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Design, Development, Implementation and Assessment of Skill Formation Process in the Frame of VET for R&D Staff

Evaluation Report of Need Analysis Survey

Abstract

In this report, the updated portrait on the current situation of R&D staff in Turkey and the project partners' countries is aimed to be demonstrated by means of the need analysis survey. The survey which is a part of the project funded by European Union in the frame of "Erasmus + Key Action 2-Capacity building in the field of higher education" was intended for the determination of the gap between engineering education and the necessary skills for R&D and P&D practices. By applying and analyzing the results of the needs analysis survey, it will be possible to highlight the needs among all the personnel working with the innovation focus for R&D staff. The need analysis survey was applied to 718 participants; 146 participants from Italy, 201 from Spain and 371 from Turkey. The selected participants work in different sectors such like business enterprise, government, higher education, private non-profit, private and public ones. The main results of the need analysis survey for all project partners are presented herein.

1. Introduction

In today's world, the importance of research and development (R&D) is a non-contestable matter. Especially in industry and technology sectors; developing competitive advantages, establishing sustainability and reaching goals in terms of innovation highly depend on R&D. When the context of developing countries all over the world is taken into consideration, R&D, patent and advanced technology indicators show that their competitiveness in terms of knowledge-based production is not at the desired level and that applies to Turkey as well. There may be several factors to that; however engineers' inadequate level of education on R&D stands as a crucial fact. To make it clear, engineers



who are employed in R&D centers generally have only bachelor degree which does not contain any specific training on R&D. In other respects, there are a critical number of engineers who reside as refugees in Turkey and the crucial need for R&D training has gained validity for them too.

In the light of the facts mentioned above and for the sake of remedying the stated deficiency, a project in which the development of an e-platform and an e-learning program are aimed was designed and developed to fulfill the critical need for R&D engineering training. Before developing the program, a need analysis survey was performed in order to detect the needed issues in the training stage of R&D staff. The purpose of this report is to present the results of the need analysis survey in terms of the demographic view.

2. The Utilized Methodology

In order to develop an e-learning program, a need analysis survey was carried out, which was applied to the R&D staff in Italy (146 participants), Spain (201 participants) and Turkey (371 participants). The need analysis survey was applied to the participants as a digital questionnaire form embedded into the official web page of the project. The questionnaire form consisted of five main parts such as Personal details, The definition, components and importance of R&D, Determining the opportunities for R&D, R&D project implementation competence and Commercializing R&D results. In order to analyze the data taken from the survey, SPSS software program was used for statistical analyses.

3. Results and Discussion

In this study, totally 718 R&D employees filled out the questionnaire forms. Table 1 shows the details on gender, level of education distribution of the participants in terms of countries. When the level of the education is considered, it is shown that the number of the employees who have graduate degrees (master and doctorate) in Turkey is seen to be lower than those in both Italy and Spain. The rates of participants with master (78.6 %) and doctorate degree (20.4 %) were higher in Spain.



Table 1. Descriptive statistics for participants.

		ITALY (n=146)	SPAIN (n=201)	TURKEY (n=371)	
		%	%	N %	P
Gender	Female	46.6	33.8	32.9	0.001*
	Male	53.4	66.2	67.1	
Do you have a master's degree?	Yes	49.3	78.6	27.5	0.001*
	No	50.7	21.4	72.5	
Do you have a doctoral degree?	Yes	9.6	20.4	4.3	0.001*
	No	90.4	79.6	95.7	

n: number of the participants *Significant at 0.05 level; Chi-square test.

Mean age of participants is found to be the highest in Spain and the lowest in Turkey (Table 2). In addition to this, the professional experience year of the employees is seen to be higher for Spanish staff when compared to Italians and Turks.

Table 2. Descriptive statistics for age and length of professional experience.

Variables	ITALY (n=146)	SPAIN (n=201)	TURKEY (n=371)	P
Your Age	35.78 ± 9.02	37.97 ± 7.54	32.07 ± 7.24	0.001*
Professional Experience (years)	9.21 ± 8.62	11.46 ± 7.29	8.26 ± 7.42	0.001*

n: number of the participants *Significant at 0.05 level; Kruskal Wallis test.

The subsectors in which the R&D staff work are given in Table 3. Participants' rates working for manufacturing are strikingly high for Italian ones (76.8%), second most frequent subsector for Italians is professional, scientific and technical activities. Among Spanish participants, 27.4% of the R&D staff are working in manufacturing sector, 20.4% of them for professional, scientific and technical activities and 14.9% of them are working for construction. Among Turkish participants 20.5% of them are working for professional, scientific and technical activities, 17.8 of them are working for construction, 18.5% of them for Information and communication and 12.3% of them for manufacturing.



Table 3. The sub-sectors for currently work places.

