The Art of Science Learning

RESEARCH RESULTS

THE BIG VAN THEORY

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1. EXPLORATORY WORKSHOPS: METHODS AND CONCLUSIONS

To identify and include key education and communication tools in PERSEIAsthat address the human dimension of science, young people's interests in STEM and the RRI values, PERFORM designed and conducted six exploratory workshops with secondary school students from UK, France and Spain. The schools were chosen from medium and low socio-economic contexts, as was stated in the Document of Action (DoA).

In this section we describe the methodology applied and the conclusions obtained for the six exploratory workshops conducted. Data collected during the exploratory workshops will be available in the public repository Zenodo, and the data analysis is shown in Annex 1.

1.1 Exploratory Workshops Design and Analysis Methodology

As stated in the introduction, the PERFORM approach tackles issues related to RRI and societal challenges. For this reason, the project consortium designed the following six exploratory workshops (EW):

- EW1 - STEM market: The role of entrepreneurial and multidisciplinary research careers in labour market
- EW2 - Stereo-science-types: Science-related stereotypes
- EW3 - Life recreation: Ethical issues in scientific research
- EW4 - Our priorities for the World: Relevant scientific topics related to current EU societal challenges
- EW5 - Science and me: Two-way dialogue between scientists and the society
- EW6 - Guess who: Gender inequality and girl's barriers in STEM

The detailed description of the activities carried out in these EWs is available in Section 7. It was decided to use exploratory workshops as a research method instead of focus groups initially planned in the DoA due to the impossibility of splitting a classroom of 25-30 secondary school students into groups of 8-10 students in any of the selected schools in the three case studies, which is a condition for conducting focus groups. In contrast, a workshop format, although presents its limits in terms of discussion, allowed for the exploration of the topics we needed for elaborating the protocol.

In order to collect information from secondary school students' EWs, 6 Data Collection Protocols were designed (see Section 7). Data were gathered in two different ways according to the nature of each workshop:

- EW1 - STEM market, EW3 - Life recreation, EW4 - Our priorities for the World, and EW6 - Guess who: Data gathered through information written on post-its by the students and sorted by them according their preferences about the different topics.

- EW2 - Stereo-science-types, and EW5 - Science and me: Data gathered through participant observation during role playing games performed by students who recreated different scenarios in which students were involved. For example, in EW 2 students were asked to design and delivery short theatre sketches representing situations like "a scientist with her/his couple in an everyday situation".

In both cases, written notes were taken on the students' comments and discussion about these topics by the facilitators during the workshops. Facilitators also took notes on non-verbal information such as the students' mood, as well as complementary data such as their reception of the activity and any other relevant factors that could affect the implementation of the EWs. These inputs were thus

useful to identify contextual particularities in the development of the activity.

A total of 27 EW were carried out in selected schools of each country between March and May 2016, with a participation of 467 secondary-school students aged between 13 and 15 years (see figure 3.1 and table 3.1).

Figure 3.1. Exploratory workshop on Gender issues. Santa Eulàlia School, Terrassa, Barcelona, Spain.

Distribution by gender and socio-economic level is reported in figure 3.2. Informed consents to participate in the activities were obtained from participant schools and parental informed consents were obtained in the case of students.

Table 3.1 Number of participants per country.

Spain	United Kingdom	France	Total
181	142	144	467

Figure 3.2: Distribution by gender and socio-economic level

1.2 EW1- STEM market: The role of entrepreneurial and multidisciplinary research careers in labour market

A total of 70 students participated in this EW aiming to identify those professions perceived by students as the most attractive considering the consensus list of "best jobs ever" they ranked. Discussions were held in small groups (4-5 members) in which students drew up their own lists of professions. Finally, the facilitator counted the mentions of each small group and elaborated a final list.

Also, students identified those features related with their ideal jobs. We measured the weight of each of them by the number of mentions they received during students' interventions in the EW in relation to the total number of mentions about the different features identified in each EW. For further details see Annex 1.

After data analysis, we observed a positive image in the way students characterize the two professions mentioned (i.e., engineers and doctors) which were strictly related to STEM careers. They saw engineers as "fun", "enjoyable" or "creative" people (UK group) while doctors were perceived as having a special ability for "teamwork", "quick-thinking" and "help people" (UK and France groups).

Paying attention to local particularities some differences in the answers of students were noted. Firstly, participant students in the UK were those who had

most mentions of jobs related to science in their list of "best jobs ever", while their Spanish counterparts only mentioned architecture as STEM career in the strict sense of the term –although in a broader sense the pilot profession can be considered to involve the use of scientific techniques -.

Secondly, professional motivations also differ in their nature. In UK, participant students appreciated the social utility of their choice and were closer to intrinsic motivations. Meanwhile, in the French schools, students also valued jobs related to support and social recognition but they differed of their UK counterparts in including professions related to the army and the police services under this tag. Incentives related to extrinsic motivations (i.e. “money”) and low effort level (i.e. “no need long studies”) were also important for some French students. Finally, the Spanish sample was fully identified with motivations that clearly fall within the extrinsic extreme and, like the French one, whose students valued that their "best job ever" did not involve a great sacrifice (related with the category “no need long studies”).

In general, our data showed a moderate relationship between STEM careers and aspirational jobs, although their intensity was irregular along the case studies. **To reinforce positive attitudes of secondary school students towards STEM careers, and according to these results, some recommendations can be extracted: (i) PERSEIAs should highlight that science and STEM jobs are everywhere, (ii) some of the features that students consider positive (travelling, helping other, etc.) can be found with STEM jobs, and (iii) some well-considered jobs are actually STEM jobs.**

1.3 EW2- Stereo-science-types: Science-related stereotypes

A total of 81 students participated in this EW, which aim was to explore the stereotypes that young people associate to scientists. To this end facilitators assigned to each small group of students -of 4 or 5 people- one situation related to

professional and personal life of scientists, and they had to deliver, in front of all the class, their short representations. After that, a discussion on the represented stereotypes was done with all the class assisted by facilitators. For further details see Annex 1.

