

HACKTEX VIRTUAL TRAINING MATERIALS FOR SMART TEXTILES

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Abstract. *Smart textiles represent a domain in full development for the textile industry, with a huge potential of growing in the near future and attractive for young specialists due to better paid jobs. This perspective need for specialists with knowledge and skills tailored to the needs of the sector has to be met by the universities. The existing curricula at B.Sc. and M.Sc. levels of many universities do not cover or cover insufficiently these topics. The Erasmus + project HACKTEX prepared a set of virtual training materials on smart textiles and another one on entrepreneurship focusing on smart textiles that will ensure not only technical knowledge, but also will support the idea of transferring the acquired knowledge toward the market. They are addressed not only to textile students, but also to students in connected domains, related to the production and use of smart textiles. The virtual training materials on smart textiles discuss significant issues related to raw materials, technological processing, testing and standardization in the domain and sustainability. The materials are designed to be user friendly and prepared in video format and as reading materials, helping students and specialists wanting to learn more about the field understanding what is required to develop a functional smart textile product that can answer the needs of the customers. The materials for entrepreneurship are designed to be a map on what to consider when developing your own business with smart textiles, how to choose the best suited business model and what steps are required. A database with information on companies already on the market completes the training materials. A guide connecting all information is also provided.*

Keywords: *multidisciplinary engineering, lessons, video format, entrepreneurship.*

1. INTRODUCTION

The HACKTEX project is an ERASMUS+ project that aims to develop innovative tools for the digital era and facilitate distance learning for the complex applications characterizing smart textiles. The consortium is made up of universities, NGOs dedicated to education and a textile cluster from 6 EU countries.

The complex context of the HACKTEX project is defined by general economic conditions, as well as the changes brought by the SARS-COV-2 pandemic, that affected the textiles and clothing industry as well as higher education system. Apart from the challenges due to the competition from the emerging markets, the sector needs to be aligned with the new European industrial strategy and its targets – climate neutrality and digital leadership. The European Union requires reassessing its position on critical factors affecting its competitiveness, such as uniqueness of its products, workforce with highly specialized and transversal skills and innovation, in order to give the competitive advantages needed in the current global economy.

Advanced/smart/functionalized textile materials [1, 2, 3] are an emerging sector within the textile industry, driven by transdisciplinary innovation in several end-markets, focusing on the technical aspects and controlled functionality of textile materials rather than on the aesthetics, that answer these requirements. For its development, the sector needs to stimulate applied research and industrial exploitation of innovation. On the other hand, universities must support the development of the smart textiles sector, anticipating and ensuring the cross sectoral knowledge and specialized skills needed by the companies and fostering innovation in the field. These skills must respond to the transition toward Industry 4.0 principles, especially digitization and add the entrepreneurial dimension that is essential in bringing research to the industry and unlock the innovation potential of advanced textiles [4, 5]. While smart textiles became part of the curricula in the last decade, the domain has still untapped opportunities at manufacturing level as both drivers of textile digitalization and development of new niche markets. Professionals that will implement those

transformations require a highly qualified education to become innovative game-changers for the sector supported by strong digital tools and virtual learning experience. Also, the academic activities were strongly affected by the pandemics, students that were usually hands-on learners both in textile engineering and textile design had to transfer to online theoretical and practical activities. The current limitations and social distancing require new tools to address the efficiency of engineering and entrepreneurial training, especially when considering the advantages demonstrated by online training that go beyond this situation: development of digital skills, flexibility in teaching and learning, remote access to knowledge, possibilities for direct contact of teachers and students with economic agents without additional costs and fostering durable innovative partnerships that can evolve into applied research projects, etc.

In this context, the HACKTEX consortium created a virtual course (MOOC) on smart textiles and a virtual guide on entrepreneurship focusing on smart textiles. These virtual training materials are designed to help students and young specialists from the textile sector, as well as other sectors connected to textiles through dedicated applications, to obtain knowledge related to smart textiles and to understand the requirements to develop an efficient and successful business model, so that the ideas developed through research can make the transition towards the market.

This paper presents and discusses the virtual training materials developed by the consortium, emphasising the purpose of the knowledge content for the learning units and lessons and the advantages of virtual training in the context of smart textiles.

