

## NEED ANALYSIS OF THE CURRENT SITUATION OF HIGHER EDUCATION FOR THE SMART TEXTILES SECTOR

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**Abstract.** *Smart and functionalised textiles represent a large sector of the textile industry that has a dynamic development and shows great potential for current and future niche markets. The sector relies heavily on innovation and technical creativity and the constant need for new materials and processes is supported by the multidisciplinary approach to solving the requirements of the applications. Another important aspect of the sector refers to the markets and the transition from research to commercially viable products (TRL9). These two issues concerning product R&D and markets are creating the need to ensure that the future specialists have the knowledge and technical and transversal skills that will answer the changes the sector faces. In this context, the HACKTEX - Innovative smart textiles & entrepreneurship project will develop virtual training materials for smart and functional textiles, as well as training materials dedicated to entrepreneurship in the sector. To develop these materials, a need analysis was carried out in the 6 countries of the consortium, where the current state of engineering education dedicated to smart textiles is evaluated. The field survey targeted three main issues: assessment of the current needs of the sector (academic, manufacturing), assessment on how to capitalize on existing initiatives and identification of weak point at Universities in training for smart textiles. Respondents were divided in three target groups: specialists from the industry, specialists from the universities and research institutes, and students. The answers were processed and the results are presented in the paper in a comparative manner, with an emphasis on knowledge and skills specific to smart textiles perceived as important by the respondents.*

**Keywords:** *Field research; target groups; present situation, existing initiatives; weak points.*

### 1. INTRODUCTION

The textile sector experiments a period of significant upheaval due to the pandemics, economic crisis, current political situation, as well as the need to transit from fast fashion toward more sustainable business models. In this context, smart textiles represent a viable option for future development with a large range of high-tech applications and high-added value products. Smart textiles can be defined as textiles that are able to sense and respond to changes in their environment [1]. Based on their response, smart textiles are classified as passive, active and ultra-smart [2, 3, 4]. These materials/products are used in medicine and healthcare, sports and leisure, personal protective equipment, military, transportation, etc.

Different reports forecast significant growth for the smart textiles market, at a CAGR varying between 23% to 35% in the first half of this decade [5, 6], justifying the interest in preparing young specialists with knowledge, skills and competences meeting the future needs of the sector. The 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.

The HACKTEX - Innovative smart textiles & entrepreneurship is an ERASMUS project that focuses on both the needs for digital education and the identified gaps and mismatches related to skills and competences that are needed to opens up new opportunities enabled by smart textiles research into advanced textiles' manufacturing.

The HACKTEX project will develop innovative tools for the digital age for engineering training that in turn will facilitate the necessary demands for skills enhancement targeted to higher education in relation to innovation in order to obtain its objectives:

- To create innovation in the virtual teaching environment in the field of smart textile.
- To support engineering students to acquire digital and transdisciplinary innovation skills in smart textiles.
- To create virtual courses (MOOC) on smart textiles.
- To foster student cooperation and multidisciplinary approach in hands-on projects.
- To provide knowledge, skills and competences for smart textiles using virtual learning methodologies and tools.
- To promote the application of good practices for the enhancement of innovative skills.
- To strengthen collaboration between HEIs and companies from the advanced textile sector.

In order to design the virtual training materials on smart textiles and entrepreneurship related to smart textiles, an analysis of the sector's needs was carried out with the goal of identifying the current state of the higher education in this field. The analysis is based on a field survey conducted in the 6 partner countries (Greece, Italy, Romania, Slovenia, Spain and Sweden).

## 2. EXPERIMENTAL PART

The need analysis for education in smart textiles was addressed to the following target groups:

- Experts/managers from companies manufacturing smart textiles or intending to transition to such applications
- Relevant experts involved in training and research (universities/research institutes)
- Students from textile engineering specializations

The questionnaires were particularized according to each target group and were structured into three main sections:

1. Current needs of the smart textiles sector in terms of manufacturing and education - key factors in developing smart textile prototypes/products; perceived main problems/challenges the sector faces in relation to developing / producing smart textiles; issues to improve the training on smart textiles; how should the needs of the smart textiles' companies be addressed by universities/research centres.
2. Existing initiatives in the smart textiles sector - level of participation in and type of initiatives such as networks, associations, clusters, projects, programs, etc.; purposes of these initiatives; funding; partners.
3. Weak points in engineering training for the field of smart textiles - issues affecting the training in smart textiles; perceived relevance of knowledge related to smart textiles; perceived relevance of skills and competences related to smart textiles; weak points in research cooperation between companies and universities; need for further training in smart textiles; intent to access the HACKTEX virtual training and preferred topics.