As an outcome of the activity it was possible to picture an image of a scientist based in those statements more commonly recorded among participant students. They identified scientists as brilliant, curious, compulsive people, with undermined social abilities that make very difficult for them to engage with others, either in public or personal contexts.

Students also considered scientists to be hard working people who are motivated more by their thirst for knowledge than by economic or material rewards. Participants stated that scientific careers are a long-term goal, which requires high levels of commitment and dedication (see figure 3.2).

Figure3.2. Exploratory workshop on stereotypes. Fairfield High school, Bristol, UK.

Additionally, students shared the impression that most research work is developed with very limited material and financial resources, as this student from Spain mentioned:

> *"In laboratories there is a boss in charge, and they usually have very little money to research and pay their workers".*

In order to understand some of the conclusions it is important to consider the EW facilitators' remarks. Among the most interesting observations made in the three case studies was the fact that most of the stereotypes which emerged during the different role plays were strongly influenced by TV fiction. In particular, by American

sitcom 'The Big Bang Theory', premiered on CBS on September 24th, 2007.

It was also noted that participants did feel comfortable playing as scientists regardless their gender, and there were no specific gender references when describing a scientist during role plays, although there were some scientific professions, such as chemist, that were strongly masculinized in some contexts. Finally, the lack of references to what have been called the 'Frankenstein Myth' that presents scientist as mad evil people should be mentioned.

A general remark that can be extracted of EW2 and should be taken into account when designing new PERSEIAs was to reinforce positive stereotypes such as "external recognition and self-confidence" or "the ability to solve problems through their imagination", as well as to break the negative ones such as scientists being "nerd", "socially awkward", "intransigent", "locked in their own world" and "without time for anything else than their own work".

1.4 EW3- Life recreation: Ethical issues in scientific research

A total of 74 students participated in this EW. In this EW we identified those ethical implications involved in scientific discoveries through the confection of two lists. In one of them students ranked some innovations provided by facilitators from "doable" to "impossible", while in a second list they reorganized the items from "unacceptable" to "desirable". For further details of the activity see section 7 and for data analysis see Annex 1.

This EW aimed to make students realize, verbalize and discuss about their own ethical feelings on science and innovations. Across the categorization of several scientific applications in the axis "doable-impossible" and "unacceptable-desirable" the students showed their own preoccupations about the eventual enforcement of these realistic ("make a bacteria that can produce energy") and fantastic ("know at

birth how you will die") items.

With regard to the rejection attitudes towards some of the items, the majority argument was revolving around their concern about the possibility of scientists to "play God", breaking the supposed natural balance. In their imaginary an association between "natural" and "good or appropriate" order existed. Accordingly, students only allowed scientific intervention when it comes to fix the deviations that human beings has caused in the natural course. Examples of this view were provided by one student from UK and another from Spain:

> *"We must revive extinct species only if the extinction was humans' fault. In other way would be unethical"*

> *"If it is to re-create extinct species killed by humans (...) then it is a very good thing"*

In this EW explicit religious arguments were barely shown, although this type of argument based on a mystification of nature could be considered as a subtle reminiscence. Other strong arguments within rejection positions to some of these applications were related to a concern about the unintended consequences of inventions, especially the loss of employment, as this student from Spain mentioned:

> *"Create humans without diseases are the most important, but would leave the doctors unemployed"*

Also they used some arguments, probably influenced by their cinematographic culture, consisting in the fear of some of the artificial creations that can rebel against humans, as this student from France:

> *"Make robots could remove the work from humans and they could take over*

the world"

Sensitivity to interference in the private life of individuals as a way of predetermination was also present in their arguments, but in a minority of the students. In particular, a student from UK was worried about the items referred to choosing some characteristics of babies before their birth:

"Being good at school should be a decision taken by the child, not by the parents"

Animal and environmental awareness in eventual scientific experiments and public participation awareness in relation to the process of scientific decision-making were among the students' shared worries, as this student from UK mentioned:

"It is compulsory to bear in mind citizens' opinion"

The underlying notion of utility associated with science in their speeches showed some peculiarities of the local contexts. In the case of Spain, for example, the usefulness of knowledge was not perceived if it did not involve humans, while in France and the UK workshops, knowledge represented a value in itself, further on that it was useful for the human well-being.

Also, UK students were able to notice many nuances in discussions and they gave much importance to their assessment of ethical considerations (as it usually said, "devil is in the details") showing more maturity in their responses than French and Spanish students. This is perhaps the reason why participant students in the UK had more difficulties to reach a consensus on ethical issues in this EW. The end point of most discussions was the need to appeal to an "expert", a figure to which they attach great relevance when it comes to assess decisions related to science. Finally,

there were also differences around problematic issues related to scientific discoveries in each national context, shown in table 3.8.

Table 3.8: Controversial issues per country.

Controversial topics of UK students
Bring back to life a person who has been under cryogenic process
Creating a custom sized dog
Create a child who will always be top of the class

Controversial topics of French students
Chose the sex of a child
Bringing back to life someone who has been under cryogenic process
Cloning a human being

Controversial topics of Spanish students
Recreate an extinct species
Build a living being from inert matter
Cloning a human being

In general, all participant students had well identified some recent advances of science; so that in the ranking from possible to impossible applications most of the groups gave answers coherent with reality. However, in the French case study some topics like “clone a human being” or “knowing at birth how you will die” reached marks that put them in the place of the “possible” applications.