Could you please select the sub-sector you currently work in?	ITALY (n=146)	SPAIN (n=201)	TURKEY (n=371)
	%	%	%
C - Manufacturing	76.8	27.4	12.3
M - Professional, scientific and technical activities	4.9	20.4	20.5
F - Construction	1.6	14.9	17.8
A - Agriculture, forestry and fishing	3.2	10.9	8.9
J - Information and communication	2.7	4.5	18.5
P - Education	2.4	5.0	2.1
G-Wholesale & retail trade; repair of motor vehicles, household	2.7	2.5	2.1
K-Real estate, renting and business activities	0.8	1.0	7.5
Q - Human health and social work activities	0.8	3.5	0.0
N- Health and social work	0.5	2.5	2.1
E - Water supply; sewerage; waste management and remediation activities	0.3	3.5	0.7
B - Mining and quarrying	0.5	2.5	0.7
O-Other community, social and personal service activities	0.8	1.0	1.4
S - Other services activities	0.5	0.5	2.1
U- Activities of extraterritorial organisations and bodies	0.8	0.0	0.0
R- Arts, entertainment and recreation	0.0	0.0	1.4
I-Transport, storage and communication	0.0	0.0	1.4
T - Activities of households as employers; undifferentiated goods - and services - producing activities of households for own use	0.3	0.0	0.0
L-Public administration and defence; compulsory social security	0.0	0.0	0.7
H-Hotels and restaurants	0.3	0.0	0.0

Frequencies of answers about patent application, scientific paper experience and project funds are given in Table 4. Patent application rate for Turkey (20.5%) is higher compared to Italy (10.3%) and Spain (11.9%). Participating in a scientific publication rate is higher for Spain (45.8%) compared to Turkey (25.9%) and Italy (15.8).



Table 4. Frequencies of answers about patent application, scientific paper experience and project funds.

		ITALY (n=146)	SPAIN (n=201)	TURKEY (n=371)	P
		%	%	%	
Do you have an official patent application?	Yes	10.3	11.9	20.5	0.001*
Have you ever participated as an author in a scientific publication?	Yes	15.8	45.8	25.9	0.001*
Have you ever taken part in an R&D project funded by any program?	Yes	24.0	61.7	48.0	0.001*

n: number of the participants *Significant at 0.05 level; Chi-square test.

Frequencies of participants who think their company has necessary, required machineries or equipment are given in Table 5. Based on the survey, 64.2% of Turkish, 60.3 % of the Italian and 56.7% of the Spanish participants claimed to have necessary, required machineries or equipment. It can be concluded that there is no significant difference among the countries.

Table 5. Frequencies of participants who thinks theirs company has necessary/ required machineries/ equipment

		ITALY (n=146)	SPAIN (n=201)	TURKEY (n=371)	P
		%	%	%	
Do you think that your company has necessary/ required machineries/ equipment or not?	Yes	60.3	56.7	64.2	0.211

*Significant at 0.05 level; Chi-square test.



Results for Questions to evaluate R&D knowledge

Results for the ordered correct answer rates for overall data to evaluate R&D knowledge for all participants are given in Table 6. Only 12.7% of the participants know the correct answer such that education and teaching cannot be considered to be within the context of R&D. Furthermore 28.1 % of the participants correctly answered the question "R&D works are only performed by industrial enterprises with the purpose of manufacturing high-added-value products". For "R&D is a process that can only be executed by universities" and "R&D works contribute to the knowledge level of the society" questions correct answer rates are very high (78.4% and 76.3%, respectively).

Table 6. Results for Ordered correct answer rates for overall data to evaluate R&D knowledge.

	%
R&D is a process that can only be executed by universities.	78.4
R&D works contribute to the knowledge level of the society.	76.3
R&D works are considered to be creative.	73.8
R&D studies can only be made in a laboratory environment.	68.8
Improvement of an existing product is within the context of R&D.	68.8
R&D is a matter of reducing the costs and enhancing the quality standards.	58.9
R&D works are only performed by industrial enterprises with the purpose of manufacturing high-added-value products.	28.1
Education and teaching are considered to be within the context of R&D	12.7

Participants claimed their knowledge level based on 51 different subjects by scoring 1 (very bad) to 5 (very good). While evaluating knowledge level scores 1 and 2 were considered as bad level. Top five most unknown subjects for Italy are Sale / Transfer / Lease procedures of IPR (%65.1), Granting a patent (64.4%), CATIA (61.6), IPR (%59.9) and A3 thinking (54.1). Brain storming (6.2%), Microsoft Office (6.2%), Critical Thinking (10.3), Creative Thinking (11.6%) and Project Management (12.3%) are very well-known subjects.

Top five most unknown subjects for Spain are DFX (77.6%), CATIA (72.1%), A3 thinking (71.6), Eviews (69.2%) and FMEA (68.2%) (Figure 2). Microsoft office (4.5%), Brainstorming (15.9%) and Benchmarking techniques and methods in the context of R&D (19.9) are very well-known subjects.



Top five most unknown subjects for Turkey are SYSTAT (89.5%), Eviews (88.9%), Statgraphics (87.6), STATA (87.1%) and Rprojects (84.6%) (Figure 3). Brain storming (8.4%), Microsoft Office (8.6%) are very well-known subjects.

Figure 1. Top 25 Subjects listed from highest percentage (%) to lowest based on the bad knowledge levels for ITALY.

