Field Research (Survey) for need analysis of the current situation of the smart textiles sector

Deliverable nº: R1A1

Need Analysis Report

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List of abbreviations

SME = small and medium enterprises

IPR = intellectual property rights

EXECUTIVE SUMMARY

The objective of the HACKTEX project is to develop the tools necessary for skills enhancement targeted to higher education in relation to innovation in smart textiles. For this purpose, the project will create a virtual training program and tools for functional and smart textiles, materials for an industrial smart textile bootcamp training for intensive summer education course, a virtual methodological guide focused on entrepreneurship and a project handbook of good practices.

In order to create training materials with relevant content (macro/micro structure), result R1 intends to develop the HACKTEX training methodology and syllabus based on activity R1A1, a tailored field research (survey) that will enable the consortium to identify and particularize the current needs of the smart textiles sector to be addressed through training, as well as anticipate the future ones. The current report refers to the need analysis carried out using the data obtained from the survey.

The survey is addressed to three 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 particularised according to each target group and were structured into three main sections:

- **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.
- **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.
- **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.

Once agreed by all partners, the online questionnaires were distributed to partners and the data was collected and processed by TUIASI. The number of respondents is: 17 for experts from

companies, 15 for experts from universities/research institutes (a total of 32 responses) and 34 for students engaged in textiles studies, including specialization in smart textiles.

The report presents the responses for each target group, discussing the particularities of the answers. After the responses of each group are detailed, a chapter of the report is dedicated to a comparative analysis of the survey findings, so that general conclusions can be drawn. These conclusions are presented below, structured according to the sections of the questionnaires.

a) Current needs of the smart textiles sector

A set of 4 factors are considered to have a substantial influence on the development of smart textile prototypes/products: 1. developing new raw materials/products; 2. HR with relevant skills; 3. understanding market requirements; 4. standardization.

The main problems/challenges in relation to developing smart textiles are the lack of funding and proper technology, and difficulties in acquiring it.

Most significant need 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 the co-creation of curricula for smart textiles to reflect sector's needs, actions to attract more young people to study smart textiles and the 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.

b) Existing initiatives in the smart textiles sector

Both companies and universities are interested in participating to different initiatives, the most common being research projects and partnerships with the industry for companies from the sector and educational initiatives and research projects for the universities.

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 for participation in such initiatives.

c) Perceived weak points in engineering training for the field of smart textiles

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

The 5 most relevant topics on smart textiles 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.

Knowledge related to non-technical aspects of smart textiles (market, business models, project management and non-technical aspects of manufacturing smart textiles) is ranked slightly lower than technical knowledge.

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 ranking for respondents from companies is very close to an average of 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

The experts from companies and from universities consider that different research agendas and different perceptions of research and innovation are the weakest points affecting the cooperation between companies and universities for research and innovation.

The survey showed that the companies and universities consider that further training in the smart textiles is needed and are interested in the training materials to be developed by the HACKTEX project. Techniques of characterization is the most selected topic. Non-technical subjects such as legislation and certification are also of interest for the industry. The preferred form of delivery for such training materials is videos.

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1. INTRODUCTION

1.1. Project context and objectives

The complex context of the HACKTEX project is defined by general economic conditions, as well as the changes brought by the SARSCOV-2 pandemic that affect both the entire textiles and clothing industry and higher education system.

From the economic perspective, the textiles' manufacturing sector in Europe is already facing several major challenges, most important being the fierce competition from emerging markets. In addition, the COVID-19 situation has strongly affected the textile and clothing sector in terms of sales and production, especially in the first and second quarter of 2020. Also, 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 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, HEIs 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 the entrepreneurial dimension that is essential in bringing research to the industry and unlock the innovation potential of advanced textiles. 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. In addition, 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.

The HACKTEX project will develop innovative tools for the digital age for engineering training that in turn will facilitate the necessity 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 course (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 advanced textile industry

1.2. Project results

HACKTEX will produce concrete and transferable results which can be exploited even after the project conclusion, both by the partners and by other stakeholders. The project deliverables will create a set of instruments to be used by students in the textile manufacturing sectors.

a) The HACKTEX training methodology and syllabus (Result R1) will be supported by a tailored field research (survey) that will enable the consortium to identify and particularize the current needs of the smart textiles sector to be addressed through training, as well as anticipate the future ones. The training methodology will set the frame for all activities in the project, establishing the roadmap that will reflect its objectives. This will enable the consortium to define the frame of the HACTEX project through the macrostructure (syllabus) of all training materials in a balanced and efficient manner, shortening the duration of the subsequent activities.

The current report refers to the Result R1, Activity A1 that carries out a need analysis to better understand the current problems of the industry following the pandemics and anticipate future skills and competences the sector will require. Its assessments will be the base to develop a general syllabus containing the macrostructure for each result of HACKTEX.

b) Development of virtual training program and tools for functional and smart textiles including specific videos and training materials. The virtual content (Result R2) will be based on the updated need analysis of the smart textiles sector of advanced textiles (Result R1A1). Materials will be organized in a MOOC format and openly available by external organizations willing to use the courses for textile manufacturing students, managers, professionals, among others.

c) Industrial smart textile bootcamp training for intensive summer education course (Result R3). The results obtained from the bootcamp such as blended methodologies, materials, presentations, templates and handouts, etc. will be used during the summer course (C1) learning activity. Once tested in the C1 activity, the material can be used for courses regarding smart textiles. This result will facilitate uptake of both digital and hands-on skills with blended methodologies.

d) Creation of virtual methodological guide focused on entrepreneurship. Its aim is to give to students some tips and industrial challenges that need to be faced in the advanced textiles' manufacturing industry and involve them into the business sector. The virtual guide will remain active and open on the project website for further implementation in training activities by higher education institutions along with textile manufacturing companies for next curricula development to support smart textiles for students to foster their skills (Result R4). This result will provide tools to develop further digital skills and complement smart textiles with entrepreneurship.

e) Project Handbook of Good practices. Training tools and methodologies to foster smart textiles into the manufacturing sector", a document containing all relevant information related to the project and its achievements as well as open challenges to be tackled. It will represent a sort of "lesson learned", which will be transferred to relevant stakeholders. It will be an extremely important output for mainstreaming project best practices and key success results and to make stakeholders aware about the unsolved challenges (Result R5). This handbook will provide tools and learning experiences in implementing digital skills and innovative virtual training best practices.

1.3. Survey methodology

The methodology defined in the Guidelines for the need analysis report considered the following aspects:

1.3.1. Definition of the target groups

The following three groups of respondents were considered for the survey. The number of respondents were distributed among all partners.

	Target group	Respondents
Group 1	Experts/managers from the T&C sector involved in manufacturing smart textiles or intending to transition to such applications	20
Group 2	Relevant experts involved in training and research (academics from HEIs with textile engineering specializations and specialists from research institutes)	10
Group 3	Students from textile engineering specializations	32

1.3.2. Definition of the questionnaires for each target group

The survey, based on questionnaires, was designed according to standard research methodology. The questionnaires were created according to their target group in online form and approved by all partners. The three questionnaires presented the following structure.

Part 1. Introduction

- Short presentation of the project and its aims, the purpose of the survey within the framework of the project;
- Indications on how to progress through the questionnaire according to the profile of the respondent, estimation for the time requirement;
- Confidentiality information.

In this part, the managers and the experts are asked to give their e-mail address.

Part 2. Body of the questionnaire

a) Questionnaire addressed to managers

A. Background information: A general assessment of the organization from which the respondent originates:
  - Company: size, type, profile, number of employees

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

C. Existing initiatives in the smart textiles sector in which the respondents are engaged**.**

D. Weak points in engineering training for the field of smart textiles as perceived by the industry, based on the sector's cooperation with universities and the needs of the companies for trained specialists.

E. Information about the respondent (position in the organization, highest qualification, working experience, gender, age, etc.)

b) Questionnaire addressed to experts (from HEIs, research institutes)

A. Background information: A general assessment of the organization from which the respondent originates:
  - Organization type, profile, etc.

B. Current needs of the smart textiles sector in terms of manufacturing and education

C. Existing initiatives in the smart textiles sector in which the respondents are engaged.

D. Weak points in engineering training for the field of smart textiles as perceived by the industry, based on the sector's cooperation with universities and the needs of the companies for trained specialists.

E. Information about the respondent (position in the organization, highest qualification, working experience, gender, age, etc.)

c) Questionnaire addressed to young professionals (students)

A. **Background information:** A general assessment of the organization from which the respondent originates: type of university, study program
B. **Current training needs for smart textiles,** as expressed by the students enrolled in textile programs**;**
C. **Information about the respondent:** field of study**,** highest qualification, gender, age

1.3.3. Implementation of the survey

The methodology of the survey involved three stages. In the first, a guide regarding survey definition and implementation was developed by TUIASI and agreed upon by all partners. After the three online questionnaires (one for each target group) were agreed upon, the partners implemented them at national level. The links for the online questionnaires created by TUIASI were sent to all partners to be distributed to the target groups. All responses for each target group were centralized in real time.

The methodology to create, apply and evaluate the questionnaires from the survey is presented graphically in Figure 1.

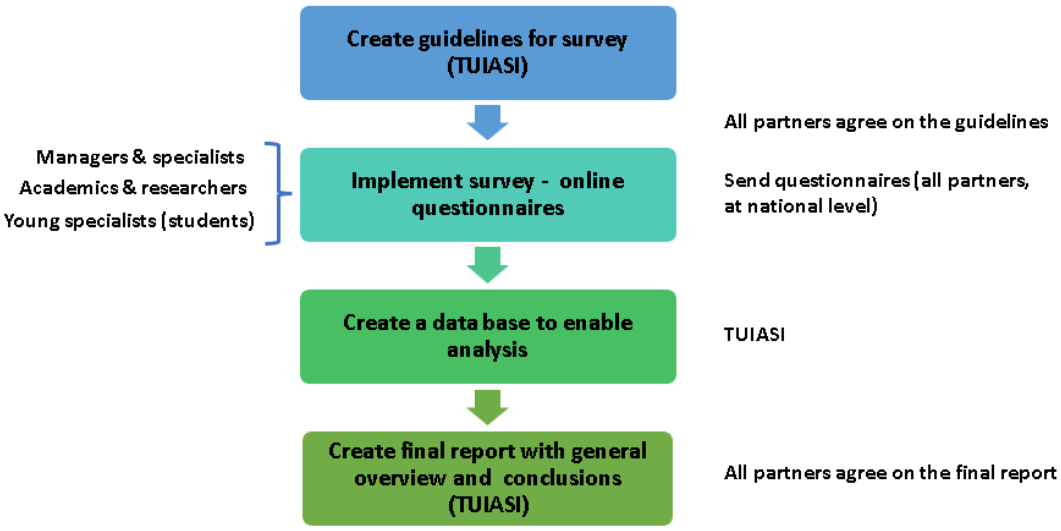


Figure 1. Logical sequence for the implementation of survey

1.3.4. Definition of the survey outputs

The expected outputs of the survey will consist in crucial info about:

1) Perceived current needs of the smart textiles sector in terms of manufacturing and education;
2) Existing initiatives in the smart textiles sector;
3) Perceived weak points in engineering training for the field of smart textiles.

The need analysis report is addressed to the following beneficiaries: high education institutions (universities, institutes of technology, academies), enterprises (suppliers, R&D centres, innovation lab, pools), public bodies (chambers of commerce, local governments, professional associations) and users (students, manufacturing companies, creative companies, teachers, researchers, designers, project managers) at European, national and regional levels.

2. SURVEY RESULTS AND DISCUSSIONS

Following the online implementation stage of the survey, when the questionnaires were distributed by the partners to representatives from the three target groups, the collected answers were gathered and processed for interpretation. Due to certain difficulties in the collection of responses and the limited time for this task, the number of respondents for companies and universities was slightly changed, without altering significantly the initial division. The survey included 17 experts from companies, 15 experts from universities (a total of 32 experts, above the number set in the project) and 34 students.

In this report, the options for factors of influence, subjects of knowledge and skills and competences evaluated through marks from 1 to 5 were ranked using a weighted average value, calculated according to equation 1, 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.