In conclusion, from this EW some general recommendations were deduced to build new PERSEIAs: (i) they should highlight that scientists follow ethical rules, and (ii) that research is not conducted to generate useful knowledge only for humans' benefit.

1.5 EW4- Our priorities for the World: Relevant scientific topics related to current EU societal challenges

A total of 54 students participated in this EW. Its objective was to identify students' choice of most pressing societal challenges and compare if such proposals coincide

with the societal challenges identified by the European Union. Facilitators set up a fiction scenario in which students were asked to decide the big challenges that the world is facing in three levels: neighbourhood / city, country, and European level. Then facilitators assigned each student's proposal to a specific European societal challenge of the H2020 Programme (i.e., "Health, demographic change and wellbeing", "Food security", "Sustainable agriculture and the bio economy", "Secure, clean and efficient energy", "Smart, green and integrated transport", "Climate action and environment" "Inclusive, innovative and reflective societies", "Secure societies, freedom and security") and students discussed about them. The specific protocol for this workshop can be seen in section 7, and the data analysis can be consulted in Annex 1.

Although health was a priority to students, it was possible to identify significant differences between the challenges receiving the highest number of proposals in each case study. While in the Spanish case study climate actions were almost as important as health issues for students, for French participants security was a key priority (see figure 3.3), more important even than health. In the case of UK, students perceived environment and security as equally relevant although the number of proposals received by these two issues was considerably lower than the number of post-its dedicated to health.

Figure 3.3. Exploratory workshop on societal challenges. School Grange aux Belles, Paris, France.

Finally, it was noted on facilitators' remarks that some challenges were not properly understood by the students, such as the concept of reflective societies. They found the item to be too ambiguous or difficult to translate into recognisable daily situations.

On the second hand, facilitators pointed out that those proposals made by students from low socio-economic neighbourhoods in the three case studies were very specific and mostly focused on solving common social problems perceived as daily situations. Meanwhile students from medium socio-economic backgrounds formulated wider proposals tending to cope globally with the problems associated to a particular challenge.

As for this EW, lessons learnt show that further PERSEIAs should address those societal challenges considered of interest by students as a hook, taking into account the local particularities discovered. For this reason,

EU societal challenges should be approached using specific and contextualized examples.

1.6 EW5- Science and me: Two-way dialogue between scientists and the society

A total of 51 students participated in this EW. The aim of this EW was to analyse how students currently interact with science and scientists and how they would like to do it. In order to reach this goal, facilitators asked students to prepare a programme on a specific media (YouTube channel, TV channel, radio program, newspaper) about science and society. Each group delivered their programmes tothe rest of the class. The specific protocol for this workshop can be seen in section 7, and the data analysis can be consulted in Annex 1.

The separate analysis of this particular EW results was especially interesting due to the important differences observed between participant students in the different countries. The level of interest varies from very low levels in the Spanish case study, where a facilitator noted that half of the participants declared not being interested at all in what scientist do; to higher levels in the UK case study, where students stated to be very interested in researchers' work, considering the important impacts of their work in society.

When participant students were asked about their main sources of information regarding science, Internet and specially Wikipedia appeared in all three countries as popular sources, but while for Spanish students those were the only cited sources, in French and UK case studies students also included their teachers as a more reliable source. In addition French students highlighted the influence of scientific museums as scientific sources, while for UK students' media, particularly the BBC channel and scientific books were also important and reliable scientific information sources (see Annex 1).

Regarding their personal experience with scientists, Spanish students stated not having any particular daily contact with researchers, as they did not identify

their science teachers as scientists, while for French and UK students the image of their science teachers being scientists was very clear. When citing relevant scientists all three groups of students mentioned both historical figures, such as Isaac Newton or Albert Einstein or celebrity scientists from the media, such as Stephen Hawking or Eduard Punset in Spain and Brian Cox in the UK.

Finally all three groups claimed to be highly motivated for participating in science but when interacting with a researcher, Spanish students were more interested in knowing about their current job, while for students in both French and UK case studies personal information about scientists' daily lives and work was also important. Participant students in UK showed higher levels of interest in improving their scientific literacy by consulting with scientists.

Out of these results some tips can be extracted to use in future PERSEIAs. It is important to highlight to students that their STEM teachers are relevant sources of scientific information. Besides, PERSEIAs should include the name of relevant scientists.

1.7 EW6- Guess who: Gender inequality and girls' barriers in STEM

A total of 92 students participated in this EW. This EW identified students' perceptions about those features associated to STEM jobs and promote discussion about whether those features can best suite a man, a woman or neither (gender neutral). With this purpose students were organised into groups of 3 or 4 members and each group worked with STEM jobs from the following list: inventor, veterinarian, chemist, astronomer, and geologist. They wrote down on different post-its 5 things that characterise the people doing those jobs. Later their notes were discussed to assign a gender (masculine, feminine or neutral) to each adjective. Finally, the total percentage of features assigned to each gender was weighted based on the number of total adjectives handled in the EWs (see figure 3.4). The percentage of the features of each gender associated with each profession was pondered by the

total of the adjectives received in a particular career. The specific protocol for this workshop can be seen in section 7, and the data analysis can be consulted in Annex 1.

Figure 3.4. Exploratory workshop on gender issues. Santa Eulàlia School, Terrassa, Barcelona, Spain.

Overall, most of the adjectives related to scientific professions were gender neutral. If we pay attention to particular professions, astronomy appeared strongly related with "feminine" attributes and the most masculinized ones were geologist and inventor. Veterinary and chemist were seen by the students as the most gender neutral careers.