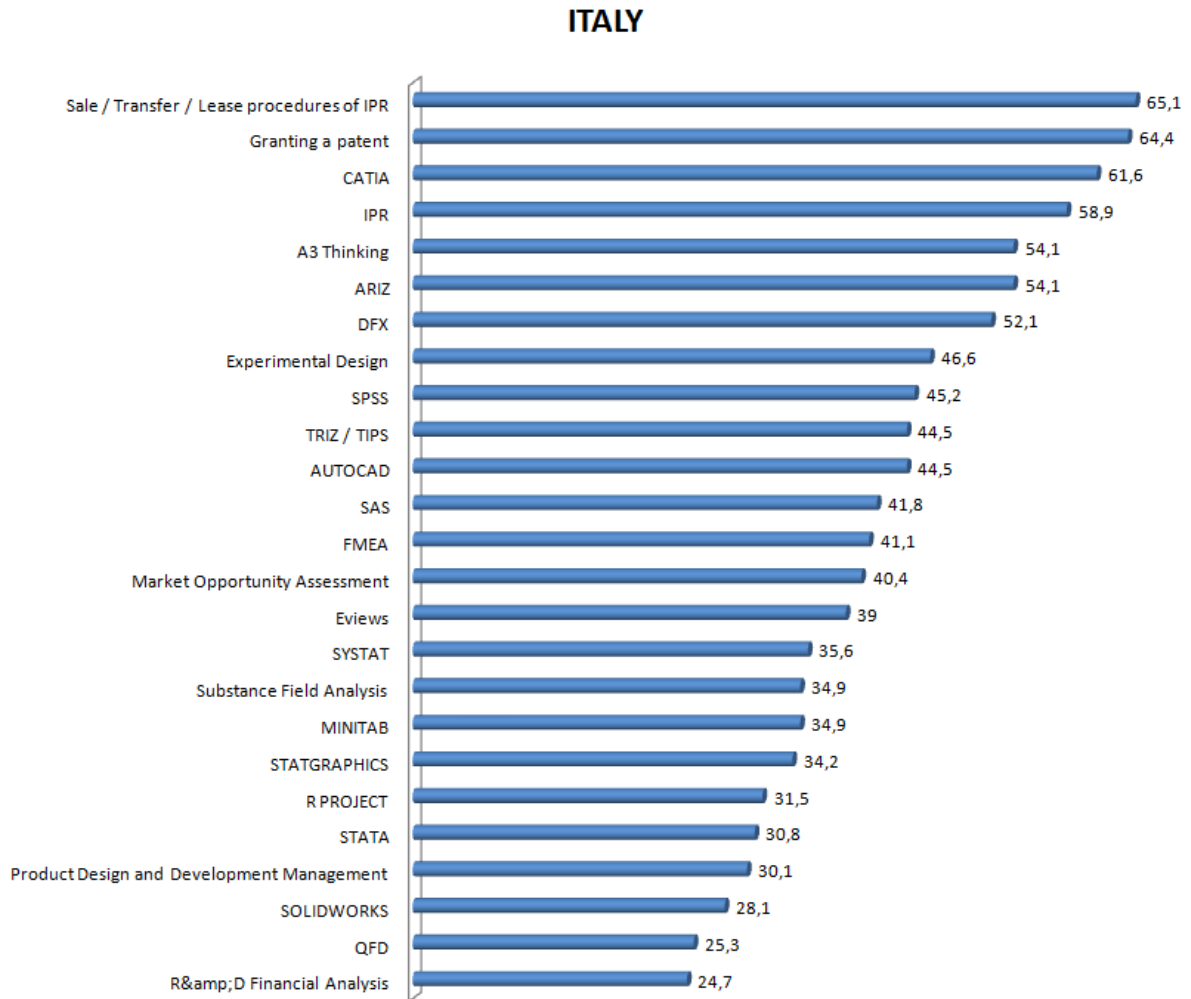


Figure 2. Top 25 Subjects listed from highest percentage (%) to lowest based on the bad knowledge levels for SPAIN.