2. VIRTUAL TRAINING MATERIALS (MOOC) FOR SMART TEXTILES

The content of the virtual training materials is organised in 5 learning units and is designed to cover all major issues related to smart textiles – raw materials, specific technologies, characterisation of smart textile materials and products. Sustainability is also considered and discussed, as its importance will increase over the next decade and the continuous innovation in the field will need to be adapted to sustainability principles [6]. An introduction in the field of smart textiles is provided in the beginning, as to help people that have little or no previous knowledge by explaining the fundamentals of smart textiles.

The learning units are divided into 3 lessons each, discussing the main aspects of the respective topic. The lessons are in a user friendly and accessible video format. For those who want to go further on a certain topic, reading materials are provided, with the information discussed in the video and with supplementary knowledge and recommendations for further reading. The structure of the training materials, learning units and lessons is illustrated in Figure 1.

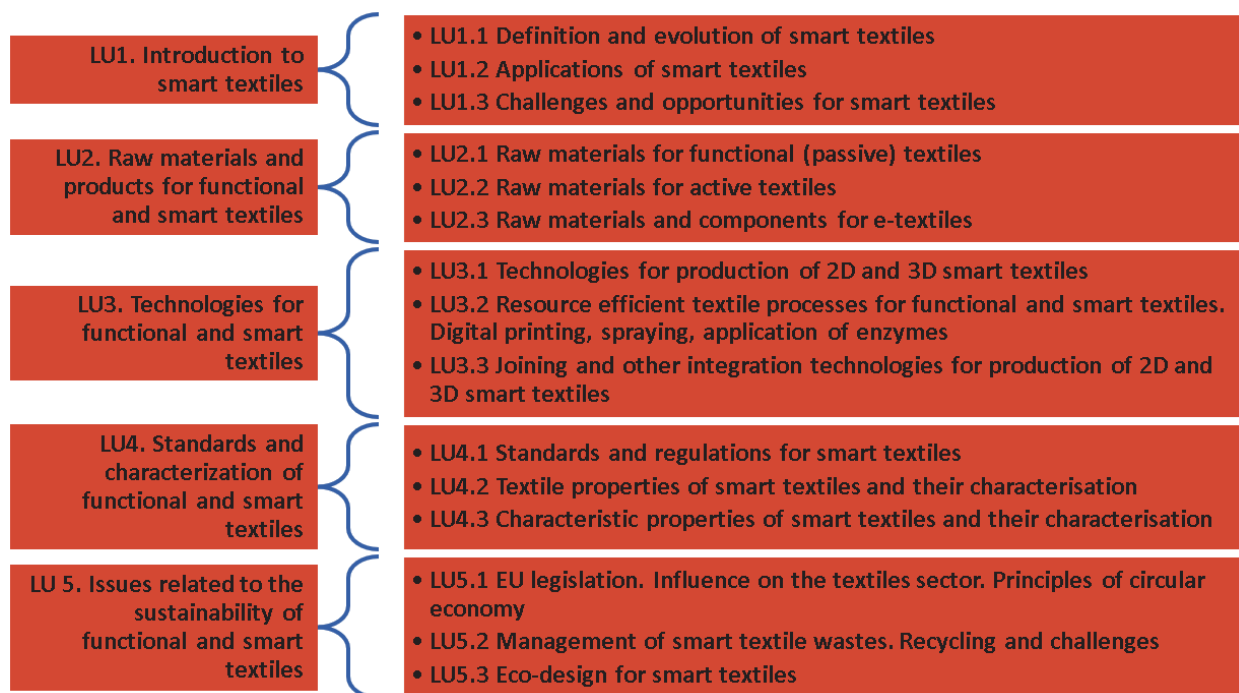


Figure 1. Structure of the virtual training materials on smart textiles

Each lesson is tailored to have specific outcomes related to smart textiles, as detailed in Table 1. These outcomes help the person taking the courses to understand fundamental knowledge regarding the domain and to use it to identify, select or use this information to develop smart textiles.