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

2.1. Results for managers and company specialists

2.1.1. Background information

Seventeen managers/specialists from the industry answered the questionnaire. Over three quarters of the respondents come from companies dealing with smart textiles (76.5%) – manufacturing (47.1%) and services (29.4%). One respondent offers research and development services, one respondent is involved in the manufacturing of protective equipment, while 41.2% are involved in producing traditional textiles. The respondent that declared to produce embedded electronics for smart textiles was considered in the manufacturing smart textiles category. No respondent was involved exclusively in trade services for smart textiles. Figure 2 presents the distribution of the respondents according to the profile of their company.

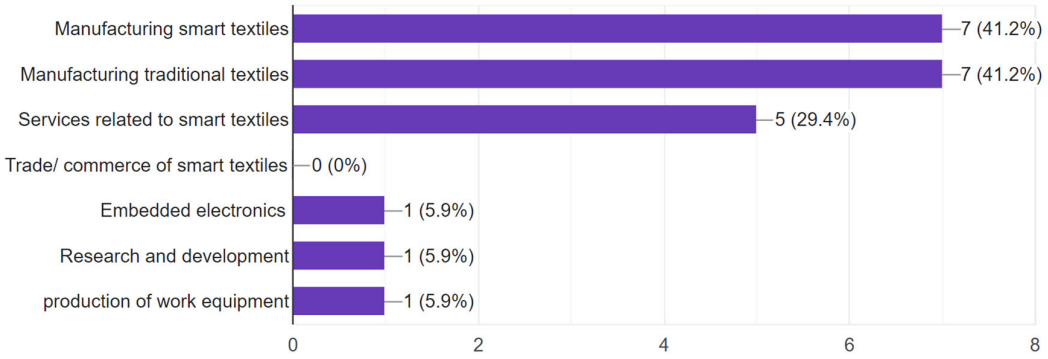


Figure 2. Distribution of respondents according to the profile of their company

For the question concerning the description of the type of smart textiles the respondents' companies are producing/selling or offers services for, the following answers were received:

- Metallized fabrics, yarns and components
- Sensors, actuators, cooling-heating textiles
- Antibacterial antistatic conductive shielding sensors
- Textile sensors, high performance textiles, SMA fabrics
- Tessuti schermanti le onde elettromagnetiche (Textiles for electromagnetic shielding)
- Smart textiles associated with home textile
- Agriculture and medical devices
- Printed electronics applicable for smart textiles
- Pressure sensor textiles
- All kind of garments with integrated electronics, hydraulics or pneumatics
- Production of niche equipment: firefighters, forest workers, security and protection services, industrial and civil engineering
- Textile sensors

Most of the companies are SMEs, small companies with 10 to 49 employees (47.1%) and medium ones with 50 to 249 employees (17.6%). Micro enterprises with up to 9 employees represent 23.5% of the respondents. These figures (see Figure 3) are specific to the sector of smart textiles, with small and micro enterprises with products dedicated to niche markets.

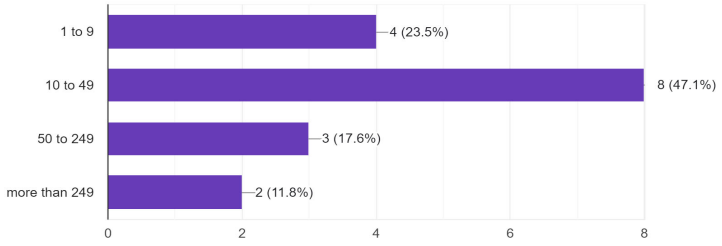


Figure 3. Distribution of companies according to their size

The distribution of respondents according to their position in the company is presented in Figure 4, with Head of R&D and owner/CEO being the most common. More than half of the respondents (56.0%) have a Master degree, 31.5% declare a B.Sc. degree or state something similar and 12.5% have a doctoral degree. Half of the respondents are in the 41 to 50 years of age, while approx. 31% are under 40 and the rest have an age over 50.

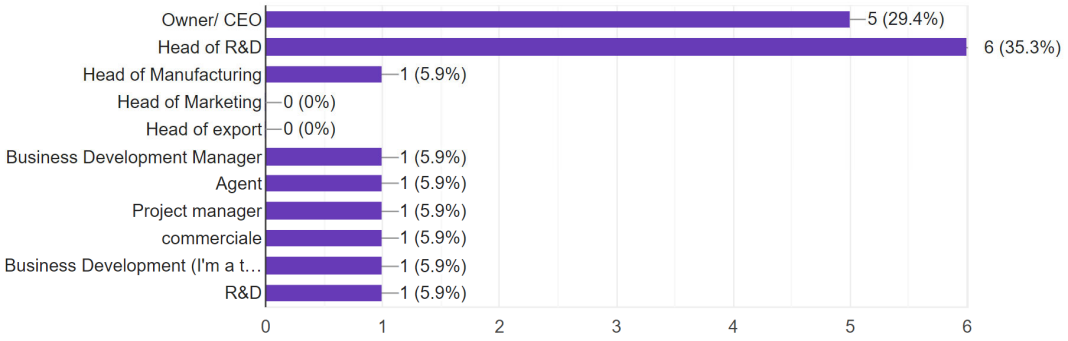


Figure 4. Position in the company for the respondents

2.1.2. Current needs of the smart textiles sector

This section of the questionnaire is designed to identify how the industry perceives the current needs and how they reflect on their present and future activity.

The first question intended to rank the key factors in developing smart textile prototypes/products. Respondents were asked to rank the importance of factors with marks from 1 (no importance) to 5 (extremely important). Based on these marks, the weighted average importance of each factor was calculated. The results are presented in Table 1 and graphically in Figure 5.

Table 1. Ranking of factors influencing the sector of smart textiles

	Factors for smart textiles sector	Level of importance					
		1	2	3	4	5	Average
1.	Developing new raw materials /products	0	1	1	8	7	4.24
2.	HR with relevant skills	0	1	3	6	7	4.12
3.	Understanding market requirements	0	1	3	7	6	4.06
4.	Standardization	1	1	2	6	7	4.00
5.	Adequate education/training programmes for smart textiles engineers	0	1	4	7	5	3.94
6.	Developing new technologies	0	2	5	6	4	3.71
7.	Business models adapted to smart textiles	0	2	4	8	3	3.71

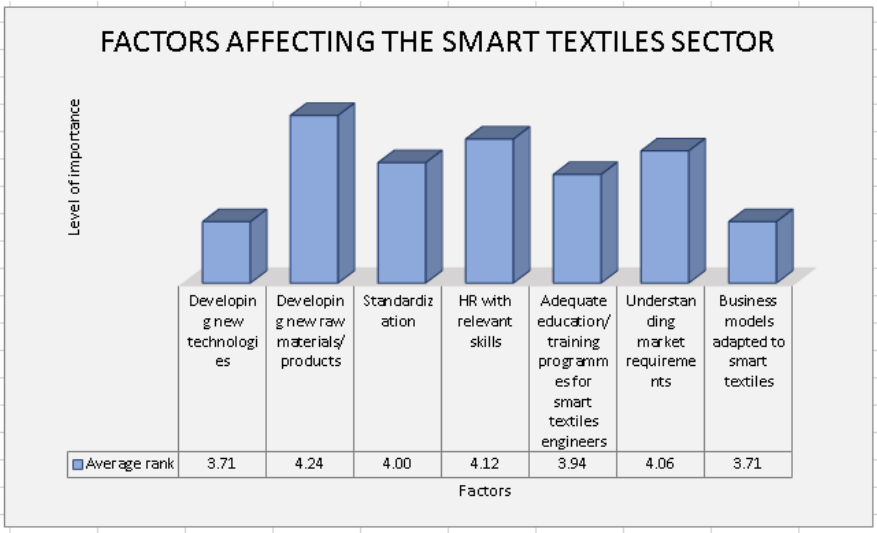


Figure 5. Graphical interpretation of the ranking of key factors for the smart textiles sector

All factors included in the question were deemed important, as their weighted averages surpassed the medium importance level, being closer and even going over the considerable importance level. Most significant factors of influence for the smart textiles sector were ranked developing new raw materials/products (4.24), HR with relevant skills (4.12), understanding market requirements (4.06) and standardization (4.0). It is therefore possible to point out that these factors cover the technological aspects of activity, adapted and adequate training of specialists and the market. Very close to these values ranks the need for adequate education/training programs for smart textiles (average 3.94), pointing out the interest of the sector toward education/training in the domain.

Developing new technologies and the development of business models adapted to smart textiles sector are significant needs for the respondents, seen as of slightly less importance than the needs mentioned above (both with averages of 3.71).

In relation to the perceived main problems/challenges companies face in relation to developing / producing smart textiles, the following issues were considered, while the respondents had the possibility to add other problems:

- Lack of proper technology; difficulties in acquiring such technologies
- Lack of market for smart textiles
- Lack of funds to develop smart textiles
- Lack of human resources
- Issues related to IPR
- Difficult access to research funding

The responses illustrated in Figure 6 show that the most important issues for the sector are: lack of proper technology, lack of funds to develop smart products and lack of specialised human resources. Another challenge is the difficult access to research funding. Less important is

considered the lack of market, a respondent adding missing customers separately. IPR is not seen as a problem, suggesting that the sector is well organised from this point of view.

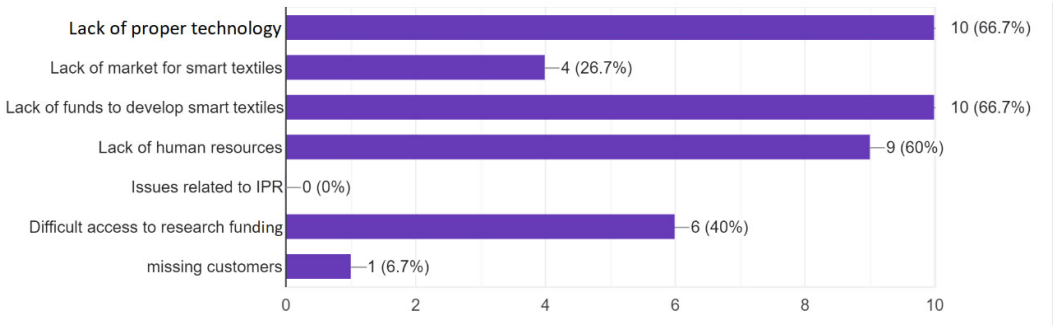


Figure 6. Main problems/challenges facing the smart textiles sector

In terms of improving the training in smart textiles, the respondents ranked the importance of the following issues presented in Table 2. Respondents were asked to rank the importance of factors with marks from 1 (no importance) to 5 (extremely important). Based on these marks, the weighted average importance of each factor was calculated. The results are presented in Table 2 and graphically in Figure 6.

The respondents consider the need for stronger links with universities to be the most significant, with a 4.0 average mark. This indicates that the companies from the sector regard universities as important partners in education. In addition, there is a need to train their staff on smart textiles with short-term dedicated programs (also an average mark of 4.0). Such a trend will be significant in the future, as a viable answer to the dynamic need for education the domain of smart textiles already experiences.

More programs on smart textiles (3.88) also support this need, as well as the desire of the companies to be involved in the curricula of such programs (3.82).

Table 2. Ranking of factors influencing the training in smart textiles

	Influencing factors for training	Level of importance					
		1	2	3	4	5	Average
1	Stronger links between the industry and universities	0	2	3	5	7	4.00
2	Improving existing laboratory infrastructure	1	2	5	8	1	3.35
3	Creation of more specializations/ programs related to smart textiles	0	1	2	12	2	3.88
4	Co-creation of curricula for smart textiles to reflect sector's needs	0	1	6	5	5	3.82
5	Short-term, dedicated trainings for the specialists from the industry	0	1	3	8	5	4.00
6	Attract more young people	1	0	5	7	4	3.76
7	More entrepreneurial education	0	1	5	8	3	3.76

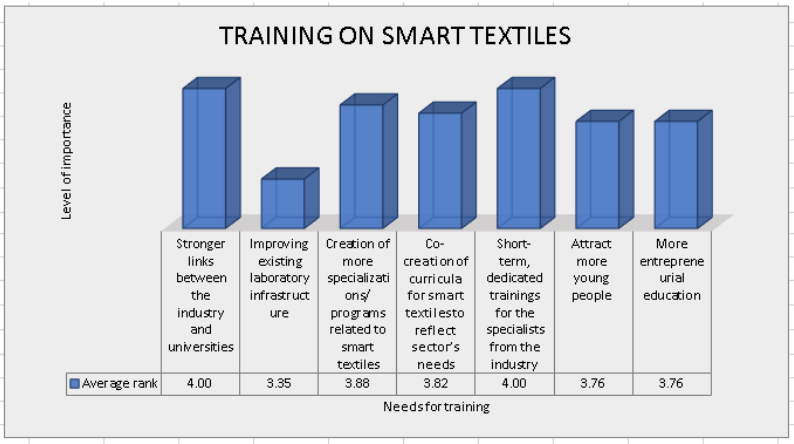


Figure 7. Perceived needs for training in smart textiles

Another question referred to how the needs of companies manufacturing smart textiles should be addressed by universities/research centres. Most respondents considered education in universities (70.6%) and research projects (76.5%) to be the answer (see Figure 8).