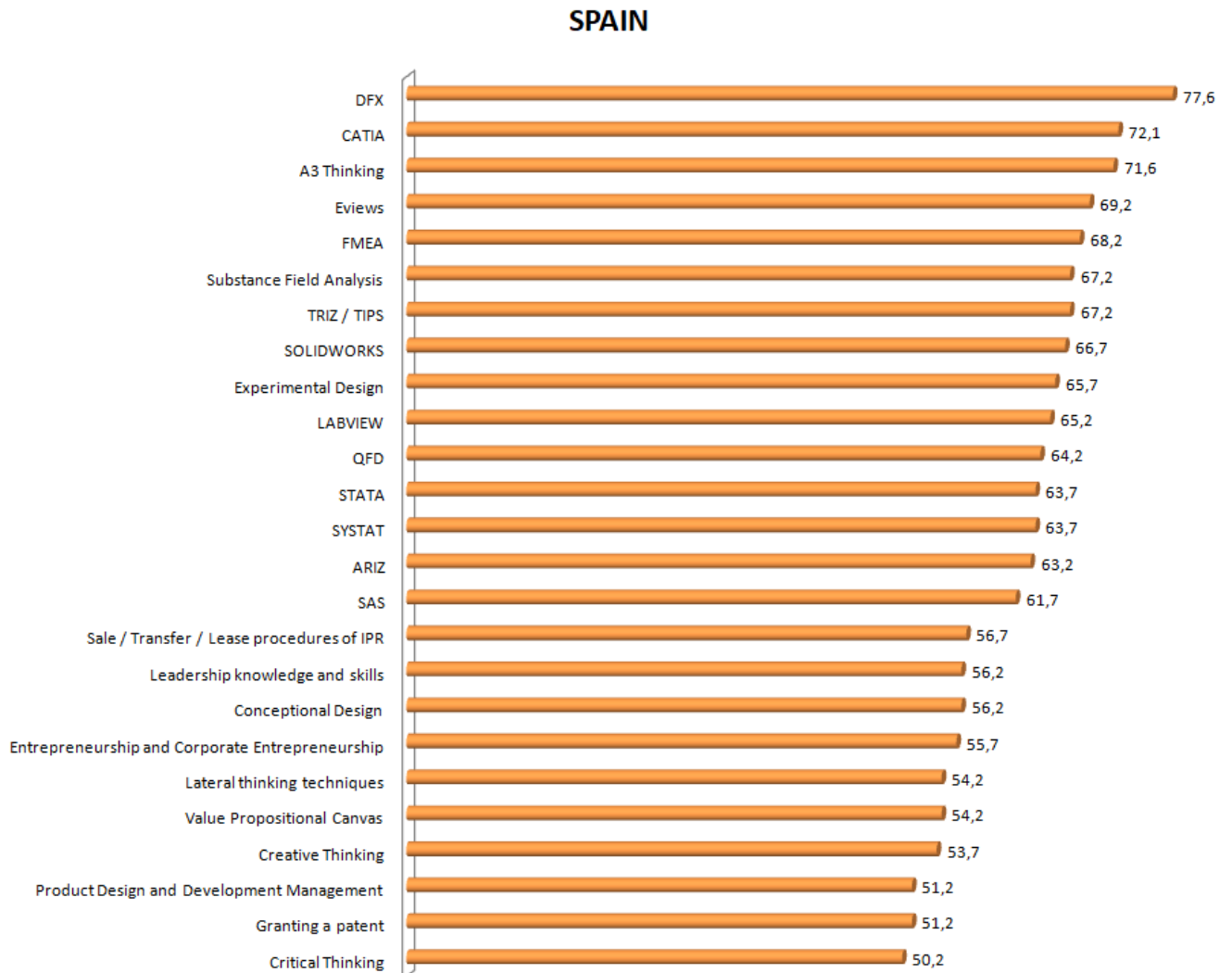
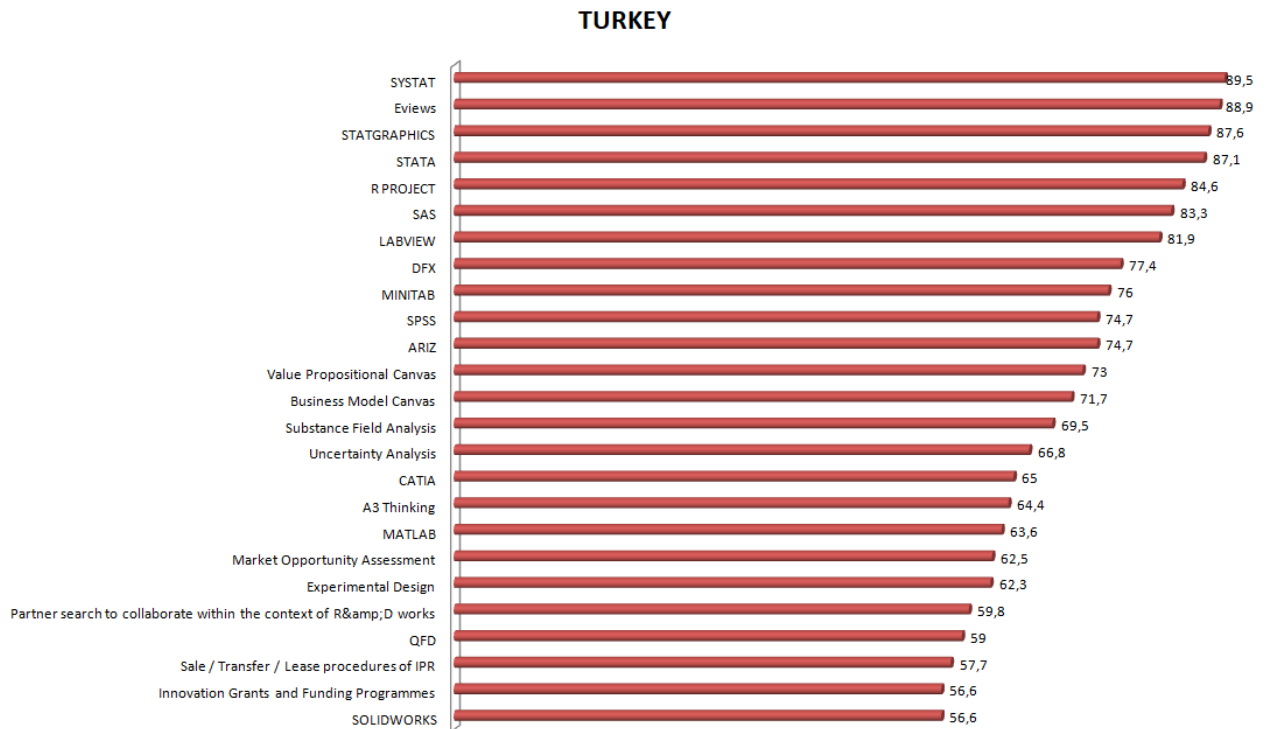


Figure 3. Top 25 Subjects listed from highest percentage (%) to lowest based on the bad knowledge levels for TURKEY.



For the same 51 subjects in the previous section were also asked to determinate level of training demand of participants. Granting a patent (60.3%), IPR (59.6%), Sale, transfer, lease procedures of IPR (59.6%), CATIA (55.5%), A3 thinking (54.8%) and ARIZ (52.1%) trainings are demanded by more than 50% of the Italian participants (Figure 4).