The association between scientific professions and gender stereotypes did not seem to be very strong. The category of "gender neutral" adjectives was the most relevant if we pay attention to the whole set of answers given in the three case studies. For this reason, **the tips that can be extracted from this EW for further PERSEIAs are to highlight that STEM** jobs are **not gendered, paying special attention to girls and chemistry. Also, to show female and male scientists as role models.**

EXPLORATORY WORKSHOPS DATA ANALYSIS

For data analysis two approaches have been used depending on the nature of each EW following Hsieh & Shannon (2005):

- Summative content analysis: 'Priorities for the world', 'gender' and 'STEM careers' EW had a very standardized guide for their development in the classroom, so they provided a type of outcome more suitable for their quantitative exploitation. In these EW students were asked to sort some topics, organize preferences, or assign values to particular categories.

- Directed content analysis: 'Science and me', 'stereotypes' and 'ethics' exploratory workshops produced more discursive outcomes suitable for a more qualitative approach. Hickey & Kipping (1996) provided by the amount of existing prior literature.

EW1- STEM market: The role of entrepreneurial and multidisciplinary research careers in labour market

For this topic we carried out four EW with the characteristics in table 3.2.

Table A1.1: Number of students per EW1 in each case.

	UK	France	Spain	TOTAL
Boys	9	17	11	**37**
Girls	6	18	9	**33**
Total	15	35	20	**70**

This EW also aimed to understand if young people associated STEM careers with future 'good' jobs. With this objective in mind participants were proposed, in first place, to discuss in small groups what could be their ideal jobs for the future. The jobs chosen by each group were written in the blackboard and, as a result, we obtained a final list with the five "best jobs ever" (see Table A1.2).

Table A1.2: "Best jobs ever" by country

Spain	**France I**		**UK**
Businessman	Architect	Military serviceman	Teacher
Airline pilot	Doctor	Architect	Doctor
Football player	Wedding planner	Police officer	Engineer
Architect	Football player	Airline pilot	Spy
Politician / Model	Businessman	Doctor	Lawyer

As can be seen, doctor and architect, followed by business man, football player and airline pilot were the most cited ones. None of the students mentioned specifically a "scientist" but if we pay attention to the specific disciplines included in STEM careers (Chemistry, Computer Science, Engineering, Environmental Science, Geosciences, Life Sciences, Mathematics and Physics/ Astronomy) we found that two of the jobs cited by students are related specifically to one of those fields (engineer and doctor). Indeed, the content of other professions reported here are (or could be) also related to science in a wide sense (such as teacher or airline pilot) but students were not able to detect this implicit relation in further discussion.

After examining which was the "best jobs ever", this EW looked over which

characteristics students usually associate with the former "best jobs ever" (figure A1.1). Students usually relate best jobs with earning money, travelling and a high degree of autonomy, which is proof of the complex intrinsic and extrinsic motivations that operate students' preferences. They seek social relevance through their "best jobs ever" but this concept changes along with the different cultural contexts. For example, in the case of Spain this relevance is related to business and media repercussion while in the case of United Kingdom it is related to teaching.

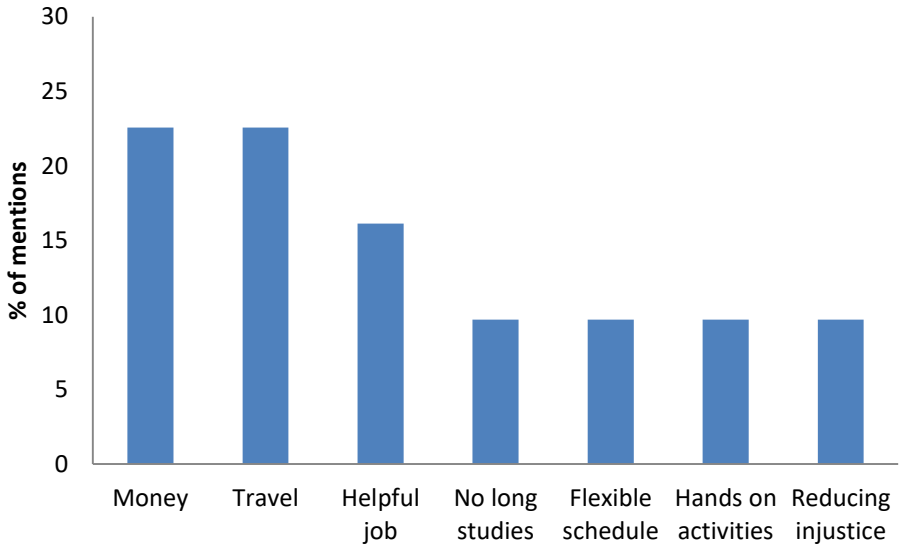


Figure A1.1: Features that student relate to their "best jobs ever". Total results

Most of these characteristics (travel, helpful job, flexible schedule) are also applicable to some STEM jobs but they do not identify this connection. On the other hand, the requirement that ideal work does not entail long studies -related with a low level of effort and short-term goals- seem to collide completely with the particularities of the research career. This is particularly evident in the case of Spain and France.

3.3 EW2- Stereo-science-types: Science-related stereotypes

For this topic we carried out four EW with characteristics shown in table A1.3:

Table A1.3: Number of students per EW2 in each case.

	UK	France	Spain	TOTAL
Boys	13	0	22	**35**
Girls	10	8	28	**46**
Total	23	8	50	**81**

Data obtained from student comments were analysed through a directed content analysis (Hsieh & Shannon, 2005). In order to apply this analysis collected data were classified according to the four topics that facilitators proposed to students (see table A1.4).