Knowledge transfer was also important to about half of the respondents (50.8%), while life-long learning is seen as less important in addressing the needs of the sector, perhaps because LLL programs are less developed in the field of smart textiles.

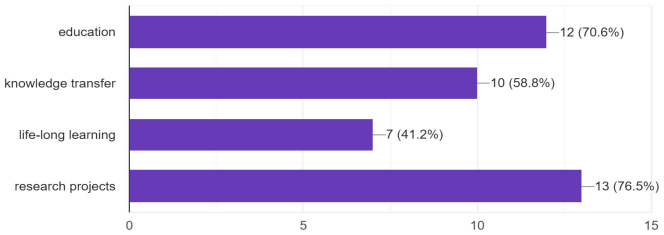


Figure 8. Perceived importance of the way to address the needs of the companies by universities

2.1.3. Existing initiatives in the smart textiles sector

This section was intended to identify in what type of initiatives such as networks, associations, clusters, projects, programs, etc. the companies are engaged.

Emphasizing the cutting-edge character of the sector, the overwhelming majority (88.2%) of the respondents declared that the companies are part of such initiatives.

The purposes of these initiatives concern mainly the development of new products/technologies (53.3%) and development of knowledge on smart textiles (33.3%), while 1 respondent indicated

sustainability as his scope to join initiatives. Partnerships for trade and new services were not selected by the respondents.

One answer given in addition to the purposes provided in the questionnaire is 'networking, facing challenges, finding use-cases, solving problems', indicating the need for knowledge and for contacts in the sector.

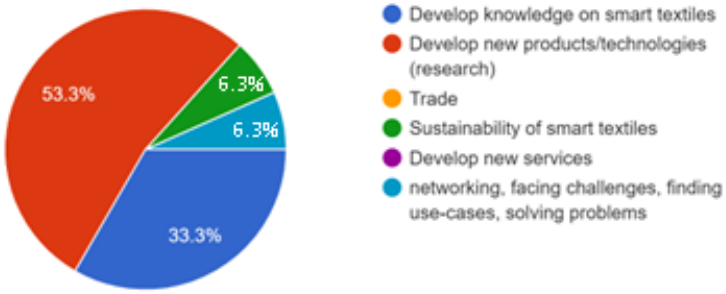


Figure 9. The purposes for participating in initiatives

With respect to the type of initiatives the companies are part of, most of them are research projects (80%), demonstrating the multidisciplinary character of the domain and its continuous need for development. Alliances with other partners from the industry (53.3%) indicate that a network of companies with common goals is already functioning at European level. Educational initiatives, though less numerous (20%), suggest that education is on the agenda of the companies from the sector and there is an opening toward such initiatives.

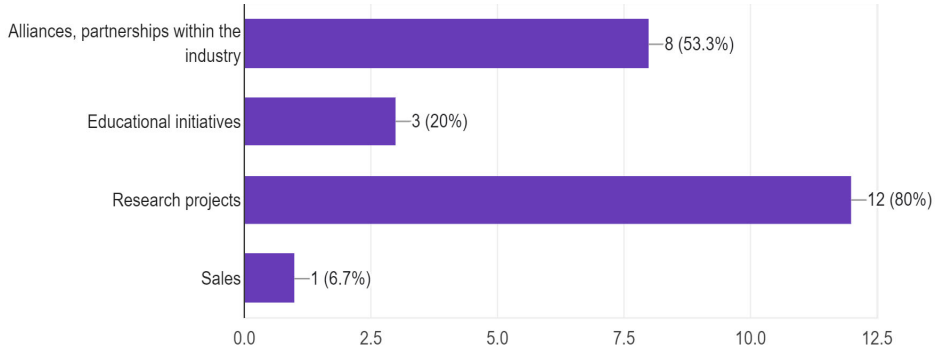


Figure 10. Types of initiatives in which companies producing smart textiles participate in

The answers received when asked to describe these initiatives are listed below:

- network for industry and education as well research for smart textile development
- 5G connected sport
- ETOP European Masterclass on innovation in smart textiles
- Develop and produce new smart textiles for sleep monitoring

- Change2twin program
- Clusters, projects I&D,
- Smart textiles project to develop a sensor mat for equine industry
- EU funded project

These partnerships are created mostly at EU level (71.4%), showcasing a European network developed by companies from the smart textiles sector. There is also a good participation in initiatives at national and regional level (totalling 57.2%). Significantly, fewer partnerships involve initiatives financed by participants, from their own funds (14.3%) or from other private sources (14.3%).

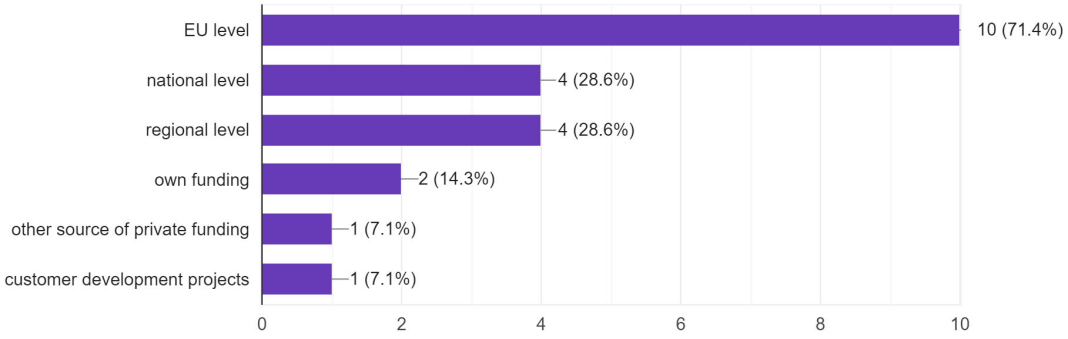


Figure 11. The level at which initiatives are organized

Most partnerships in such initiatives are with universities (46.7%), while almost 40% are represented by partnerships with other companies in the sector (26.7%) and beneficiaries from other sectors (13.3%).

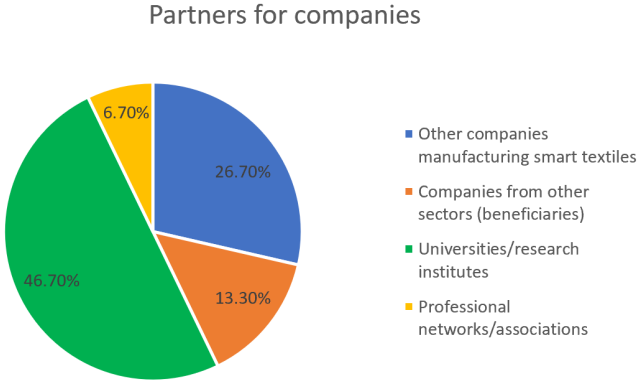


Figure 12. Partners in these initiatives

2.1.4. Perceived weak points in engineering training for the field of smart textiles.

In order to evaluate what companies from the sector perceive as being the weak points in academic training for smart textiles, the questionnaire discussed the main influencing factors, as well as a ranking of knowledge, respectively skills and competencies acquired by students in universities.

The following issues affecting the training in smart textiles were listed for ranking with marks from 1 (no influence) to 5 (very high influence). The resulting weighted average values are presented in Table 3 starting with the factor with the highest influence to the one with the lowest influence.

Table 3. Ranking of issues affecting the academic training in smart textiles

Influence factor	Level of influence					
	1	2	3	4	5	Average
Companies are not involved enough in co-creation of curriculum for smart textiles	0	1	3	7	5	**4.00**
Existing curricula do not include enough courses on smart textiles	0	0	5	8	3	**3.88**
Students need more skills related to the R&D of smart textiles	0	1	3	10	2	**3.81**
Curricula should include more internships for students in companies manufacturing smart textiles	0	0	6	8	2	**3.75**
More students should have their graduation thesis on smart textiles (especially M.Sc. and Ph.D.)	0	0	8	6	2	**3.63**
The content of lectures on smart textiles is not reflecting the latest developments in the industry	0	1	6	4	4	**3.50**

Table 3 shows that companies consider their lack of involvement in the co-creation of curricula for smart textiles as the most significant issue affecting the efficiency of training, with an average of 4.0. It suggests that they feel compelled to express their needs in terms of academic education. Including more courses on smart textiles and developing relevant skills related to the R&D of smart textiles are also important issues.

The respondents consider that the current course content is reflecting the latest developments in the industry, this influencing factor having the lowest average (3.5). They also consider that an increased number of students having their graduation thesis on smart textiles (especially M.Sc. and Ph.D.) is a less significant factor, suggesting existing ties between the sector and the universities.

Knowledge and skills relevant to the R&D and manufacturing of smart textiles are also very important in defining the future specialists. The respondents rated in terms of importance several domains of knowledge, of technical nature, as well as non-technological nature.

Table 4 presents the ranking of knowledge specific to smart textiles and therefore important to engineering education, from 1 (no importance) to 5 (extremely important).

Table 4. Ranking of knowledge related to smart textiles

Type of knowledge	Level of importance					
	1	2	3	4	5	Average
New advanced/smart textile materials/ products	0	0	1	9	7	4.35
New advanced/smart textile raw materials	0	0	2	9	6	4.24
Complementary knowledge related to smart textiles (like physics, chemistry, electronics)	0	0	4	6	7	4.18
Functionalization methods and processes for smart textiles	0	2	4	5	7	4.18
Standards for smart textiles; evaluation of properties/product functionality	0	0	4	7	6	4.12
Research methods and techniques specific to smart textiles	0	2	3	8	4	3.82
Sustainable value chains specific to smart textiles	0	2	5	6	4	3.71
Market trends	0	4	5	6	3	3.65
Non-technical aspects of advanced manufacturing specific to smart textiles	0	1	8	6	2	3.53
Business models	0	5	3	5	4	3.47
Project management concepts	0	1	10	4	2	3.41

In general, technical knowledge was ranked as most significant: advanced/smart textile materials and products and raw materials (average level of importance 4.35, respectively 4.24), functionalization and technological processes (average 4.18), as well as sciences complementary to smart textiles (average 4.18). With a high level of importance then we have standardization, evaluation of properties (average 4.12), as well as research methods and techniques specific to smart textiles (average 3.82).

Respondents considered non-technological knowledge less important, most significant being knowledge concerning market trends (average 3.65). This difference could be explained by the position in the company of the respondents, most of them being involved in R&D, therefore considering the technological knowledge more significant.

Sustainability is an issue that will gain even more weight in the near future. Even if the respondents ranked it with an average of 3.71, the sustainability will affect the design of smart textiles and its influence will reflect in technological, as well as non-technological knowledge.

In regard to the skills and competencies related to smart textile to be acquired/enhanced through engineering education, Table 5 shows the ranking by the respondents of their perceived relevance, from 1 (no relevance) to 5 (extremely relevant).