The questionnaire for students contained less questions, focusing mostly on the perceived needs for training, knowledge and skills required for the development of the smart textiles sector.

The questionnaires used mostly questions with multiple answers and with the ranking of influence/importance factors from 1 (no influence/importance) to 5 (very high influence/importance). The significance of these factors was calculated according to equation 1, using a weighted average value WA, based on the sum of the number of answers provided for each mark ( $n_i$ ) multiplied by the value of the mark (i) and then divided by the total number of answers received.

$$WA = \frac{\sum_{i=1}^5 n_i \times i}{\sum_{i=1}^5 n_i} \quad (1)$$

The questionnaires were available online and the results for each target group were processed and analysed. A comparison analysis was also carried out to show the general opinion of the respondents, indicating the

most relevant aspects of training for smart textiles, as well as the differences between respondent categories. All data and the conclusions drawn from their processing constitute a deliverable of the HACKTEX project.

### **3. RESULTS AND DISCUSSION**

As a general observation, all respondents ranked the factors of influence/importance nominated in the questionnaires above a 3.0 average, showing that they perceive these factors as significant.

The results are discussed and compared to establish a hierarchy and identify the most important ones, to be emphasised in the training materials. In addition, respondents from companies tend to evaluate consistently with slightly lower marks than the ones from the academic environment.

#### **3.1. Current needs of the smart textiles sector in terms of manufacturing and education**

Based on the evaluation of academics and companies, a set of 4 factors are considered to have a considerable influence on the development of smart textile prototypes/products: developing new raw materials/products; HR with relevant skills; understanding market requirements; standardization.

Developing new technologies, adequate education/training programmes for smart textiles engineers and business models adapted to smart textiles are seen as significant, but less important than the first four. Adequate education/training programmes for smart textiles engineers is perceived as the most important by the academics and the less important by the companies.

The main problems/challenges in developing smart textiles are lack of funding and lack of proper technology (for the companies), difficulties in acquiring it. The lack of human resources is also perceived as very important by the companies.

Most significant thing that needs to be ensured in order to improve training in smart textiles is to create stronger links between companies and universities. Other needs with a common evaluated level of importance are co-creation of curricula for smart textiles to reflect the sector's needs, actions to attract more young people to study smart textiles and creation of more specializations/ programs related to smart textiles.

All respondents consider that these needs have to be addressed mainly through education and research projects.

#### **3.2. Existing initiatives in the smart textiles sector**

Both group of respondents - companies and universities - are interested in participating in different initiatives, most common being research projects and partnerships with the industry for companies from the sector and educational initiatives and research projects for the universities. This emphasizes the need to increase partnerships between industry and universities/research institutes.

Partnerships are motivated by the need to develop new products/technologies and to develop knowledge. For companies, the development of new products/technologies is more important, while for universities development of knowledge is their main scope.

#### **3.3. Weak points in engineering training for the field of smart textiles**

The main issues affecting training in smart textiles, as presented in Figure 1, are the need for more skills related to the R&D of smart textiles and the need for more courses on smart textiles.

More internships for students, including for graduation theses in companies manufacturing smart textiles are considered by both types of respondents as of slightly less importance for training in smart textiles, suggesting that a network for internships is already in place and functioning efficiently.

The two groups of respondents view differently the involvement of companies in co-creation of curricula for smart textiles specializations, ranked first by the respondents from companies and fifth by the academics.

A similar position is identified for the content of lectures on smart textiles - companies consider it up to date, while universities perceive it as not reflecting the latest knowledge.