A3 thinking (71.1%), TRIZ/TIPS (69.7%), DFX (68.7%), Creative thinking (66.7%), FMEA (64.7%) and CATIA (64.2%) trainings are highly demanded by Spanish participants (Figure 5). But there are several subject voted for more than 50% of the participants.

SYSTAT (83.3%), Statgraphics(82.2%), STATA (82.2%), Eviews (81.1%) and Rproject (80.3%) trainings are demanded by more than 80% of the Turkish participants (Figure 6). But there are several subject voted for more than 50% of the participants.

Figure 4. Top 25 Subjects listed from highest percentage (%) to lowest based on the training needs for ITALY.

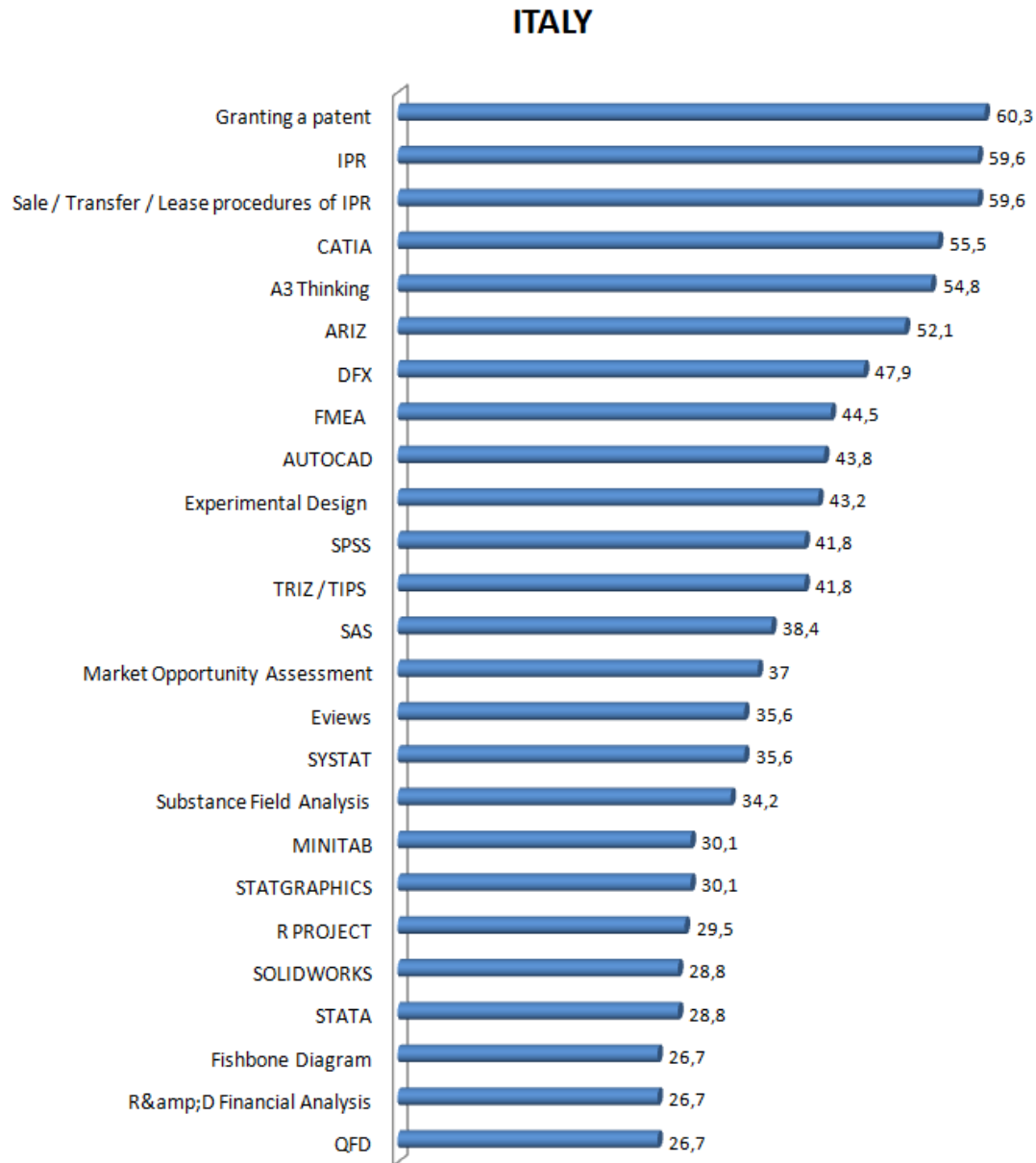


Figure 5. Top 25 Subjects listed from highest percentage (%) to lowest based on the training needs for SPAIN.