Table 5. Ranking of relevance of skills and competencies for young specialists in smart textiles

Skills and competencies	Level of relevance					
	1	2	3	4	5	Average
Capacity to generate new ideas (creativity) for the development of smart textiles	0	0	1	5	10	4.56
Use and adapt textile technologies to produce smart textiles	0	1	0	6	9	4.44
Pro-active understanding of customers' and market needs	0	0	0	10	6	4.38
Work in a team	0	0	2	7	8	4.35
Use and adapt textile knowledge related to fibres/yarns/materials structure to create smart fibres/yarns/materials	0	0	2	6	7	4.33
Change-orientated approach to product development	0	0	1	9	6	4.31
Understand and use the requirements specific to the application domain – multidisciplinary approach to the design of smart textiles	0	0	3	5	8	4.31
Identify, pose and resolve R&D problems	0	0	1	10	5	4.25
Identification of market development and trends for the smart textiles sector	0	0	1	11	4	4.19
Abstract thinking	0	0	2	10	5	4.18
Plan, design and execute research projects / prototypes referring to smart textiles	0	1	3	6	6	4.06
Advanced digital skills; ability to use specific software for design and production of smart textiles (CAD/CAM systems)	0	1	5	4	6	3.94
Search for, process and analyse information from different sources	0	0	5	10	2	3.82
Conduct risk assessment analysis in R&D projects for smart textiles	0	1	4	9	2	3.75
Plan and manage time in research activities	0	0	8	7	2	3.65
Ability to manage and optimize production processes	0	3	4	6	3	3.56
Recognition and implementation of opportunities for business growth	0	2	5	7	2	3.56

The ranking illustrates that creativity (average 4.56) is viewed as a capital asset in companies from the smart textile sector, together with the change-orientated approach to product development (average 4.31) and identification and solving of R&D problems (average 4.25), all of them required to support and advance the continuous process of innovation specific to the industry. Skills related to textile structures (average 4.33) and technologies (average 4.44) and their adaptation to smart applications are also very important to companies, as many of them have staff that is not trained in textiles. Furthermore, the multidisciplinary dimension of smart textiles is reflected in the responses for skills regarding the multidisciplinary approach to the design of smart textiles, ranked with an average of 4.31. Digital skills are not ranked in front

(average 3.94), suggesting that such skills are currently widely spread among specialists and the engineering education provides for them so they are not an issue.

Skills and competencies needed to carry out different projects are also seen as important: work in a team (average 4.35); abstract thinking (average 4.18); search for, process and analyse information from different sources (average 3.82); conduct risk assessment analysis in R&D projects for smart textiles (average 3.75); plan and manage time in research activities (average 3.65).

Pro-active understanding of customers and market needs (average 4.38) and identification of market development and trends for the smart textiles sector (average 4.19) are seen as the most significant non-technological skills. The ability to manage and optimize production processes (average 3.56) and recognition and implementation of opportunities for business growth (average 3.56) have less relevance for the respondents from companies.

Cooperation between companies and universities for research on smart textiles was also evaluated and respondents selected the issues perceived as weak points, as illustrated in Figure 13. The responses show companies consider universities to have a different position on research and innovation (62.5%), they perceive research in a different manner (50%) and that their efforts in establishing meaningful contacts with the sector are not enough (50%). However, only 13.3% of the responses cited a lack of trust in the universities.

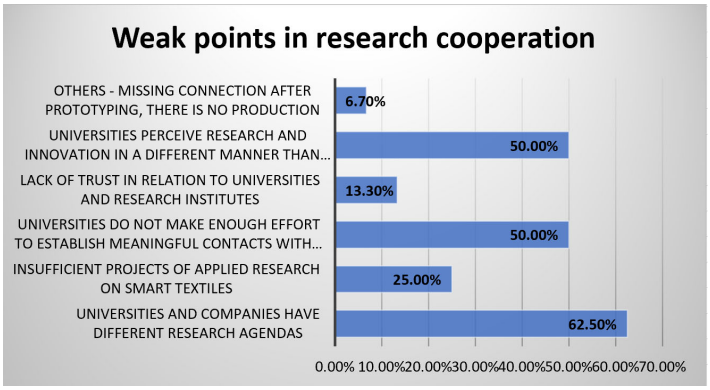


Figure 13. Weak points of the cooperation for research on smart textiles

More than 3 quarters of the respondents (76.3%) consider that the company staff needs further training in the domain of smart textiles, with the same proportion indicating that they would access the HACKTEX online courses.

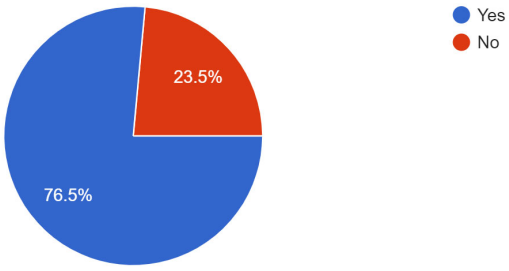


Figure 14. Need for further training of company staff and intent to access the HACKTEX virtual training

All subjects proposed to the respondents for training in smart textiles, listed in Table 6, were opted for by more than 50%. Techniques for characterization of smart textiles was of interest for the highest number of respondents (81.3%). Sustainability is also a topic that interested 62.5% of respondents, showing that the sector understands its importance and wants to gain knowledge about it. Other subjects of interest mentioned by the respondents were issues and solutions related to legislation, certification and production. Even if only one respondent mentioned this subject, legislation and certification applied to smart textiles are topics that could be considered to be included in the training materials.

Table 6. Options regarding knowledge on smart textiles companies would be interested in

Subjects	Responses	
	Number	Percentage
Techniques for characterization of smart textiles	13	81.30%
Materials for smart textiles (fabrics, functional treatments)	11	68.80%
Textile and non-textile manufacturing processes/technologies	10	62.50%
Aspects related to the sustainability of smart textiles	10	62.50%
Raw materials for smart textiles (fibres, yarns)	9	56.30%
Study cases	9	56.30%
Others - Legislation and certification	1	6.30%
Others- Production (issues and solutions)	1	6.30%

2.2. Results for academics and researchers

2.2.1. Background information

The questionnaire for experts from universities and research institutes was answered by 15 respondents, most of them academics in universities (73.3%).

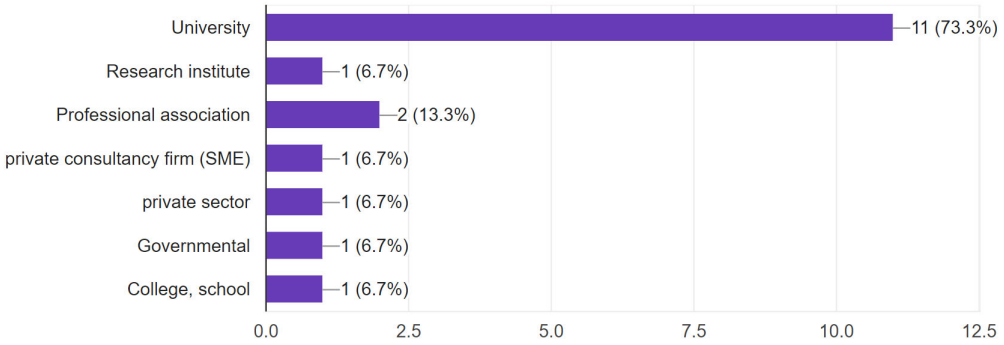


Figure 15. Distribution of the respondents according to affiliation

Most of the respondents are involved in education and research (73.3%), with the rest doing consultancy (20%), quality management and administrative activities in projects, as seen in Figure 16.

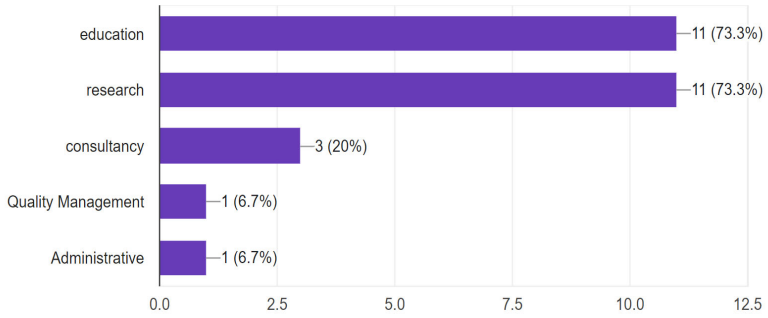


Figure 16. Distribution of respondents according to their activity

Over 85% of respondents indicated that they teach/research smart textiles. The rest indicated the following options that are particular applications of smart textiles:

- Research on the application of smart textiles in military uniforms or camouflage related items
- Fashion design, fabric conservation, natural dyeing etc.
- Bio finishing

According to the position of the respondents in their institution (Figure 17), 60% are academics (professors, associate professors and lecturer in equal proportion, 20%), 26.7% are researchers and the rest (2 respondents) have positions in research programs.

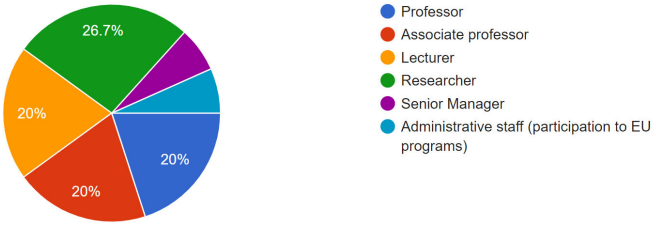


Figure 17. Position of the respondents in their institution

2.2.2. Current needs of the smart textiles sector

This section of the questionnaire is designed to identify how the specialists from education and research perceive the current needs and how these needs reflect on their present and future activity.

The first question intended to rank the key factors in developing smart textile prototypes/products. Respondents were asked to rank the importance of factors with marks from 1 (no importance) to 5 (extremely important). Based on these marks, the weighted average importance of each factor was calculated. The results are presented in Table 7 and graphically in Figure 18.

Table 7. Ranking of factors influencing the sector of smart textiles

Factors for smart textiles sector	Level of importance					
	1	2	3	4	5	Average
Adequate education/training programmes for smart textiles engineers	0	0	1	5	9	4.53
HR with relevant skills	0	1	1	3	10	4.47
Developing new raw materials /products	0	0	4	2	9	4.33
Standardization	0	1		7	7	4.33
Understanding market requirements	0	0	2	8	5	4.20
Developing new technologies	0	2	2	4	7	4.07
Business models adapted to smart textiles	1	0	2	5	7	4.07

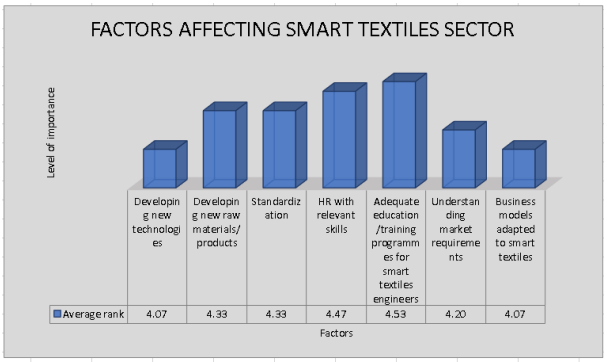


Figure 18. Graphical interpretation of the ranking of key factors developing smart textile prototypes/products

All factors were rated as considerably important, with an average over 4 for each, suggesting that all options of this question are deemed of significant importance by the respondents. Reflecting the academic activity of most of the respondents, adequate education/training programmes for smart textiles engineers was considered as the most important factor of influence (average 4.53), followed by the need for specialists with skills relevant to the sector (average 4.47). Developing new materials/products and standardization have each an average of 4.33, reflecting the need for research in the field. Understanding market requirements (average 4.20) is deemed a bit more important than business models adapted to the sector (average 4.07).

Considering the main problems/challenges in relation to developing smart textiles, most respondents see the lack of funds as the most important issue (66.7%). The lack of proper technology and difficulties in acquiring it is a challenge to almost half of respondents (46.7%). Lack of adequate staff (40%) and difficulties in accessing funds for research (40%) are deemed less problematic in developing smart textiles. Only 20% of respondents consider the lack of market for smart textiles as a problem, while IPR is not an issue, as only 1 respondent marked it as a problem.

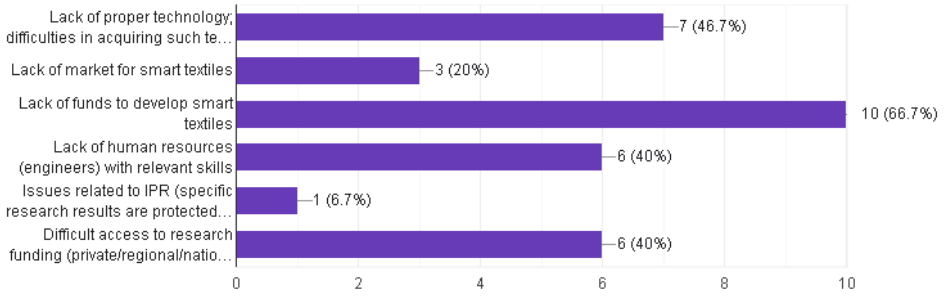


Figure 19. Ranking of the main problems/challenges in relation to developing smart textiles

In terms of what needs to be done to improve training in smart textiles, their weighted average ranking is presented in Table 8, using marks from 1 (no importance) to 5 (extremely important).