### Issues affecting training in smart textiles

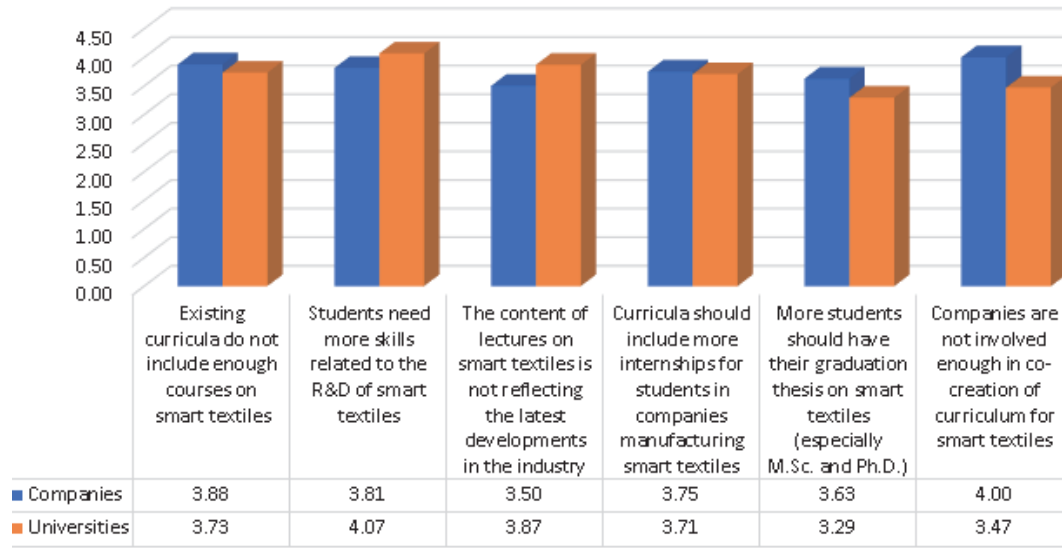


Figure 1. Graphical comparison of ranking of issues affecting training in smart textiles

In relation to the knowledge specific to smart textiles, all topics proposed by the survey were considered to be of considerable relevance to the training process by all respondents, as illustrated by Figure 2.

### Knowledge related to smart textiles

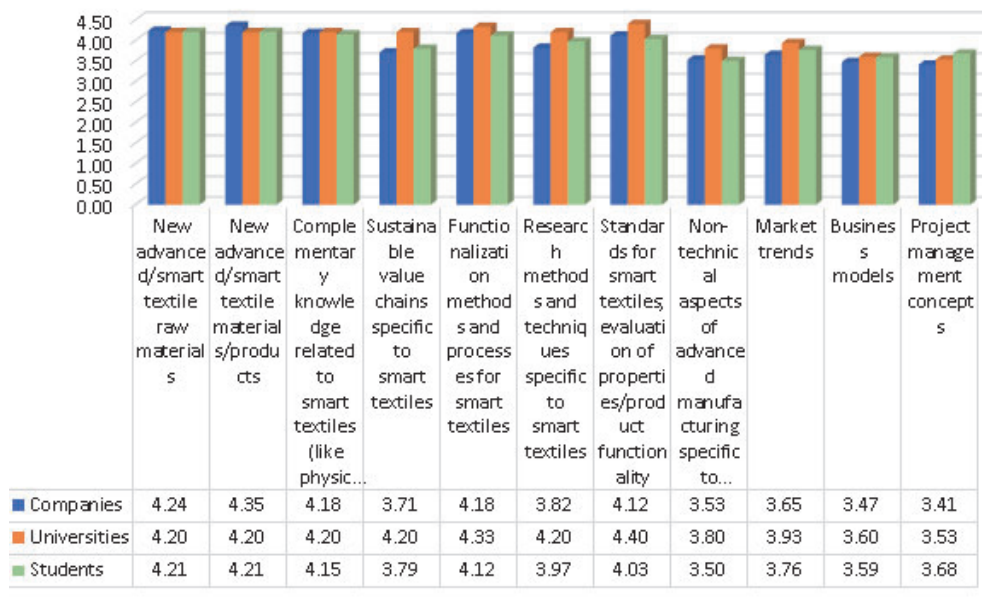


Figure 2. Graphical comparison of ranking of knowledge on smart textiles

A comparison of the ranking resulted for each group of respondents' shows an interesting conclusion: respondents from companies and students have the same position toward relevant knowledge topics for smart textiles, with almost identical ranking. The 5 most relevant topics according to respondents from companies and students are:

1. new advanced smart materials/products,
2. new advanced smart textiles - raw materials,
3. complementary knowledge related to smart textiles (like physics, chemistry, electronics),
4. functionalization methods and processes for smart textiles,
5. standards for smart textiles; evaluation of properties/product functionality.

The lower ranking regarding knowledge on sustainability by respondents from companies and students suggests that this very important issue is not yet fully considered by the sector and that the current content

of lectures does not facilitate students from all the countries involved in this survey to have a better understanding on the subject.