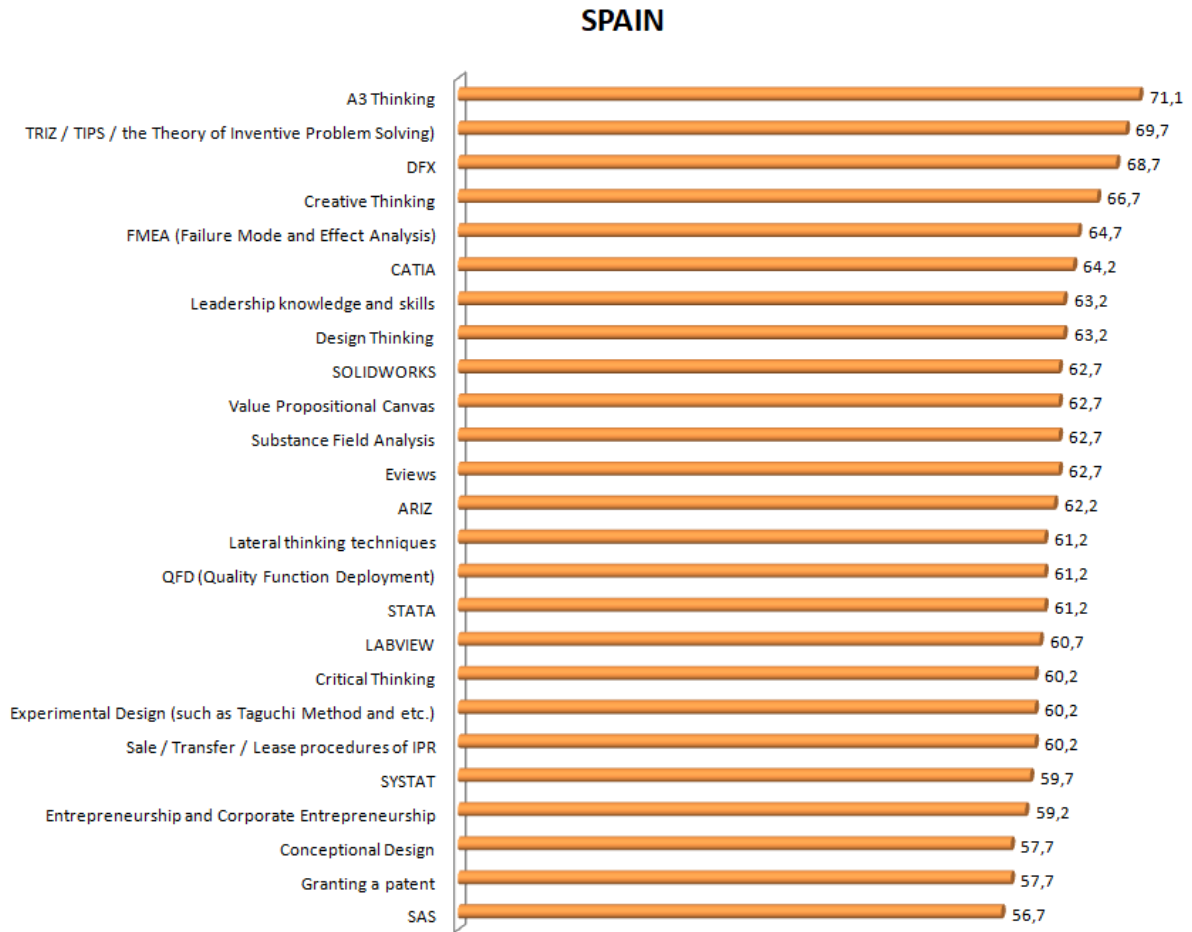
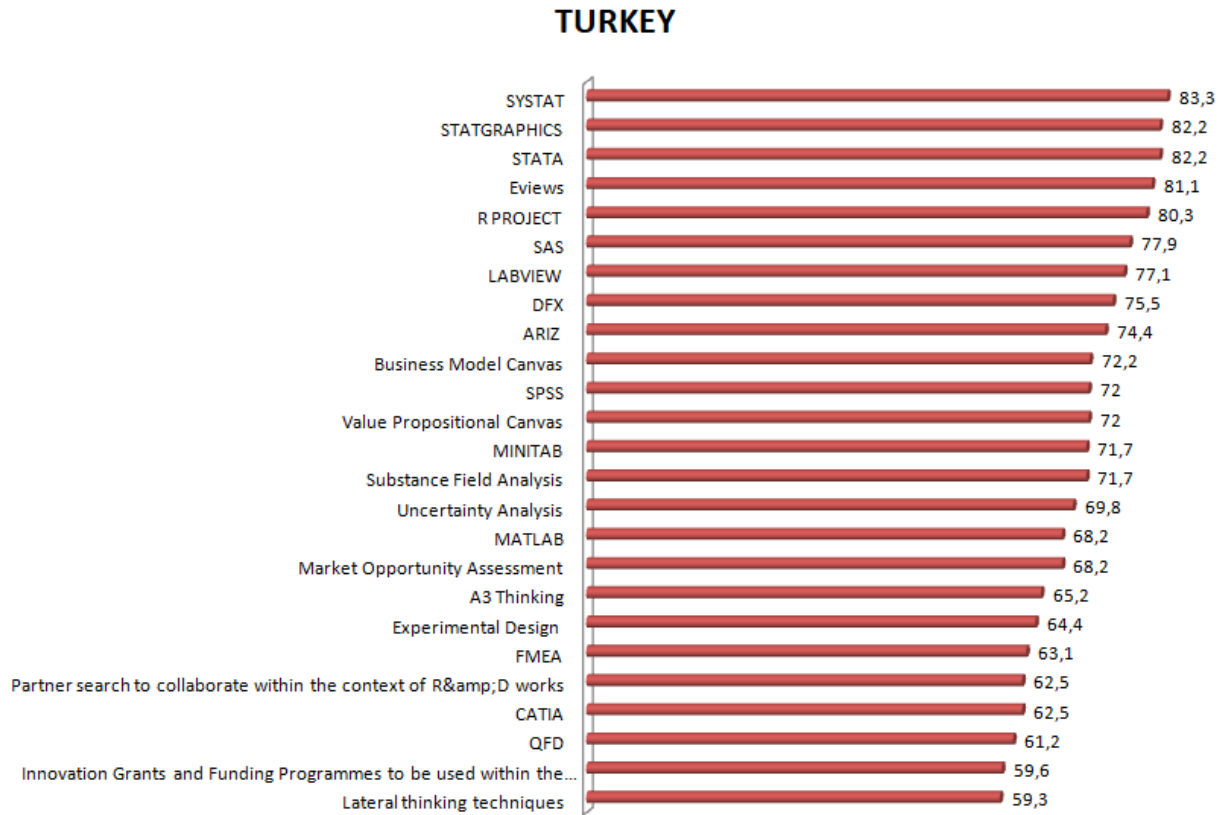