Table 8. Needs to improve training in smart textiles

Needs	Level of importance					
	1	2	3	4	5	Average
Stronger links between the industry and universities	0	1	0	4	10	4.53
Improving existing laboratory infrastructure	0	0	1	6	8	4.47
Co-creation of curricula for smart textiles to reflect sector's needs	0	0	4	4	7	4.20

Attract more young people	0	0	2	8	5	4.20
Creation of more specializations/ programs related to smart textiles	0	0	4	5	6	4.13
Short-term, dedicated trainings for the specialists from the industry	0	1	3	9	2	3.80
More entrepreneurial education	0	3	7	3	2	3.27

Stronger links with the business environment is considered as the most important (weighted average 4.53). Improving laboratory infrastructure is also an extremely important issue to be solved (average 4.47), suggesting that academics feel that students and subsequently the sector could benefit from modern, state-of-the-art equipment.

In terms of programs related to smart textiles, the respondents see this need as considerably important (average 4.13), together with the need to involve the companies in the process of co-creation (average 4.20). More programs/specializations on smart textiles could also attract young people to study smart textiles (average 4.20), an issue facing the sector throughout Europe.

Respondents rated slightly less the need for short-term trainings for the industry (average 3.80), while promoting more entrepreneurial education was considered only of medium importance (average 3.20). This could be explained by the existence of a significant number of entrepreneurial education programs/projects in universities; such being the case, academics perceive entrepreneurial education as already implemented.

In reference to how the needs of the smart textile companies should be addressed by universities/research centres, all options included in the questionnaire are deemed important solutions, research projects being most selected by the respondents (86.7%), followed by knowledge transfer (80%). Fewer respondents selected the options for education through life-long learning (66.7%) and academic education (60%), situation that reflects that the respondents perceive education as a solution to the sector's needs already in place.

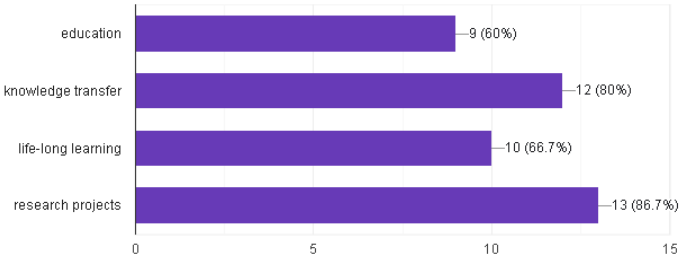


Figure 20. Ways to address the needs of the smart textiles' companies

2.2.3. Existing initiatives in the smart textiles sector

A substantial percentage of the respondents (80%) declared that their institution is part of an initiative regarding smart textiles, such as networks, associations, clusters, projects, programs, etc. The most common scope of such initiatives is to develop knowledge on smart textiles (83.3%), followed by developing new products (41.7%). A significant number of respondents (41.7%) declared sustainability of smart textiles to be the intention of the initiatives, showing that academics and researchers are interested in this issue and understand its importance. Trade and new services are not the object of participation in different initiatives for the respondents, justified by the fact that universities are not involved in trade.

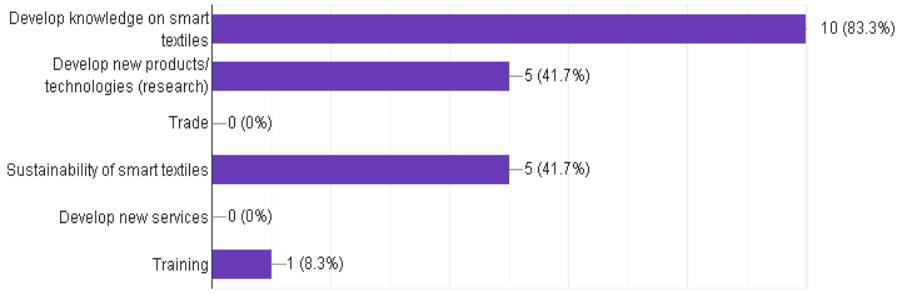


Figure 21. Scope of initiatives

Educational initiatives and research projects (each representing 66.7% of the options) are the most common type of initiatives. A reason of concern is the lower level of alliances, partnerships between universities and the companies; only 1 respondent (8.3%) stated his/her institution participates in such an initiative with the sector. One respondent acknowledged such an initiative, but was not sure about the type.

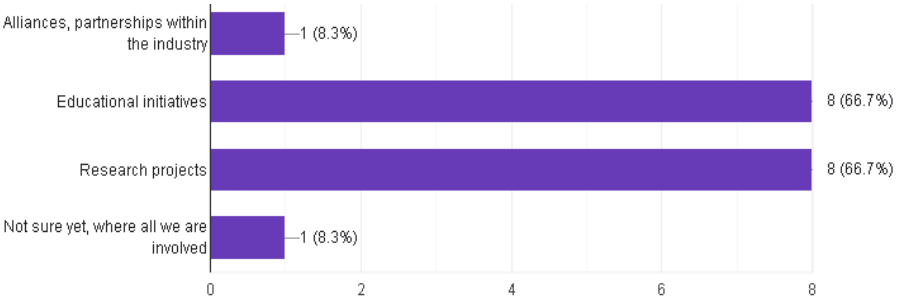


Figure 22. Types of initiatives universities participate in

When asked to specify what are these initiatives, respondents listed the followings:

- Cost Action, Autex, ETP, Smart Textiles
- EU-funded projects, company training courses, consultancy projects

- https://ict-tex.eu/ - https://destexproject.eu/ - https://www.datemats.eu/about/#four-areas
- obtaining smart fabrics used in medicine
- general education on smart textiles, e-textiles
- Wearable sensors and e-textiles
- Knowledge transfer from European to Asian Universities

Respondents take part mainly in initiatives at EU level (72.7%) and national level (36.6%). Funding is a significant issue, only 1 respondent indicating participation using their own funds, and none other source of private funding.

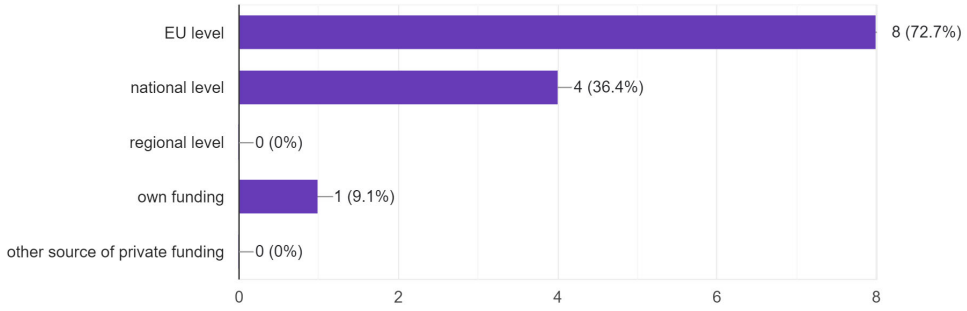


Figure 23. Funding of the initiatives

In terms of partners in different initiatives, universities/research institutes account for 58.3% of answers. Companies from the sector of smart textiles represent 25% of partnerships. Professional networks/associations represent 8.3% of the total, perhaps because such organizations dedicated to smart textiles are still less numerous.

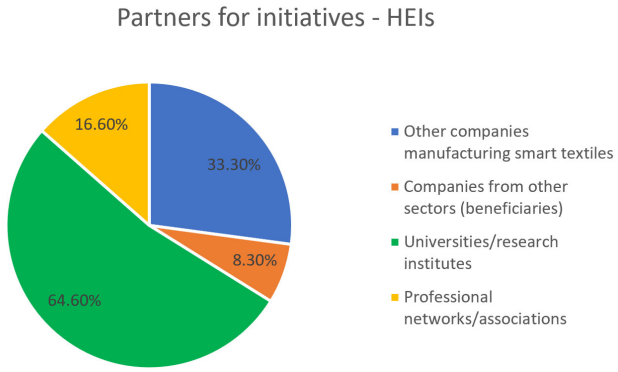


Figure 24. Partners in these initiatives

2.2.4. Perceived weak points in engineering training for the field of smart textiles.

In order to evaluate how universities/research institutes perceive the weak points in academic training for smart textiles, the questionnaire discussed the main influencing factors, as well as a ranking of knowledge, skills and competencies to be acquired by students in universities.

The following issues affecting the training in smart textiles were listed for ranking with marks from 1 (no influence) to 5 (very high influence). The resulting weighted average values are presented in Table 9.

Table 9. Ranking of issues affecting the academic training for smart textiles

Influence factor	Level of influence					
	1	2	3	4	5	Average
Students need more skills related to the R&D of smart textiles	0	0	4	6	5	4.07
The content of lectures on smart textiles is not reflecting the latest developments in the industry	0	0	4	9	2	3.87
Existing curricula do not include enough courses on smart textiles	0	1	5	6	3	3.73
Curricula should include more internships for students in companies manufacturing smart textiles	0	2	1	4	8	3.71
Companies are not involved enough in co-creation of curriculum for smart textiles	0	1	3	7	4	3.47
More students should have their graduation thesis on smart textiles (especially M.Sc. and Ph.D.)	0	0	6	7	2	3.29

The ranking of the factors influencing training in smart textiles show that respondents see the skills adapted to the needs of the sector as the most important one (average 4.07). In the opinion of the respondents, courses on smart textiles should update their content to reflect state-of-the-art knowledge (average 3.87) and curricula should contain more such courses (average 3.73).

Reflecting a well-established interaction with the industry, internships, including graduation thesis, are considered to have already demonstrated their efficiency, with an average of 3.71, respectively 3.29. The respondents see the involvement of companies in co-creating curricula for smart textiles as being with a lower level of influence (average 3.29) in addressing the problems of education in the field.

Knowledge and skills relevant to the R&D and manufacturing of smart textiles are also very important in defining the future specialists. Several domains of knowledge of technical, as well as non-technological nature were rated in terms of importance by the respondents.

Table 10 presents the ranking of knowledge specific to smart textiles and therefore important to engineering education, from 1 (no importance) to 5 (extremely important).

Table 10. Ranking of knowledge related to smart textiles

Type of knowledge	Level of importance					
	1	2	3	4	5	Average
Standards for smart textiles; evaluation of properties/product functionality	0	0	1	7	7	4.40
Functionalization methods and processes for smart textiles	0	1	1	5	8	4.33
New advanced/smart textile raw materials	0	1	3	3	8	4.20
New advanced/smart textile materials/ products	0	0	3	6	6	4.20
Complementary knowledge related to smart textiles (like physics, chemistry, electronics)	0	0	4	4	7	4.20
Sustainable value chains specific to smart textiles	0	2	5	6	4	4.20
Research methods and techniques specific to smart textiles	0	1	1	7	6	4.20
Market trends	0	0	4	8	3	3.93
Non-technical aspects of advanced manufacturing specific to smart textiles	0	1	5	5	4	3.80
Business models	0	2	4	7	2	3.60
Project management concepts	0	2	5	6	2	3.53

The average rating shows that the respondents considered technical knowledge as of considerable importance. Standards for smart textiles and methods for their evaluation are rated as most significant in engineering education (average 4.40), followed by functionalization methods and processes for smart textiles (average 4.33). All other domains of technical knowledge are rated equally, with an average of 4.20. This suggests that universities are interested in including such courses in their curricula. Knowledge related to non-technical issues, market, business models and project management is perceived of importance, but slightly lower than technical knowledge (averages between 3.53 and 3.93). In general, entrepreneurial programs are separated from technical programs, such as textiles and smart textiles, and courses for technical specializations include less entrepreneurial courses, as they focus on the technical subjects.

In regard to the skills and competencies related to smart textiles to be acquired/enhanced through engineering education, Table 11 shows the ranking by the respondents of their perceived relevance, from 1 (no relevance) to 5 (extremely relevant).