Knowledge related to non-technical aspects of smart textiles (market, business models, project management and non-technical aspects of manufacturing smart textiles) is ranked lower than technical knowledge, illustrating that the sector is built on continuous research and innovation and technical issues take precedence for the moment. It could also reflect the niche character of the sector. Still, non-technical knowledge applied to the specificities of smart textiles is extremely important for the commercial stage, when innovative products are brought to TRL 8 or 9. Due to the small intervals of variation for the weighted average marks of all topics of knowledge showing considerable relevance, it can be concluded that the ranking of topics is coherent and can be used as a base for the training materials to be developed in the HACKTEX project.

The weighted averages of skills and competencies considered to be of importance for training in smart textiles are presented Table 3 together with the ranking of each topic resulted for companies (1), experts from universities (2) and students (3).

**Table 3.**

Skills and competencies important to training in smart textiles

Skills and competencies	Rank			Level of importance		
	1	2	3	1	2	3
Capacity to generate new ideas (creativity) for the development of smart textiles	1	7	3	4.56	4.27	4.26
Use and adapt textile technologies to produce smart textiles	2	5	1	4.44	4.40	4.38
Pro-active understanding of customers' and market needs	3	15	8	4.38	3.73	4.03
Work in a team	4	3	9	4.35	4.53	4.03
Use and adapt textile knowledge related to fibres/yarns/ materials structure to create smart fibres/yarns/materials	5	2	2	4.33	4.53	4.35
Understand and use the requirements specific to the application domain – multidisciplinary approach to the design of smart textiles	6	1	11	4.31	4.80	3.91
Change-orientated approach to product development	6	10	7	4.31	4.00	4.06
Identify, pose and resolve R&D problems	8	6	6	4.25	4.33	4.09
Identification of market development and trends for the smart textiles sector	9	11	13	4.19	3.93	3.88
Abstract thinking	10	16	12	4.18	3.73	3.91
Plan, design and execute research projects / prototypes referring to smart textiles	11	4	5	4.06	4.47	4.12
Advanced digital skills; ability to use specific software for design and production of smart textiles (CAD/CAM systems)	12	9	4	3.94	4.13	4.21
Search for, process and analyse information from different sources	13	8	10	3.82	4.27	3.97
Conduct risk assessment analysis in R&D projects for smart textiles	14	13	14	3.75	3.87	3.88
Plan and manage time in research activities	15	14	15	3.65	3.80	3.79
Ability to manage and optimize production processes	16	12	16	3.56	3.93	3.79
Recognition and implementation of opportunities for business growth	17	17	17	3.56	3.73	3.35

In this case, the ranking of each group was non-homogeneous, due to different backgrounds, activities and interests. Such a dispersion of evaluation makes the analysis difficult.

Therefore, in order to identify the most relevant skills for the training in smart textiles, the criterium used is to select skills for which averages of each group of respondents go over 4.0, defined as considerable to very high relevance. Based on this criterium, the following skills and competencies can be considered most relevant:

a) Technical skills

- Use and adapt textile knowledge related to fibres/yarns/materials structure to create smart fibres/yarns/materials

- Use and adapt textile technologies to produce smart textiles
- Understand and use the requirements specific to the application domain – multidisciplinary approach to the design of smart textiles
- Change-orientated approach to product development
- Advanced digital skills; ability to use specific software for design and production of smart textiles (CAD/CAM systems) (the value of the weighted average for respondents from companies is very close to 4.0)

b) Skills related to projects and transversal skills

- Work in a team
- Plan, design and execute research projects / prototypes referring to smart textiles
- Identify, pose and resolve R&D problems
- Capacity to generate new ideas (creativity) for the development of smart textiles

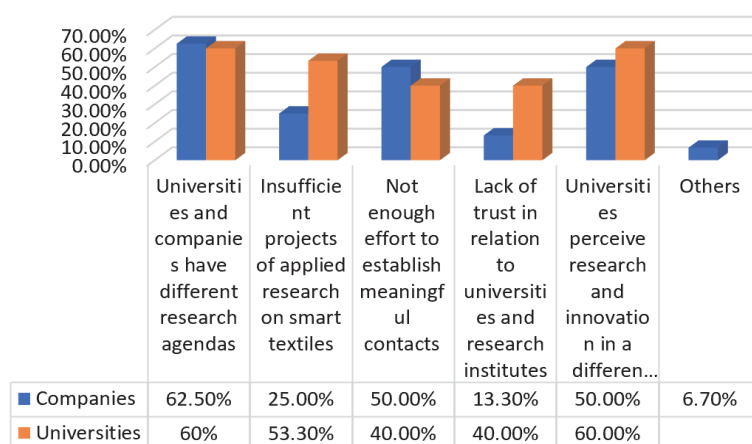
c) Skills related to market

- Pro-active understanding of customers and market needs

Nonetheless, it has to be emphasised that all skills and competencies included in the list presented in Table 3 have received marks that rate them as relevant and could be considered when developing training materials. The differences and the selection of relevant skills are maintained when we compare only the ranking of experts from companies and from experts from universities.