Table A1.4: Dimensions and categories identified through the exploratory workshops (indicators and/or criteria previously identified in the literature review but with no mention in EWs are indicated with an asterisk)

Dimensions	Categories	Examples
Scientists at leisure	**Boring**	*"Scientists work during the weekend and go out very little" (S_Spain)*
	Bad material conditions	*"In laboratories there is a boss in charge, and this usually has very little money to research and pay their workers" (S_Spain)*
	Freaky, nerd	"Scientists are nerds, people unsocial" (S_Spain)
	Social rejection	"In class he is a brainier who

		knows everything. Outside class he has social problems and classmates hit him" (S_Spain)
	Imaginative	*"Scientists are able to invent things tosolve their own problems"*(S_Spain)
	External recognition	*Manager recognises scientist and gets autograph (in the role play)*(S_UK)
Future scientist at school	**Freaky, nerd**	*"They can only speak with scientific words"* (S_Spain)
	Social rejection	*"Outside class he has social problems and classmates hit him"*(S_Spain)
Scientific professional projections	**Knowledge motivation**	*"To be a scientist you must be motivated by scientific phenomena"*(S_Spain)
	Long term goal	*"It is too much time to spend studying"*(S_Spain)
	Self-confidence is necessary	*"To become a scientist you must have great self-confidence"* (S_Spain)

Scientist´ personal features	**Unable of social relations**	*"Girlfriends ask not to talk about work or science but the scientist forgets"* (S_UK)
	Mad scientist*	"They can't stop working, even when they are supposed to take a break or have some fun" (S_FR)

EW3- Life recreation (LR): Ethical issues in scientific research

For this topic we carried on five EW with characteristics shown in table A1.5:

Table A1.5: Number of students per EW in each case

	UK	France	Spain	TOTAL
Boys	7	7	12	**26**
Girls	13	15	19	**47**
Total	20	22	31	**73**

Data obtained from students' comments were analysed through a directed content analysis (Hsieh & Shannon, 2005). Data were classified into dimensions and categories shown in table A1.6.

Table A1.6. Dimensions and categories identified through the exploratory workshops (indicators and/or criteria previously identified in the literature review but with no mention in EWs are indicated with an asterisk)

Dimensions	Categories	Subcategories	Examples
Research integrity and good research	Gap between codified rules and scientific		

practice*	practice		
	Accountability with respect to research integrity		
	Neutrality, conflict of interest and bias		
Research ethics for the protection of the objects of research	Animal awareness		It was fair to kill a pig to save a human? (LR_UK) Custom sized dogs would be sad and that was unfair (LR_UK)
	Environmental awareness		"If we need to pollute to produce these bacteria, then it is not a good option" LR_Fance
	Human awareness *		
Societal relevance and ethical acceptability of R& I outcomes	Religion awareness		"People might not want a pigs heart (Muslims)" (LR_UK)
	Public participation awareness, public engagement		"It is compulsory to bear in mind the opinion of the

			citizens" (LR_Spain)
	"Bio" issues	Genetic diagnosis	"Would only make us more scared of what would kill us" (LR_France)
		Cloning	"You have to think about the feelings of the clone" (LR_Spain)
		Brake the natural balance	"We must revive extinct species only if the extinction was fault of human been. In other way would be unethical" (LR_Spain)
		GMOs*	
	Robotic issues	Loss of employment	"Create humans without disease is the most important, but would leave the doctors unemployed" (LR_Spain)

		Risk of humanizing	"they could take over the world" (LR_Spain)
	TICs issues *	Technological dependence	
		Loss of privacy	
		Data security	
	Security *		
	Social issues*	Social justice/inclusion	
		Education	
		Gender	

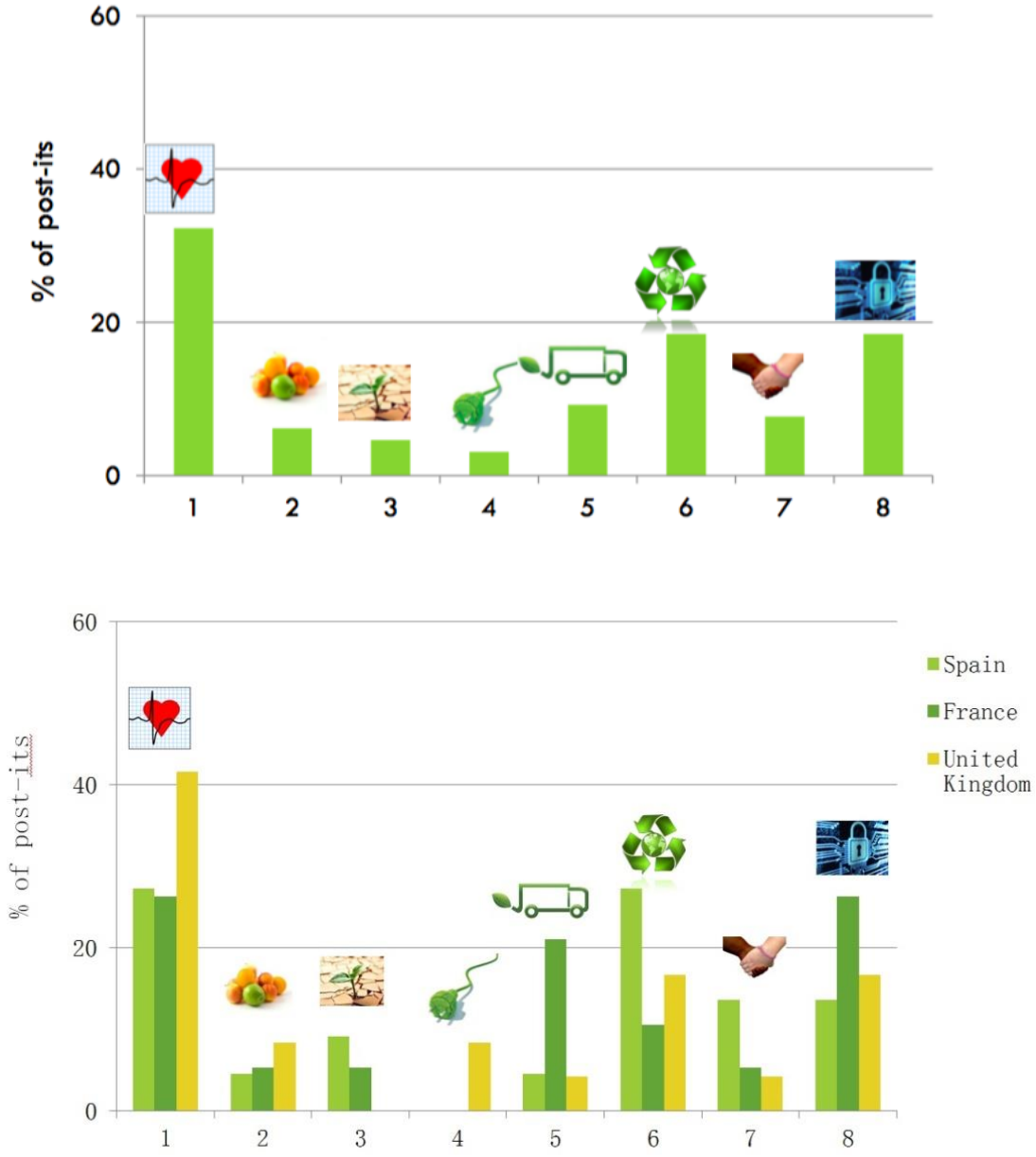
EW4- Our priorities for the World: Relevant scientific topics related to current EU societal challenges