Table 11. Ranking of relevance of skills and competencies for young specialists in smart textiles

Skills and competencies	Level of importance					
	1	2	3	4	5	Average
Understand and use the requirements specific to the application domain – multidisciplinary approach to the design of smart textiles	0	0	1	1	13	4.80
Work in a team	0	0	0	7	8	4.53

Use and adapt textile knowledge related to fibres/yarns/materials structure to create smart fibres/yarns/materials	0	0	2	3	10	4.53
Plan, design and execute research projects / prototypes referring to smart textiles	0	0	2	4	9	4.47
Use and adapt textile technologies to produce smart textiles	0	0	3	3	9	4.40
Identify, pose and resolve R&D problems	0	1	0	7	7	4.33
Search for, process and analyse information from different sources	0	3	3	6	5	4.27
Capacity to generate new ideas (creativity) for the development of smart textiles	0	0	1	9	5	4.27
Advanced digital skills; ability to use specific software for design and production of smart textiles (CAD/CAM systems)	0	2	3	1	9	4.13
Change-orientated approach to product development of smart textiles	0	1	3	6	5	4.00
Ability to manage and optimize production processes	1	1	2	5	6	3.93
Identification of market development and trends for the smart textiles sector	0	0	6	4	5	3.93
Conduct risk assessment analysis in R&D projects for smart textiles	0	1	5	4	5	3.87
Plan and manage time in research activities	0	0	7	4	4	3.80
Abstract thinking	0	2	4	5	4	3.73
Recognition and implementation of opportunities for business growth	0	1	6	4	4	3.73
Pro-active understanding of customers' and market needs	0	2	5	3	5	3.73

The average marks presented in Table 11 show that the respondents consider all skills and competencies included in the questionnaire to be of considerable up to extreme importance, with an emphasis on skills related to technical knowledge.

Multidisciplinary approach to the design of smart textiles is ranked as skills of utmost importance for students (average 4.80). The capacity to use and adapt textile knowledge related to fibres/yarns/materials structure to create smart fibres/yarns/materials (average 4.53), as well as to use and adapt textile technologies to produce smart textiles (average 4.40) and advanced digital skills (average 4.13) are the other highest ranked skills and competences.

Seen as very important are the abilities to participate in R&D projects: plan, design and execute research projects / prototypes referring to smart textiles (average 4.47), identify, pose and resolve R&D problems (average 4.33), search for, process and analyse information from different sources (average 4.27), the capacity to generate new ideas (creativity) for the development of smart textiles (average 4.27) and change-orientated approach to product development of smart textiles (average 4.0). The ability to conduct risk assessment analysis in R&D projects for smart textiles (average 3.87) is seen as slightly less important for R&D projects.

Significant transversal skills are ranked the ability to work in team (average 4.53), plan and manage time in research activities (average 3.80) and abstract thinking (average 3.73).

Respondents rated slightly less entrepreneurial skills, as follows: the ability to manage and optimize production processes (average 3.93), identification of market development and trends for the smart textiles sector (average 3.93), recognition and implementation of opportunities for business growth (average 3.73) and pro-active understanding of customers' and market needs (average 3.73).

Cooperation between universities and companies for research on smart textiles was also evaluated and respondents selected the issues perceived as weak points. The respondents selected all issues listed for the question (Figure 25).

Respondents considered different research agendas and different perceptions of innovation (both 60% of the options) as the most important issues affecting the cooperation between companies and universities for research on smart textiles. Insufficient projects of applied research were also a significant weak point (53.3%). Less important were the lack of trust and the efforts for networking (both 40%), suggesting that academics/researchers have a positive view of the sector and are open to cooperation with companies on smart textiles.

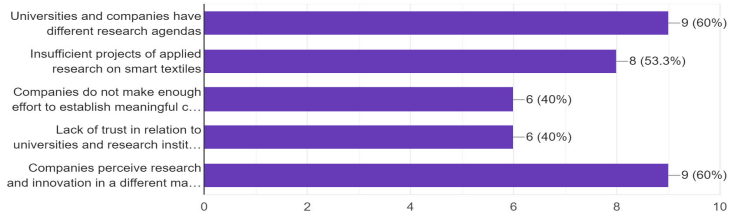


Figure 25. Weak points of the cooperation for research on smart textiles

All respondents are willing to recommend the courses on smart textiles for virtual training developed by the HACKTEX project to their students/young specialists, as well as to use the content in their activity.

When asked what type of courses they would be interested in, the respondents selected all options included in the questionnaire with a distribution of answers in the 40% to 60% interval. Most selected were techniques for characterization of smart textiles and study cases (60%), raw materials for smart textiles and sustainability of smart textiles (both 53.3%) and materials for smart textiles (46.7%). Textile and non-textile manufacturing processes/technologies is a topic less selected (40%), leading to the idea that it is covered by a great number of universities.

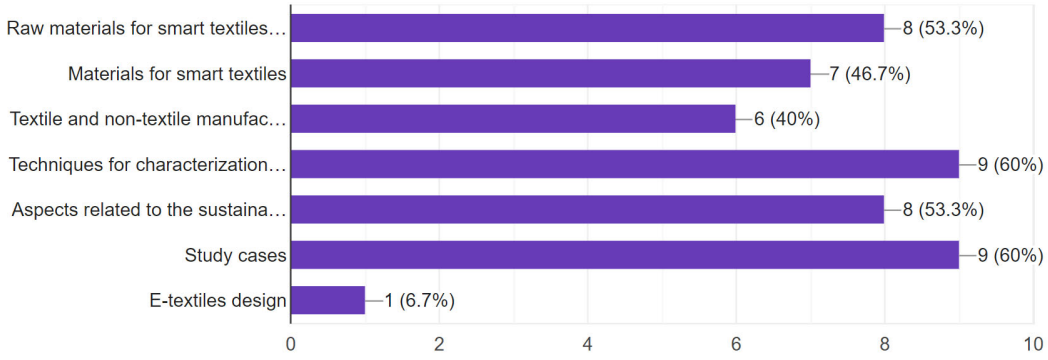


Figure 26. Options regarding knowledge on smart textiles respondents would be interested in

2.3. Results for young specialists (students from textile engineering specializations)

2.3.1. Background information

The questionnaire for students/young specialists was answered by 34 respondents, most of them from technical universities (70.6%).

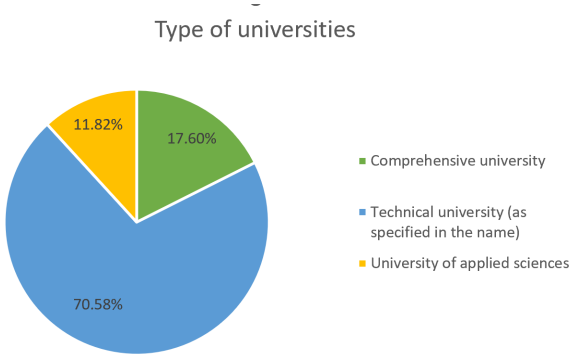


Figure 27. Distribution of universities where the respondents study

Most of the respondents are studying textile and clothing (73.5%), design/product development (64.7%), industrial management (44.1%). Only 35.3% declare to study smart textiles.

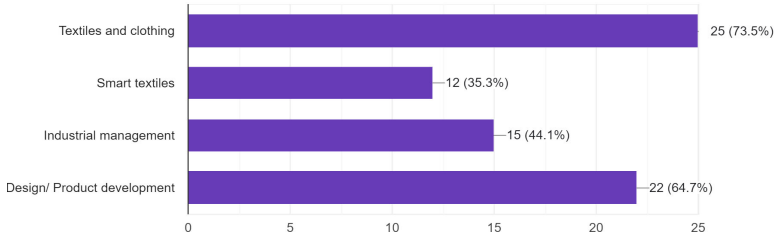


Figure 28. Distribution of the study programmes

Considering the level of education of the respondents, 55.9% of them are in B.Sc. programmes, 14.7% in M.Sc. programmes and 29.4% are completing their doctoral studies.

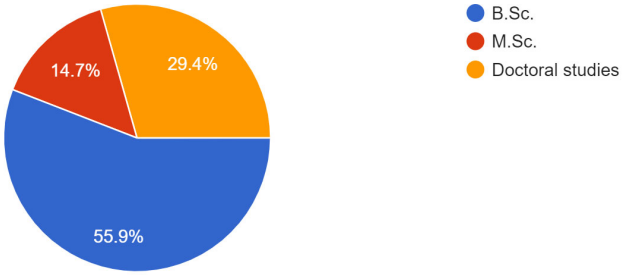


Figure 29. Distribution of respondents according to the study programme

2.3.2. Current needs of the smart textiles sector

This section of the questionnaire is designed to identify how the students/young specialists perceive the current needs and how these needs reflect on their present and future activity.

In total, 81.3% of the respondents declared to have had courses about smart textiles and are acquainted with the domain. 88.2% consider that they need further training in smart textiles.

The following issues affecting the training in smart textiles were listed for ranking with marks from 1 (no influence) to 5 (very high influence). The resulting weighted average values are presented in Table 12.

Students viewed improving laboratory infrastructure as the most significant issue affecting the educational process (average 4.44). Respondents considered that more programmes on smart textiles should be created (average 4.12). The link with companies from the sector should be addressed through more internships in such companies (average 4.35).

Table 12. Needs for training in smart textiles

Needs for training	Level of importance					
	1	2	3	4	5	Average
Improving the infrastructure of existing laboratory	0	0	3	13	18	**4.44**
More internships in companies producing smart textiles	0	1	4	11	18	**4.35**
Creation of more specializations/ programs related to smart textiles	0	0	8	14	12	**4.12**
Short-term, dedicated trainings on smart textiles during your academic education and after	0	4	4	15	11	**3.97**
More entrepreneurial education related to smart textiles	0	3	9	10	12	**3.91**

The need for further education is reflected by short-term trainings on smart textiles during university and after (average 3.97) and increased entrepreneurial education reflecting the specificities of smart textiles (average 3.91).

The respondents were asked to rank the relevance of certain subjects on smart textiles, using marks from 1 (no importance) to 5 (extremely important).

Table 13. Ranking of knowledge related to smart textiles

Type of knowledge	Level of importance					
	1	2	3	4	5	Average
New advanced/smart textile raw materials	0	0	9	9	16	4.21
New advanced/smart textile materials/ products	0	1	6	12	15	4.21
Complementary knowledge related to smart textiles (like physics, chemistry, electronics)	0	0	8	13	13	4.15
Functionalization methods and processes for smart textiles	0	1	7	13	13	4.12
Standards for smart textiles; evaluation of properties/product functionality	0	1	10	10	13	4.03
Research methods and techniques specific to smart textiles	0	0	3	14	14	3.97
Sustainable value chains specific to smart textiles	0	5	7	12	10	3.79
Market trends	0	6	6	12	10	3.76
Project management concepts	0	6	7	13	8	3.68
Business models	2	5	7	11	9	3.59
Non-technical aspects of advanced manufacturing specific to smart textiles	0	5	13	10	6	3.50

The students considered as most relevant knowledge related to new advanced/smart textile raw materials (average 4.21) and new advanced/smart textile materials/products (average 4.21), as well as complementary knowledge related to smart textiles, like physics, chemistry, electronics (average 4.15). Functionalization methods and processes for smart textiles (average 4.12), standards for smart textiles; evaluation of properties/product functionality (average 4.03) and research methods and techniques specific to smart textiles (average 3.97) are also ranked as very important.

Sustainable value chains specific to smart textiles (average 3.79) are seen as less relevant, suggesting that students do not always link technical knowledge on smart textiles and the issues of sustainability and there is a need to include forms of sustainable design of smart textiles in courses on smart textiles.

A lower rank for market trends (average 3.76), project management concepts (average 3.68), business models (average 3.59), non-technical aspects of advanced manufacturing specific to

smart textiles (average 3.50) could indicate that students are more focused on the technical aspects of the sector and less on market and entrepreneurship.

In order to rank the skills and competencies required for smart textiles, respondents were asked to rank their relevance, using marks from 1 (no importance) to 5 (extremely important).

