be rooted in the traditional educational system that encourages extrinsic motivation. But how do we get intrinsically motivated students? Teaching students in the field of textile and clothing technology and management with different didactical approaches has led to a bunch of helpful experiences concerning this topic. We combined research-based learning with edutainment in the “Smart Textiles” lecture pursued with Master students. The combination of developing a new product in an interdisciplinary team and at the same time creating a crowdfunding campaign did lead to more fun, higher motivation and a more in-depth learning. Moreover, the students had to face the challenge of organizing themselves and handling the freedom they got for this task. In the lecture “production and processing of technical textiles” the students were given the task to develop their own learning game and writing a specification for this game in a group setting. This was a dual use task and the students afterwards were very proud of their achievements. We also observed this with another group of undergraduate students who got tasked with developing a cuddly toy instead of a standard part of clothing in a smaller scale. As soon as the motivation and the fun in a lecture are higher than normal the learning experience was rated better than in a classical setting.

4. The challenge of heterogenic groups and interdisciplinary work within the Smart Textiles educational module
Especially in the field of Smart Textiles, the challenge exists that specialists with different backgrounds have to work closely together in order to create innovative products that are fit for use. Moreover, there might be a mixture of novice students straight from school, and professionals doing further education, but having already experience e.g. with product development or project management. The module has to be generated in a way that different initial positions can be considered.

4.1. The difference between idea, prototype and reality
Whilst teaching smart textiles we used the WEARIC Smart Textiles Kit to bring different heterogenic groups of students in contact with this innovative new field of combining textiles and electronics. The WEARIC Kit is promoted as “the world’s first do-it-yourself package with textiles sensors” and 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. [13] 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.](image)

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. Due to its size and construction the kit cannot be integrated in a prototype and is not washable. In order to support students in developing new products and to realize a prototype the whole system must be miniaturized and become more flexible. This is the idea behind the application-oriented construction kit which is in development right now. An application-oriented construction kit gives users
the chance to experiment and to experience learning by doing and trial and error. This is the key factor for learning according to Hüther and Quarch in “Save the game: Because life is more than just functioning” [14]. While this will be a big step towards enabling innovations this kit will at the moment not be suitable for the industrial manufacturing of the products. Following serial industrial production this will then be the next step which could be realized either in a virtual manner or directly with a specialised company.

4.2. Realisation
The bespoke educational module with the new concept will be developed within the framework of the SEKT research project. The SEKT project systematically investigates the integration and IT security of electronic communication systems in smart textile products and develops practical security concepts as well as smart demonstrators. The main objectives of the research project are the scientific investigation of the area of IT security of smart textile products, the transfer of existing security concepts as well as the development of secure and innovative prototypes. In the last module, ”Knowledge and Technology Transfer”, the newly collected knowledge is prepared in an application-oriented way using guidelines and a teaching module in blended learning format. This allows direct incorporation into the development and improvement of new Smart Textiles. At the same time, the publication of guidelines can raise awareness the general public. Whilst self-learning phases are supported by didactically prepared study materials available to participants, a practical part utilizes a learning kit for exercises aimed at strengthening the competence of participants. The application-oriented construction kit together with the blended learning module should help to enable cross innovations instead of linear innovations. In order to develop the new module in line with the target group regular surveys and revisions are planned. Finally we will evaluate if the new concept met the outlined specific requirements for this important and innovative new field and helped to successfully prepare students for the upcoming challenges.

5. Conclusions
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, specifically in the area of research and development. This requires that knowledge be prepared in a suitable way for a heterogenic and interdisciplinary target group. The focus of this work is therefore the development of an innovative educational concept for the teaching of Smart Textiles competences via a blended learning module. This learning module is suitable for the bespoke target groups because it uses appropriate didactic concepts and is interlinked with an application-oriented construction kit for smart textiles applications.

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