Figure 6. Top 25 Subjects listed from highest percentage (%) to lowest based on the training needs for TURKEY.



4. Conclusion

The need analysis has been conducted among 718 participants who work as a R&D staff; 146 participants from Italy, 201 from Spain and 371 from Turkey. Most of the participants have bachelor's degree. Especially in Turkey, the number of the staff who have master or doctorate degree is too low. The doctorate level is higher for Spanish staff. Among all participants, the level of the average age is higher in Spain. This also causes that the professional experience is higher in Spain. Most of the participants are from private sector in Turkey and Spain. But, the most of them are from business enterprise in Italy. Over 57% of participants in all countries claim that their company has necessary/required machineries/equipment. For Turkey, the training needs are generally focused on the statistical methods and programs. TRIZ/ARIZ is also more frequently desired one for training in all countries. Also, each need analysis survey report for the project partners is given below:



The conclusion taken directly from the report of the project partner “I-BOX CREATE S.L”

The gathered surveys have helped us delineate the profile of the respondents. The majority of the surveyed R&D professionals is male – 66% of respondents, while only the 34% is women. The average age of the respondents is 38 years old and has an average of 11 years of professional experience.

Most of the professionals (more than 60%) interviewed holds a Master’s Degree. 19% of them is a PhD Doctorate, followed by those holding a Bachelor (10%) and then those holding a VET degree (9%). The majority of the professionals working in the R&D sector is highly educated and only a low percentage comes from a vocational background – most of them coming from the basic sciences field.

More than half of the interviewees is employed in the private sector, especially in the manufacturing, scientific research and development, construction and agriculture, forestry and fishing fields. 88,06% of them does not hold an official patent application and most of them has never participated as an author in a scientific publication.

Most of the respondents has taken part in R&D funded projects and has experience in designing projects for national and European funding programmes. Most of the interviewed professionals has in fact taken part in governmental funded projects. For the implementation of their projects, respondents have collaborated with a wide range of partners – local universities, R&D centres, private enterprise and international institutions.

The majority of the interviewees do not think that their companies have the necessary equipment to conduct R&D and more than half of the R&D professionals has never taken part in a R&D project that does not fall within their area of expertise.

From the second part of the survey, the following conclusions can be drawn:

- The majority of the respondents affirms that R&D works are performed to develop new products, that they contribute to the knowledge level of the society and that they are considered to be creative works;
- The majority of the respondents strongly disagree with this statement: R&D studies can only be made in a laboratory environment and that R&D is a process that can only be executed by universities;
- Respondents were divided when replying to the following statement: R&D works are only performed by industrial enterprises with the purpose of manufacturing high-added-value products: in fact, 99 respondents agree, while 74 disagree with the assertion;



- The majority of the R&D professionals interviewed agrees that improving an existing product is within the context of R&D and that R&D is a matter of reducing the costs and enhancing the quality standards;
- Education and teaching are considered to be within the context of R&D for more than 70% of the respondents.

As for the third part of the survey, the main results show that:

- Benchmarking techniques, brainstorming, marketing research, project development stages and techniques suitable to the corporate strategy and performance measurement are topics well known by respondents. Only a third of them would require training.
- Systematic innovation and innovation techniques are known by 38% of the respondents, but also unknown by 32% of them. 36% of the sample declares to have middle knowledge and requires training. The same happens for the Fishbone Diagram, which is known by 57% of the respondents and unknown among 43% of them. Training is needed by 43% of the sample
- Lateral thinking, TRIZ/TIPS/the theory of inventive problem solving, QFD (Quality Function Deployment), ARIZ (the Algorithm for Inventive Problem Solving), FMEA (Failure Mode and Effect Analysis), Substance Field Analysis and Pareto Analysis are unknown by the majority of the sample and, as expected, more than half of them states that they would need training.
- Most of the respondents have none or little knowledge about Entrepreneurship and Corporate Entrepreneurship, Design Thinking, Creative Thinking, Critical Thinking, A3 Thinking, Value Propositional Canvas and Business Model Canvas. Training is needed for the majority of the respondents.

The data gathered from the responses of the last part of the survey illustrates that:

- Literature survey techniques and methodologies in R&D, R&D Financial Analysis and uncertainty analysis are not well known by the R&D professionals who took part to the survey and most of them expressed the need of further training of these topics;
- R&D performance measurement is a topic well known by 58% of the sample, reflected by the fact that only 38% of the respondents needs training.