Table 14. Ranking of relevance of skills and competencies for young specialists in smart textiles

Skills and competencies	Level of importance					
	1	2	3	4	5	Average
Use and adapt textile technologies to produce smart textiles	0	0	5	11	18	**4.38**
Use and adapt textile knowledge related to fibres/yarns/materials structure to create smart fibres/yarns/materials	0	0	5	12	17	**4.35**
Capacity to generate new ideas (creativity) for the development of smart textiles	0	1	6	10	17	**4.26**
Advanced digital skills; ability to use specific software for design and production of smart textiles (CAD/CAM systems)	0	3	3	12	16	**4.21**
Plan, design and execute research projects / prototypes referring to smart textiles	1	0	7	12	14	**4.12**
Identify, pose and resolve R&D problems	0	1	6	16	11	**4.09**
Change-orientated approach to product development of smart textiles	1	0	7	14	12	**4.06**
Work in a team	0	2	5	17	10	**4.03**
Pro-active understanding of customers' and market needs	0	4	4	13	13	**4.03**
Search for, process and analyse information from different sources	0	2	7	15	10	**3.97**
Abstract thinking	1	2	7	13	11	**3.91**
Understand and use the requirements specific to the application domain – multidisciplinary approach to the design of smart textiles	1	0	3	22	7	**3.91**
Conduct risk assessment analysis in R&D projects for smart textiles	1	2	9	10	12	**3.88**
Identification of market development and trends for the smart textiles sector	0	4	8	10	12	**3.88**
Plan and manage time in research activities	0	3	9	14	8	**3.79**
Ability to manage and optimize production processes	1	4	6	13	10	**3.79**
Recognition and implementation of opportunities for business growth	1	7	6	14	5	**3.35**

The ranking of the relevance of skills and competencies related to smart textiles is somewhat dispersed, mixing technical skills and transversal skills, reflecting the work students carry out in universities that requires such a mix.

Among technical skills, most relevant to the respondents were the ability to use and adapt textile technologies to produce smart textiles (average 4.38), use and adapt textile knowledge related to fibres/yarns/materials structure to create smart fibres/yarns/materials (average 4.35) and advanced digital skills; ability to use specific software for design and production of smart textiles (CAD/CAM systems) (average 4.21). Understanding and using the requirements specific to the application domain – multidisciplinary approach to the design of smart textiles (average 3.91) is a relevant skill for engineering in smart textiles.

Creativity in generating new ideas for the development of smart textiles (average 4.26) is an important skill for the respondents, showing that they understand the continuous development that characterises the sector. This is supported by the relevance of the change-orientated approach to product development of smart textiles (average 4.06).

Team work and project implementation skills considered to be most relevant are the ability to plan, design and execute research projects / prototypes referring to smart textiles (average 4.12), identify, pose and resolve R&D problems (average 4.09) and work in a team (average 4.03). Other aspects of team work and project implementation are covered by pro-active understanding of customers' and market needs (average 4.03), search for, process and analyse information from different sources (average 3.97), conduct risk assessment analysis in R&D projects for smart textiles (average 3.88), plan and manage time in research activities (average 3.79). The capacity of abstract thinking (average 3.91) is seen slightly less relevant by the respondents.

Entrepreneurial and market skills are considered important, but not as relevant as the technical skills related to smart textiles. It is the case of identification of market development and trends for the smart textiles sector (average 3.88), ability to manage and optimize production processes (average 3. 79), recognition and implementation of opportunities for business growth (average 3.35).

When asked if they would be interested in online training based on the training materials developed by the HACKTEX project, 85.3% of the respondents declared that they would participate in the training.

The topics that would be of interest to them are technologies for manufacturing smart textiles (79.4%), smart materials/products (73.5%) and raw materials for smart textiles (41.2%). Two respondents stated their interest in the evaluation of smart textiles, technologies for textile wearables and one was interested in everything related to the current state-of-the-art of smart textiles.

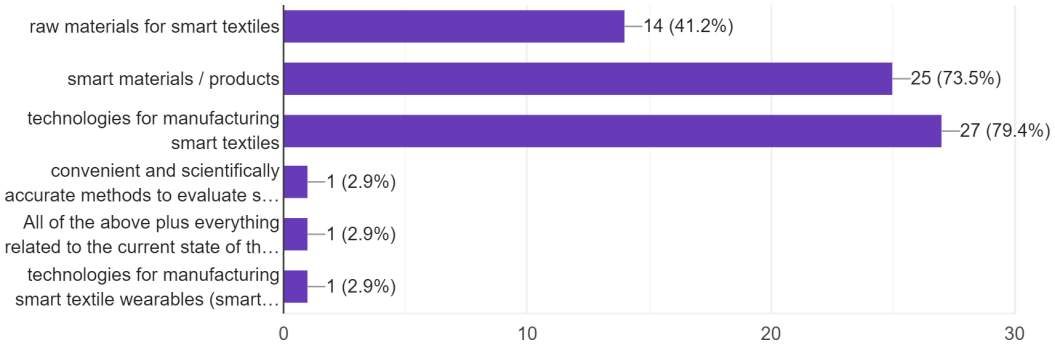


Figure 30. Distribution of topics of interest for training

Most of the respondents would prefer the video format for the online training (82.4%), with 58.8% being interested in lectures and 23.5% also in forums.

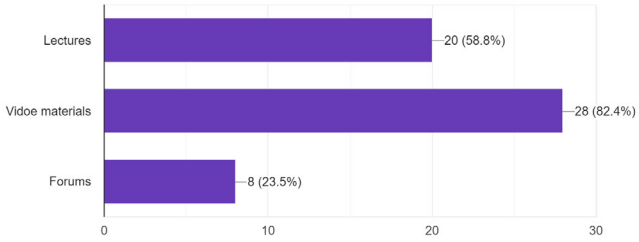


Figure 31. Preferred forms of presentation for the training materials

2.4. Comparative results for managers/specialists from the smart textiles sector, academics/researchers and students

This chapter discusses and compares the results of the survey, as described in the previous chapter in order to draw-up conclusions that will be used in the other results of the HACKTEX program, namely the development of virtual training materials, training materials for the bootcamp, virtual guide focused on entrepreneurship.

For this purpose, the results obtained for each group of respondents will be analysed and the most relevant options will be underlined.

2.4.1. Current needs of the smart textiles sector

This section of the questionnaires was addressed to experts from companies and from universities/research institutes. The section contains a number of 4 questions.

The first question discussed the importance of different key factors needed to develop smart textile prototypes/products. The respondents from companies have constantly rated these factors with lower marks than the ones from universities.

Table 15. Key factors for smart textile prototypes/products

Key factors for smart textile prototypes/products	Level of importance	
	Companies	Universities
Developing new technologies	3.71	4.07
Developing new raw materials/products	4.24	4.33
Standardization	4.00	4.33
HR with relevant skills	4.12	4.47
Adequate education/training programmes for smart textiles engineers	3.94	4.53
Understanding market requirements	4.06	4.20
Business models adapted to smart textiles	3.71	4.07

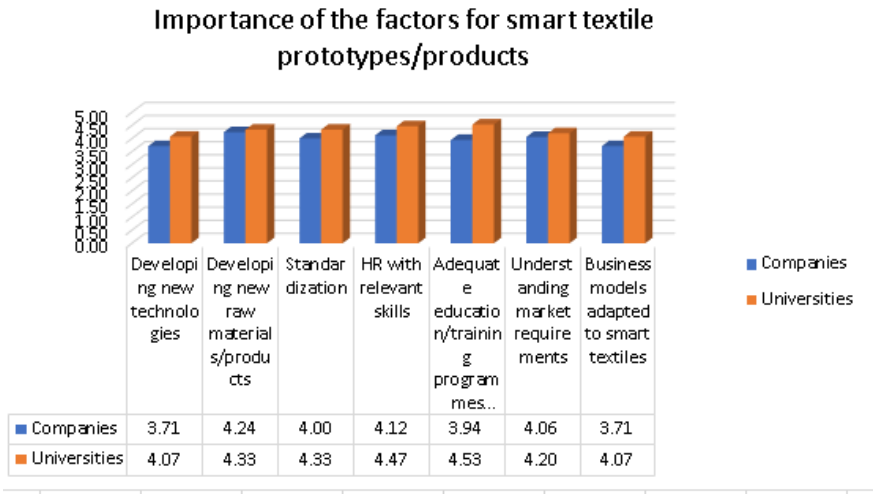


Figure 32. Graphical comparison of factors of influence on smart textiles

The data shows that both groups consider a set of 4 factors as having a considerable influence on the development of smart textile prototypes/products: developing new raw materials/products; HR with relevant skills; understanding market requirements and standardization. The factors related to the market (business models adapted to smart textiles) and the development of new technologies have been evaluated also in a similar manner. Both factors were rated as having the lowest level of influence from the list, but still of significant importance.

The only difference in evaluation by the two groups of respondents concerns the factor adequate education/training programmes for smart textiles engineers. The respondents from companies rate the level of influence with an average of 3.94, ranking this factor as 5th in the

level of importance. The respondents from universities rate the same factor with an average of 4.53, considering it with the highest level of importance from all factors.

When considering the main problems/challenges in relation to developing smart textiles, the respondents from the two groups evaluated them in a similar manner, especially in the case of lack of funding, considered the most relevant problem by both types of respondents. This shows that the lack of funding is a general issue, that affects both the sector and the academic/research institutes environment. The respondents from companies also consider the lack of proper technology and difficulties in acquiring it as a problem of utmost importance, while for the respondents from universities this is not such an important issue, as they are not involved directly in industrial manufacturing.

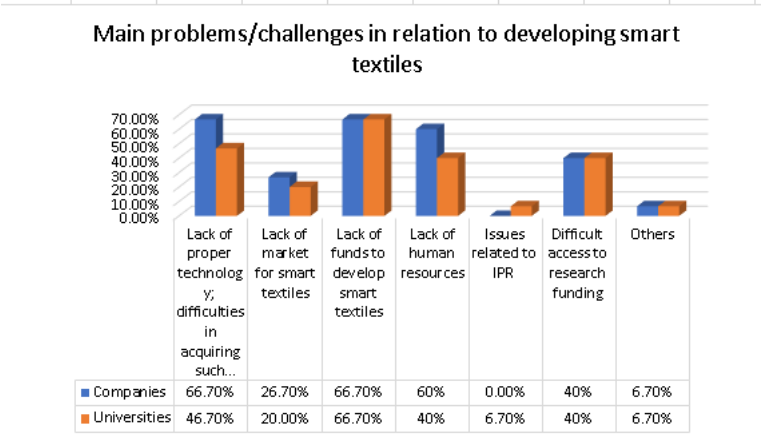


Figure 33. Graphical comparison of the ranking of main problems/challenges for smart textiles

The two groups agree that the 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. These evaluations show that these issues are a common ground for both groups on which they can build stronger links. Both sets of respondents consider that these needs have to be addressed mainly through education and research projects and then knowledge transfer.

Table 16. Actions to improve training in smart textiles

Actions	Level of importance		
	Companies	Universities	Total
Stronger links between the industry and universities	4.00	4.53	4.25
Improving existing laboratory infrastructure	3.35	4.47	3.88
Creation of more specializations/ programs related to smart textiles	3.88	4.13	4.00

Co-creation of curricula for smart textiles to reflect sector's needs	3.82	4.20	4.00
Short-term, dedicated trainings for the specialists from the industry	4.00	3.80	3.91
Attract more young people	3.76	4.20	3.97
More entrepreneurial education	3.76	3.27	3.53

This question referring to what needs to be done to improve training on smart textiles was also addressed to students. Similar to the evaluation of academics, they considered with considerable importance improving existing laboratory infrastructure and creation of more specializations/ programs related to smart textiles.

All groups of respondents granted a slightly lower level of interest to entrepreneurial education. The highest average belongs to the respondents from companies, showing there is interest in entrepreneurial education, especially applied to smart textiles.

2.4.2. Existing initiatives in the smart textiles sector

The second section of the questionnaires was addressed to experts from companies and from universities/research institutes and evaluated the participation of the respondents to different types of initiatives. Initiatives such as networks, associations, clusters, projects, programs, etc. are objects of interest for the companies, as well as universities/research institutes.

Both groups of respondents indicate that their companies, respectively institutions are part of such initiatives – 88.2% of the respondents from companies and 80% of the respondents from HEIs.

The two groups of respondents rank differently the motivation of participation in different initiatives (Figure 35). For companies, it is firstly based on the need to develop new products/technologies and then to develop knowledge. The main motivation of universities in taking part in different initiatives is to develop knowledge, followed by the desire to develop new products/technologies. This switch in motivation comes from the nature of the activity of each group of respondents.

Companies are more interested in research projects and partnerships with the industry, while universities are involved mainly in educational initiatives and research projects. For both groups of respondents, these initiatives are funded more at EU level. National funding is less frequent, accounting for around half of the EU initiatives. Private funding or use of other funds is not well represented. Respondents indicate that initiative partners are universities/research institutes, confirming the need for research of the domain. Partnerships with companies from the sector are also indicated by all respondents.