Table 1
Learning outcomes for the lessons of the learning units

Topics of the lessons	Learning outcomes
LU1 Introduction to smart textiles	
LU1.1 Definition and evolution of smart textiles	<ul style="list-style-type: none"> ● Recognize and define the term smart textiles. ● Understand the subgroups and exhibit specific examples ● Identify important milestones
LU1.2 Applications of smart textiles	<ul style="list-style-type: none"> ● Classify the main fields of applications of smart textiles ● Explain the scientific issues and propose solutions regarding various prototypes ● Developing products using the concept of smart textiles
LU1.3 Challenges and opportunities for smart textiles	<ul style="list-style-type: none"> ● Recognize and outline the challenges facing smart textiles ● Breakdown the key challenges of smart textiles in terms of user experience, technology and critical factors. ● Identify the opportunities of smart textiles in different application areas.
LU2 Raw materials and components for functional and smart textiles	
LU2.1 Raw materials for functional (passive) textiles	<ul style="list-style-type: none"> ● Recognize the main raw materials to develop functional (passive) textiles ● Classify the main raw materials by their smart functionalities ● Identify the type of raw material required to impart certain functionalities to textiles
LU2.2 Raw materials for active textiles	<ul style="list-style-type: none"> ● Recognize the main raw materials to develop active smart textiles ● Classify the raw materials by their smart functionalities ● Identify the type of raw material required to impart certain smart functionalities to textiles
LU2.3 Raw materials and components for e-textiles	<ul style="list-style-type: none"> ● Knowledge about specific fibres and their use in smart textile systems ● Understand the functions of various technology components and their applications in textiles ● Be familiar with a wearable technology system in everyday life
LU3 Technologies for functional and smart textiles	
LU3.1 Technologies for production of 2D and 3D smart textiles	<ul style="list-style-type: none"> ● Acquire knowledge on the latest developments in textile technology suitable for the production of smart textiles ● Understand and compare the possibilities of each technology and select the one that can produce textiles with the required specifics ● Develop skills in designing textile materials/products with smart behaviour
LU3.2 Resource efficient textile processes for functional and smart textiles. Digital printing, spraying, application of enzymes	<ul style="list-style-type: none"> ● Explain the existing problems and challenges in production of functional and smart textiles ● Classify different digital printing technologies ● Explain the printing mechanisms as well as spray technology ● Recognize the differences of conventional production methods with the resource-efficient ones. ● Classify the main fields of application of different resource-efficient technologies in textile research and industry
LU3.3 Joining and other integration technologies for production of 2D and 3D smart textiles	<ul style="list-style-type: none"> ● Recognize the different integration techniques for design, development, and manufacturing of smart textiles. ● Differentiate among the principles as well as pros and cons of different integration techniques. ● Identify the best practices to produce smart textiles.

LU4 Standards and characterization of functional and smart textiles	
LU4.1 Standards and regulations for smart textiles	<ul style="list-style-type: none"> ● Understand the importance of standards and their applicability in smart textiles ● Become familiarised with the organisations creating standards for smart textiles (EU and in the world) ● Understand what is required to make a standardised evaluation of a smart textile product
LU4.2 Textile properties of smart textiles and their characterisation	<ul style="list-style-type: none"> ● Match textile properties with requirements for a determined smart application ● Differentiate the appropriate testing methods for the characterisation of textile properties ● Judge the importance of textile properties in smart applications
LU4.3 Characteristic properties of smart textiles and their characterisation	<ul style="list-style-type: none"> ● Select the appropriate standard/s in connection to the type of application ● Understand the specificity of equipment and testing method/s required for testing smart textiles ● Develop knowledge related to the qualitative evaluation of smart textiles ● Develop skills for testing and evaluating smart textiles ● Develop skills to design and conduct an experimental program for the evaluation of smart textiles
LU5 Issues related to the sustainability of functional and smart textiles	
LU5.1 EU legislation. Influence on the textiles sector. Principles of circular economy	<ul style="list-style-type: none"> ● Understand the reason of evolution of the latest legislation establishment in EU in textiles industry ● Understand the term circular economy and its importance in textiles industry ● Become familiar with related legislations
LU5.2 Management of smart textiles wastes. Recycling and challenges	<ul style="list-style-type: none"> ● Knowledge about the cycle of life of an e-textile, the types of produced wastes and their recycling methods. ● Realise the importance of a sustainable management of the produced wastes during the life of a smart textile. ● Understand what sustainable waste management is and confront the challenges of the procedure.
LU5.3 Eco-design for smart textiles	<ul style="list-style-type: none"> ● Identify potential sustainability weaknesses during the design phase of smart textiles ● Examine potential solutions to the potential sustainability weaknesses ● Use eco-design strategies for the development of smart textiles ● Assess the sustainability of smart textile products

3. VIRTUAL GUIDE FOR ENTREPRENEURSHIP FOCUSING ON SMART TEXTILES

The virtual guide for entrepreneurship is a useful tool to help students and young specialists to understand what is required to develop a successful business model and where to start from. The guide will offer students and other external users helpful tips and industrial challenges that need to be faced in the smart textiles sector.