Regarding the main statistics and analysis tools, respondents indicate that:

- The most known software and tools are SPSS, MINITAB, R PROJECT, Eviews, Microsoft Office;



- SAS, SYSTAT, STATA, STATGRAPHICS, SOLIDWORKS, LABVIEW, CATIA and AUTOCAD are not known or little known by the respondents. More than half of them expressed the willingness to be further trained on these tools;

- The largest part of the respondents shows a middle knowledge about the software MATLAB. 38% of them would require training.

Among the topics related to funded project management and implementation:

- Respondents show little knowledge about product design, R&D innovation grants and funding programmes, partner search, leadership knowledge and skills and more than half of them demonstrate their willingness to be trained on these themes;

- Project management is instead a well-known subject by 73% of the sample. Results are reflected in the need of training, by 32% of the respondents.

Respondents are quite unfamiliar with topics such as Conceptual Design, Experimental Design and DFX (Design for anything/ X), the majority of them manifesting a need for training. IPR (Intellectual Property Rights) and Sale/Transfer/Lease procedures of IPR are little known by respondents and most of the sample manifests need for training. Finally, regarding patent granting and market opportunity assessment, the largest part of the respondents would require training.

The conclusion taken directly from the report of the project partner “VITECO”

The analysis has been conducted among 146 Italian personnel working in R&D field, among which 78 males and 68 females. The level of education is quite high, as the largest part of the respondents holds a degree, mainly in engineering, technological and architectural studies. They work primarily within private companies in activities related to management consultancy, computer programming and civil engineering. The largest part of the respondents participated in R&D project fund by different programmes, especially European, in collaboration with SMEs, local universities, R&D centers, governmental organizations and international institutions. Surprisingly, many of them took part to projects outside their specialization. Only few respondents hold a patent application and less than 15% published scientific articles.

Going more in deep in the analysis, it is possible to say that, in the second part of the survey, most of the respondents seem to be:

- neutral on the assertion that R&D works are performed to develop new products and that they are a matter of reducing the costs and enhancing the quality standards;



- in disagreement with respect to the affirmation that R&D works can only be made in a laboratory environment or executed by solely universities or only performed by industrial enterprises with the purpose of manufacturing high-added-value products;
- in agreement with the fact that R&D works:
 - contribute to the knowledge level of the society,
 - are considered to be creative,
 - include the improvement of exiting products,
 - englobe education and teaching

In general, the findings of the third section highlight good results in terms of knowledge of more than 70% of the proposed topics. It is possible to say that the positive results are inversely proportional to the need for training in almost all answers. In particular:

- The topics regarding Benchmarking and innovation techniques, marketing research, performance measurement and methods in the context of R&D are very well known by more than 50% of the sample. Few people marked the need for training.
- Design Thinking, Creative Thinking, Critical Thinking and Latera thinking techniques are topics well known by the largest part of the respondents, on the contrary A3 Thinking, which results unknown by more than half of the sample (only in this case it is highlighted the need for training).
- Respondents are very aware of Entrepreneurship topics such as Corporate Strategy, the Canvas Business Model and Value proposition. Brainstorming is also a topic deeply knowns by almost the totality of the sample. Few people would require training in these fields.
- Regarding the methods for analysis and problem solving, only Fishbone Diagram, Quality Function Deployment and Pareto Analysis seem to be quite well known by respondents. Data show an average knowledge of the sample with respect to Substance Field Analysis, while only few acknowledgements on the Theory of Inventive Problem Solving, as well as for the Algorithm for Inventive Problem Solving and for Failure Mode and Effect Analysis. Half of the respondents would require training for these last three topics.



The last part of the survey highlights good results in terms of competences in R&D project implementation tools, techniques, methodologies and measures. Results, also in this section, are inversely reflected in the need for training: the higher the knowledge, the lower the required formation.

- Literature techniques and methodologies in R&D related to survey process, together with R&D Performance Measurement, Financial Analysis and Uncertainty Analysis are well known among almost 80% of the sample.
- With reference to the software for managing and analysing results, we can notice that Microsoft Office, Product Design and Development Management are the most known among the sample, with a percentage of awareness up to 90%. Good results also for SOLIDWORKS, LABVIEW and MATLAB, quite well known by about 70% of the sample (training would be required by one third of respondents). Average degree of awareness for statistical software such as MINITAB, SYSTAT, R PROJECT, STATA, STATGRAPHICS and EViews, with a percentage of awareness around 35-40%. The sample is half split with regard to “AUTOCAD” knowledge. More than 40% of the respondents would require training. Instead, the software SPSS, SAS and CATIA are not so known by the sample and the need for training has been marked by almost 50% of the respondents.
- The topics referring to the management process within R&D projects (Project management, Product Design and Development, Innovation Grants and Funding Programmes) are very well known by the largest part of the sample and, apparently, around 80% of the respondents have good expertise in Leadership skills.
- Middle-high knowledge above Conceptional Design and middle-low familiarity with Experimental Design, while DFX method seems to be unknown among more than half of the respondents. Differences are highlighted in the need for training, required mainly for the second and the third topics.
- Finally, arguments concerning Intellectual Property Rights, the procedures of IPS, including granting a patent are not well known by respondents. Almost 60% of them manifest the need for training.