The experts from companies and from universities consider that different research agendas and different perception of research and innovation are the weakest points affecting the cooperation between companies and universities for research and innovation. The graphic from Figure 3 also shows that not enough effort for efficient networking is another thing with negative consequences on research partnerships. This last issue was mentioned also separately by a respondent from a company.

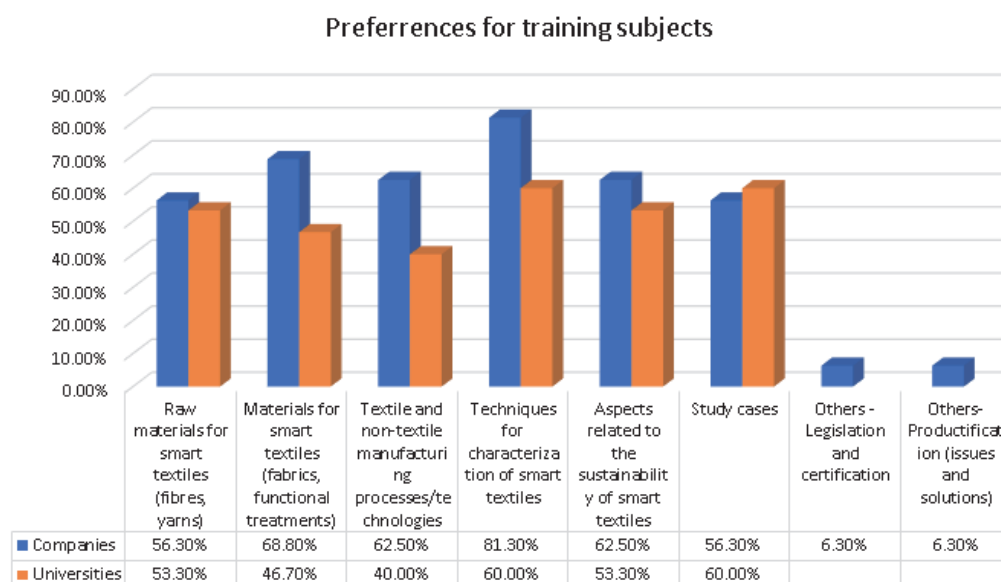
### Weak point in research cooperation



**Figure 3.** Graphical comparison for the weak points in research cooperation as perceived by companies and universities

An overwhelming majority of respondents (over 80% for experts from companies and students and 100% for experts from universities) indicated that they are interested in further training in smart textiles, be it for staff (from companies) or for students. The same situation was recorded for a possible participation to HACKTEX training.

In terms of preferred subjects for smart textiles, the interest of companies is a good indicator for the appetite of the sector for knowledge in the field. Techniques of characterization is the most selected topic. A special mention for the need for non-technical subjects, like legislation and certification, topics of high interest in the industry.



**Figure 4.** Preferred subjects for training materials for smart textiles

The last question of the section was addressed to students, concerning the form in which the HACKTEX training should be delivered. Three options were proposed – lectures, video materials and forums. Video materials were preferred by over 80% of the respondents, emphasising that the need to develop virtual training materials is in agreement with the users.

#### 4. CONCLUSIONS

The purpose of the survey conducted within the frame of the HACKTEX project was to determine the needs of the sector of smart textiles in terms of training and to anticipate the relevant future skills and competencies for the sector. The results of the survey represent the basis for all other HACKTEX project' outputs in terms of methodology and syllabus.

Following the stages defined in the guidelines, questionnaires were created for each target group and collected by the partners. The results obtained from processing the responses given by each target group allowed the HACKTEX consortium to create a clear picture of the current needs of the smart textiles sector in terms of manufacturing and education, the involvement in existing initiatives in the smart textiles sector and to draw relevant conclusions on the weak points in engineering training for the field of smart textiles

The need analysis carried out by the members of the HACKTEX consortium is relevant for educational purposes and can be a base for other stakeholders in the sector to shape their educational strategies or the development of human resources in the sector.

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