For this topic we carried on five EW with characteristics shown in table A1.6:

Table A1.6: Number of students per EW4 in each case

	UK	France	Spain	TOTAL
Boys	2	6	14	**22**
Girls	6	11	15	**32**
Total	8	17	29	**54**

For data analysis the number of proposed challenges expressed by students and assigned to each European societal challenge was counted (in total, figure A1.2). Aggregated results show that most of the students' proposals, in the three case studies, were related to health, demographic change and wellbeing, followed by climate and environmental actions. Secure societies, freedom and security was the third challenge with the highest number of proposals.



Figures A1.2 and 3.4: Relation of projects and societal challenges overall (3.3) and per country (3.4). Challenges legend:1: Health, demographic change and wellbeing, 2: Food security, 3: Sustainable agriculture and the bioeconomy, 4: Secure, clean and efficient energy. 5: Smart, green and integrated transport, 6: Climate action and environment, 7: Inclusive, innovative and reflective societies, 8: Secure societies, freedom and security.

EW5- Science and me: Two-way dialogue between scientists and the society

For this topic we carried on five EW with characteristics shown in table A1.7:

TableA1.7: Number of students per EW5 in each case

	UK	France	Spain	TOTAL
Boys	9	7	6	**22**
Girls	16	7	6	**29**
Total	25	14	12	**51**

Data analysis was based on students' final discussion about the result of their programmes and notes taken by facilitators about their role playing performances. In order to apply a directed content analysis (Hsieh & Shannon, 2005) students' comments were classified into the dimensions and categories defined in table A1.8.

Table A1.8. Dimensions and categories identified through the EW (indicators and/or criteria previously identified in the literature review but with no mention in EWs are indicated with an asterisk)

Dimensions	Categories	Subcategories	Examples
Interest	Professional questions		*"What are you Researchingabout?"* (SM_SP)
	Pragmatic questions		"What is the use of your job?" (SM_FR)
	Personal questions related to their profession		*"What do you like/ don't like in your job?" (SM_FR)*
	Scientific literacy questions		"How did they invent the balloon?" (SM_UK1)

Closeness	Scientist identification	Scientists	
		Family/friends	
		Teacher	
		None	
Sources of scientific information	Internet		
	Science museums		
	Teacher		
	Scientific Literature		
	TV		

Figure A1.3 gathers the answers given by students in all three cases. It represents discourses trends in a simplified and visual manner.