The guide is based on 4 units developed by the consortium, lectures organised on the topics presented in Figure 2. As for the virtual training materials, the information is presented in video format, with reading materials attached, so that the users can access the written version, with proposals for further study on each subject. All videos make direct reference to smart textiles and how the specificities of the sector influence the decision-making process.

In order to give real-life examples of EU companies that develop smart textiles, supporting the knowledge presented in the 4 units, a database was created. It offers practical solutions for how business models are created for different types of companies.

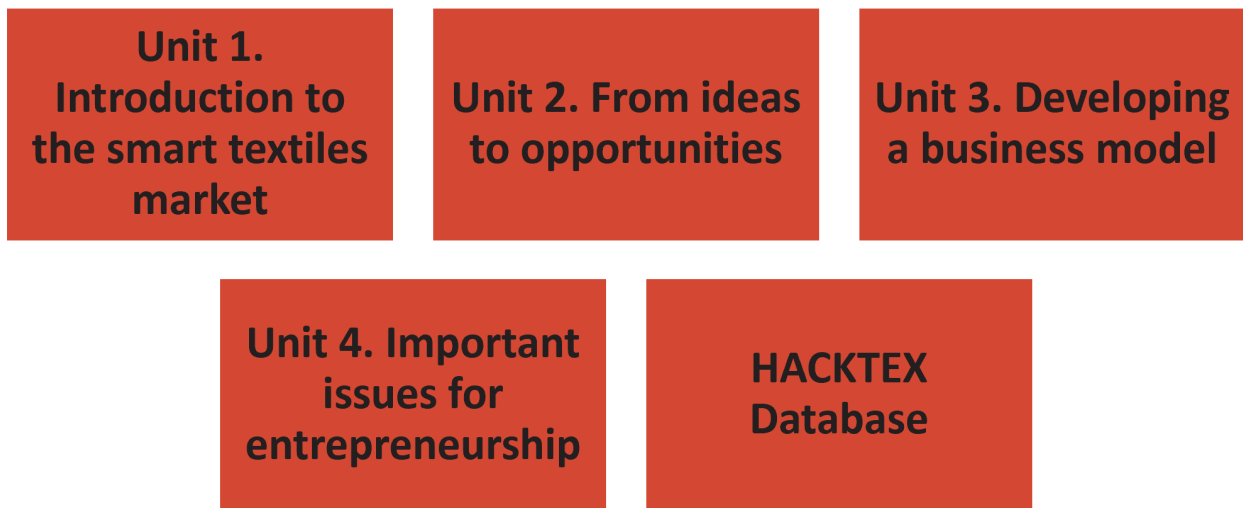


Figure 2. Topics for the knowledge related to the virtual guide on entrepreneurship

Unit 1. Introduction to the smart textiles market

This unit provides an overview of the situation and main trends and players in the smart textiles market, discussing specific supply chains, relevant manufacturing companies, and industries using smart textiles.

Unit 2. From ideas to opportunities

There is a lot of research done in the field of smart textiles, but few ideas make the transition toward the market. In this context, the unit will cover topics referring to various tools to understand and recognize unmet needs and market opportunities, methods and techniques used to develop and validate business ideas and how to recognise future market developments, opportunities and challenges.

Unit 3. Developing a business model

The users learn how to better understand the needs and behaviour of potential customers and create a value proposition for these customers. The unit also covers aspects regarding the activities and resources needed in order to develop the business and the marketing most suitable to be used in order to commercialise the company's products.

Unit 4. Important issues for entrepreneurship

This unit covers other aspects important for the success of an entrepreneurial endeavour, such as the process of designing a business pitch in order to find potential funding, tools to ensure business sustainability and how to choose the most suitable exit strategy. It discusses the concept of business strategy, the phases of a project, benefits of rules and responsibilities in a project, as well as concepts related to project management through the concept of games, market positioning in two steps and the BCG matrix approach.

3. CONCLUSIONS

The ERASMUS+ project HACKTEX aims to create efficient education tools to respond to the needs of the smart textile sector in terms of preparing specialists that have the anticipated skills to innovate and develop such products. Furthermore, currently, the results of research regarding smart textiles do not transition towards the market. Apart from technical consideration, one of the reasons for the existing situation is the lack of entrepreneurial education applied to the needs and requirements of the sector.

The paper presents the virtual training materials created by the HACKTEX consortium for smart textiles and for entrepreneurship in the field. The content of these materials is presented and discussed, explaining the topic selection and the expected outcomes for each lesson (for the MOOC).

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