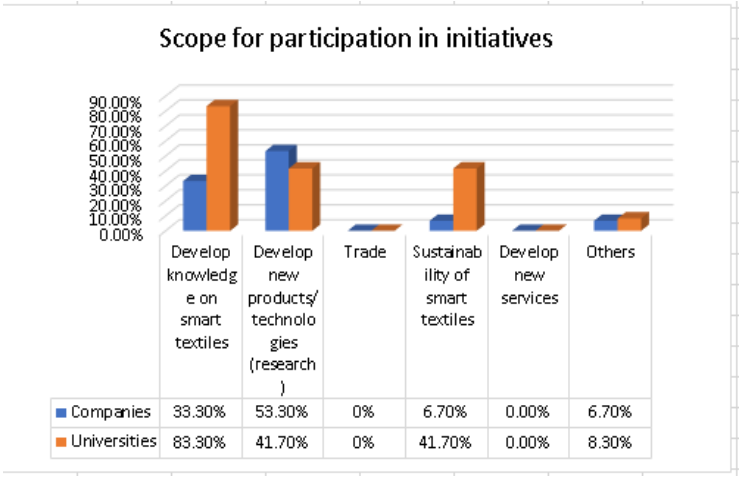


Figure 35. Motives for participation in initiatives

2.3.3. Perceived weak points in engineering training for the field of smart textiles

This section of the questionnaires was addressed to all groups of respondents: experts from companies and from universities/research institutes and students (part of the questions). The conclusions of this section have the most relevance to the development of the following results of the HACKTEX project, namely the macro/microstructure of the training materials to be created.

The first question referred to the issues affecting the training of smart textiles. This question was addressed to respondents from companies and from universities. Table 17 shows the average marks for each group, as well as the ranking of each topic resulted for companies (1) and experts from universities (2).

Table 17. Issues affecting engineering education on smart textiles

	Issues	Rank		Level of importance	
		1	2	Companies	Universities
1.	Students need more skills related to the R&D of smart textiles	3	1	3.81	4.07
2.	The content of lectures on smart textiles is not reflecting the latest developments in the industry	6	2	3.50	3.87
3.	Existing curricula do not include enough courses on smart textiles	2	3	3.88	3.73
4.	Curricula should include more internships for students in companies manufacturing smart textiles	4	4	3.75	3.71
5.	Companies are not involved enough in co-creation of curriculum for smart textiles	1	5	4.00	3.47
6.	More students should have their graduation thesis on smart textiles (especially M.Sc. and Ph.D.)	5	6	3.63	3.29

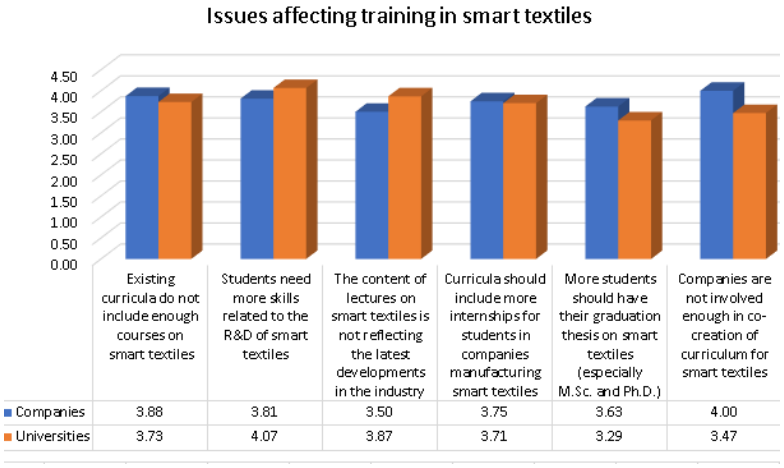


Figure 36. Graphical comparison of ranking of issues affecting training in smart textiles

Similar evaluations from the respondents from companies and those from universities rank higher the need for more skills related to the R&D of smart textiles (ranked 3rd by companies and first by universities), and more courses on smart textiles (ranked 2nd by companies and 3rd by universities). The respondents consider these two factors of influence are generally considered very important.

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 (ranked 5th by companies and 6th by universities), 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: respondents from companies rank 1st the importance of this factor, while universities rank it 5th. In addition, the respondents from universities consider that the content of lectures on smart textiles is not reflecting the latest developments in the industry and ranked 2nd this issue, while the respondents from companies think that the content of lectures on smart textiles reflects the latest developments in the industry and ranked it 6th in terms of importance.

The second question of the section targeted the type of knowledge considered to be of importance for training in smart textiles. This question was addressed to all groups of respondents. Table 18 shows the average marks for each group, as well as the ranking of each topic resulted for companies (1), experts from universities (2) and students (3).

Table 18. Knowledge relevant to engineering education in smart textiles

	Topic of knowledge	Rank			Level of importance		
		1	2	3	Company	University	Student
1.	New advanced/smart textile materials/ products	1	3	1	4.35	4.20	4.21
2.	New advanced/smart textile raw materials	2	3	1	4.24	4.20	4.21
3.	Complementary knowledge related to smart textiles (like physics, chemistry, electronics)	3	3	3	4.18	4.20	4.15
4.	Functionalization methods and processes for smart textiles	4	2	4	4.18	4.33	4.12
5.	Standards for smart textiles; evaluation of properties/product functionality	5	1	5	4.12	4.40	4.03
6.	Research methods and techniques specific to smart textiles	6	3	6	3.82	4.20	3.97
7.	Sustainable value chains specific to smart textiles	7	3	7	3.71	4.20	3.79
8.	Market trends	8	8	8	3.65	3.93	3.76
9.	Project management concepts	11	11	9	3.41	3.53	3.68
10.	Business models	10	10	10	3.47	3.60	3.59
11.	Non-technical aspects of advanced manufacturing specific to smart textiles	9	9	11	3.53	3.80	3.50

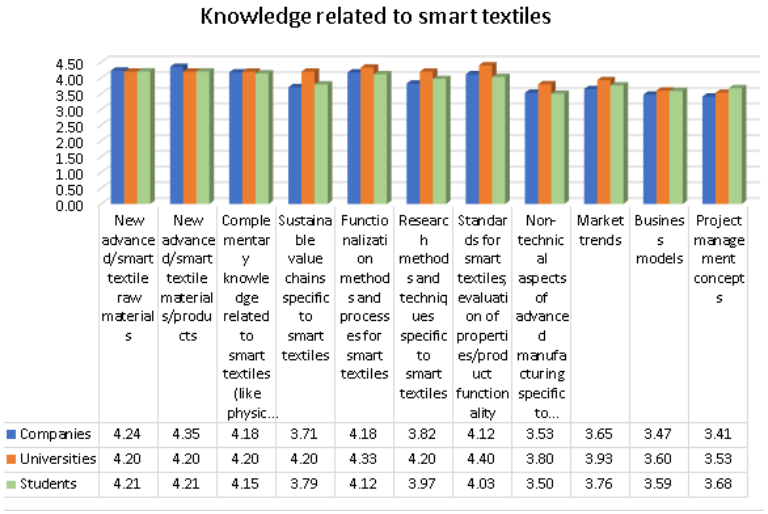


Figure 37. Graphical comparison of ranking of knowledge on smart textiles

All topics of knowledge on smart textiles were considered to be of considerable relevance to the training process.

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.

In reference to the topics selected as the 5 most relevant by experts from companies and students, the ranking resulting from the questionnaire for experts from universities is different, as it can be seen in Table 18. The largest difference in evaluation refers to standards for smart textiles; evaluation of properties/product functionality, ranked the 1st by experts from universities and 5th by the other two groups of respondents. However, for this group of respondents the relevance of knowledge topics is less separated: 4 topics have the same average mark (4.20), two of the topics on the list of the 5 most relevant presented above and two with slightly lower ranking for experts from companies and students: research methods and techniques specific to smart textiles and sustainable value chains specific to smart textiles. This ranking regarding knowledge on sustainability by respondents from companies and students suggests that this very important issue is not yet fully accepted by the sector and that the current content of lectures does not facilitate students form all the countries involved in this survey 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 third question of the section targeted the skills and competencies considered to be of importance for training in smart textiles. This question was addressed to all groups of respondents. Table 19 shows the weighted average marks for each group, as well as the ranking of each topic resulted for companies (1), experts from universities (2) and students (3).

Table 19. Skills and competencies important to training in smart textiles

Skills and competencies	Rank			Level of importance		
	1	2	3	Companies	Universities	Students
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 19 have received marks that rate them as relevant and could be considered when developing the 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 next question intended to rank the issues perceived as weak points in relation to cooperation between companies and universities for research on smart textiles. This question was addressed to experts from companies and universities.

The graphic from Figure 37 shows that both groups of respondents consider that different research agendas and different perception of research and innovation are the weakest points affecting the cooperation between companies and universities. 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.

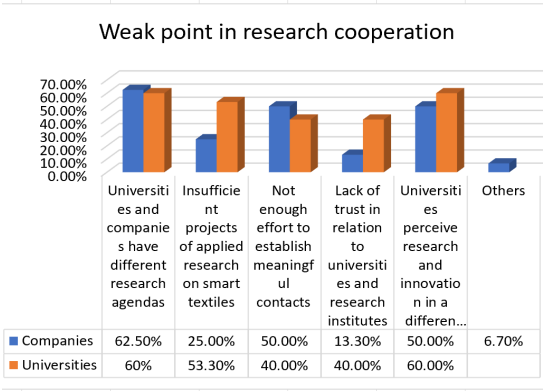
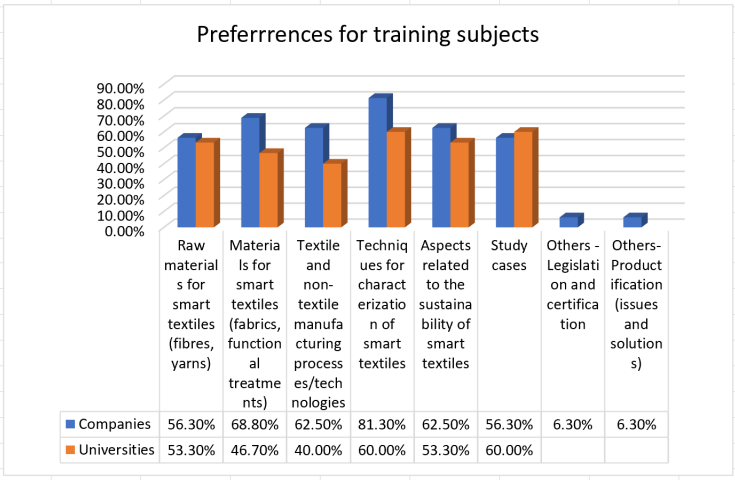


Figure 37. Graphical comparison for the weak points in research cooperation between companies and universities

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 from universities) or for themselves (students). The same situation was recorded in case of participation to HACKTEX training.

In terms of preferred subjects for smart textiles, the interest of companies is a good indicator for the appetence 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.



	Raw materials for smart textiles (fibres, yarns)	Materials for smart textiles (fabrics, functional treatments)	Textile and non-textile manufacturing processes/technologies	Techniques for characterization of smart textiles	Aspects related to the sustainability of smart textiles	Study cases	Others - Legislation and certification	Others-Productification (issues and solutions)
Companies	56.30%	68.80%	62.50%	81.30%	62.50%	56.30%	6.30%	6.30%
Universities	53.30%	46.70%	40.00%	60.00%	53.30%	60.00%		

Figure 38. Preferred subjects for training materials for smart textiles

Students expressed a lower level of interest in technical topics (less than 50%), but this can be due to possible less information on smart textiles, especially for B.Sc. students.

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.

3. CONCLUSIONS

The purpose of this survey 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 HACTEX project' outputs.

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 group of respondents allowed us to draw the following conclusions.

a) Current needs of the smart textiles sector

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.

The main problems/challenges in relation to developing smart textiles are lack of funding and lack of proper technology, difficulties in acquiring it.

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.

b) Existing initiatives in the smart textiles sector

Both 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.

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.

c) Perceived weak points in engineering training for the field of smart textiles

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

The 5 most relevant topics on smart textiles 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.

Knowledge related to non-technical aspects of smart textiles (market, business models, project management and non-technical aspects of manufacturing smart textiles) is constantly ranked slightly lower than technical knowledge.

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 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

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 survey showed that the companies and universities consider that further training in the smart textiles is needed and are interested in the training materials to be developed by the HACKTEX project. Techniques of characterization is the most selected topic. Non-technical subjects such as legislation and certification are also of interest for the industry. The preferred form of delivery for such training materials is videos.

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