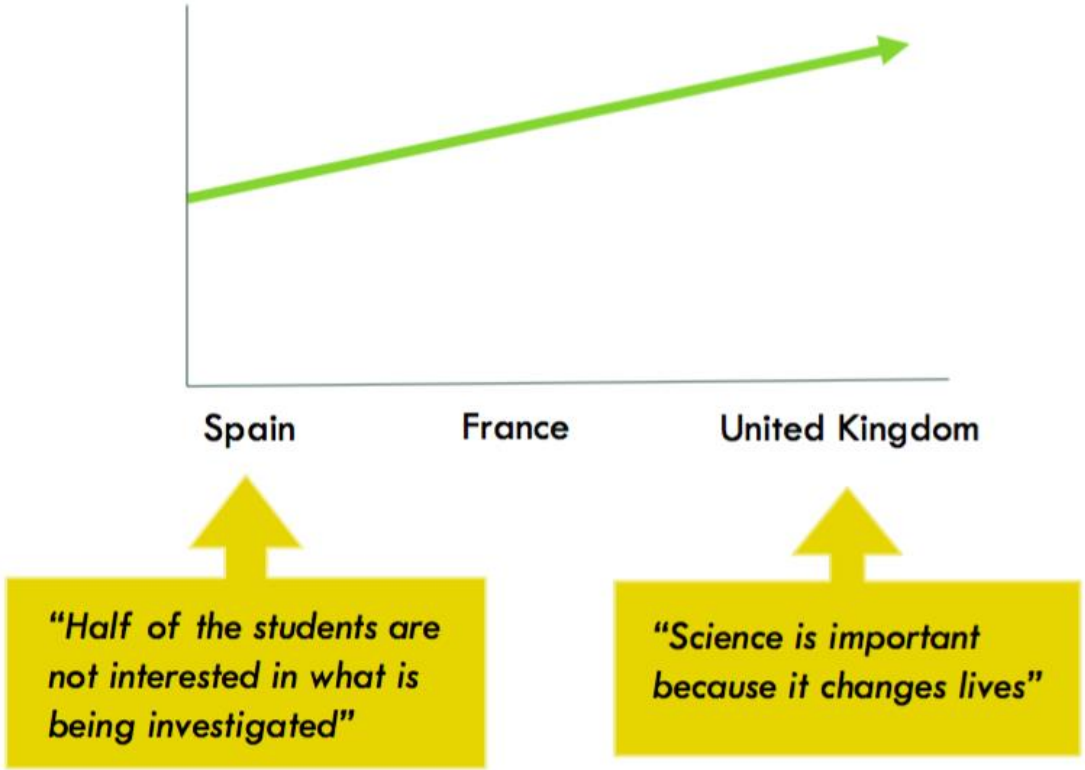


Figure A1.3: Discourse tendencies in Spain, France and UK regarding students'

interest in science and scientist work.

Between those with lower level of interest in science there were clear differences regarding the importance of different scientific areas (Figure A1.4). For the Spanish case study students' health, anthropology and technology seem to be more important than other scientific issues, while for French students health and environment were the key topics. Finally, for UK students, those showing a higher interest in researchers work, all scientific areas were equally important.
Finally, figure A1.5 shows the sources of information that students consider relevant when looking for scientific information.

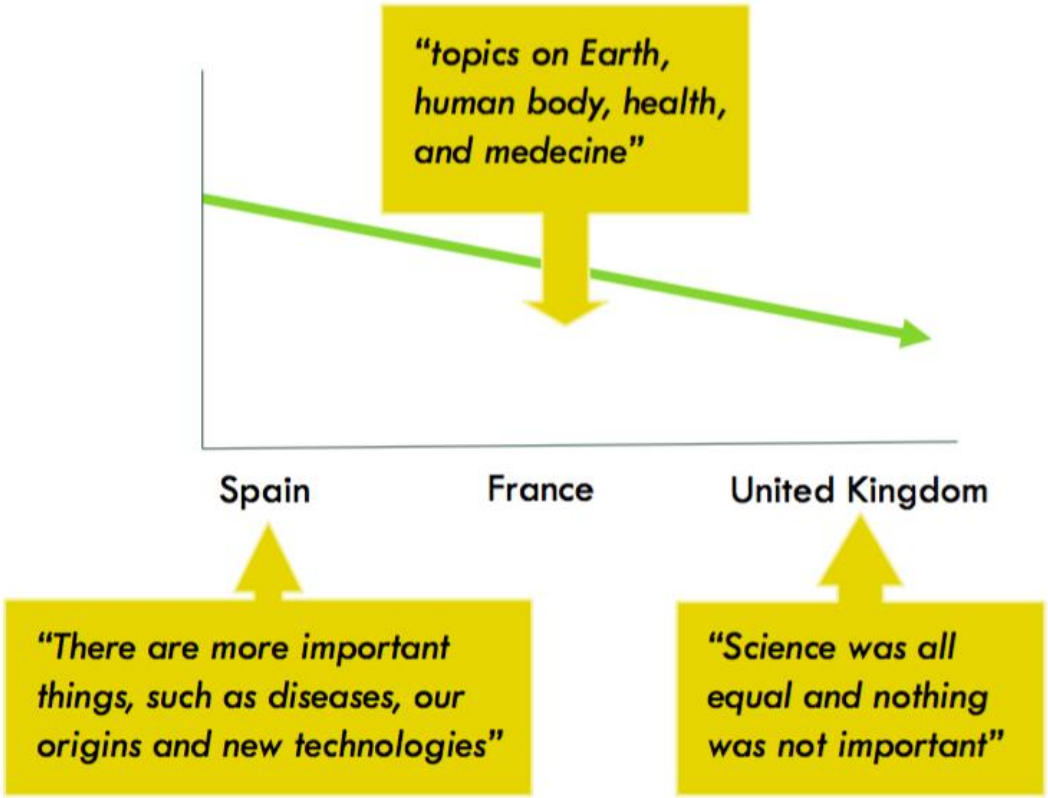


Figure A1.4: Discourse tendencies regarding priority thematic areas in science per country.

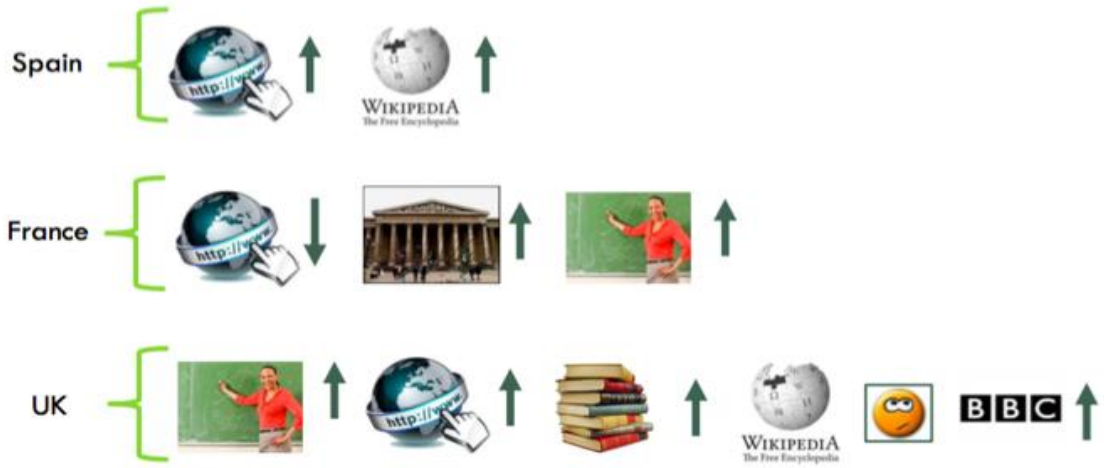


Figure A1.5: Sources of information and confidence level per country

EW6- Science and me: Two-way dialogue between scientists and the society

For this topic we carried on five EW with characteristics shown in table A1.9:

Table A1.9: Number of students per EW6 in each case

	UK	France	Spain	TOTAL
Boys	20	9	17	**46**
Girls	15	9	22	**46**
Total	35	18	39	**92**

Findings from this EW allowed for finding out whether students perceived that certain STEM jobs were gender stereotyped and the reasons why. As a result of their interventions we obtained a general portrait of some STEM careers (see figure A1.6) and particular portraits of each profession (see figure A1.7).

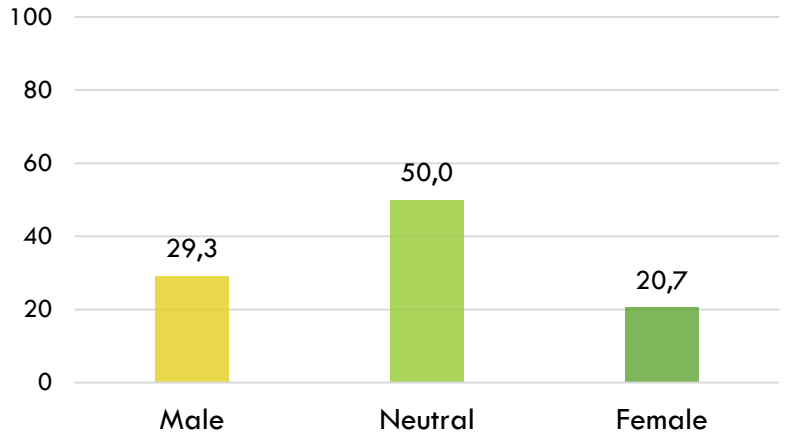


Figure A1.6. STEM jobs descriptions

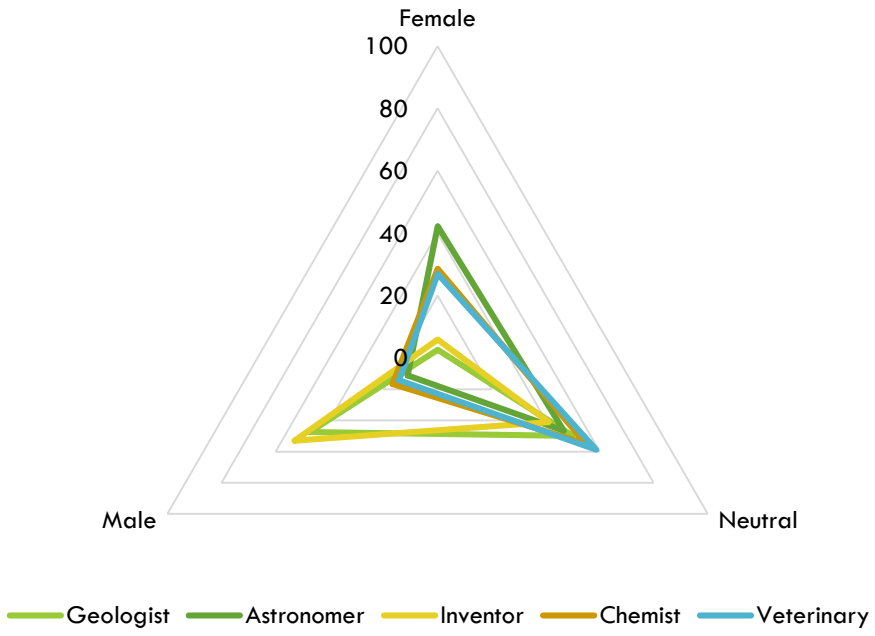


Figure A1.7. STEM descriptions by job

We did not find significant differences between case studies. It is only worth mentioning the case of some professions strongly gender-stereotyped, such as the case of chemist career in Spain (figure A1.8) which was strongly masculinized, while in UK (figure A1.9) astronomy was particularly feminized. In the case of the French case study there was not enough sample to make a separate analysis.

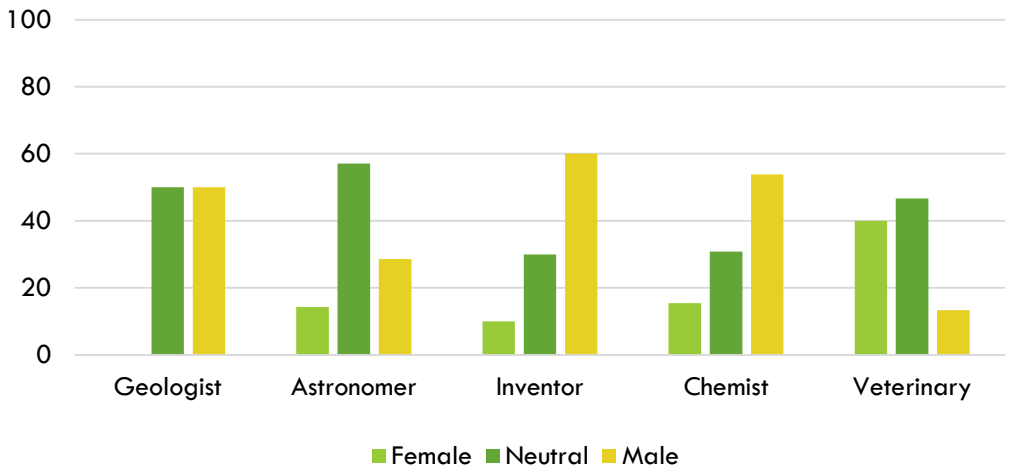


Figure A1.8. STEM jobs description by country (Spain)

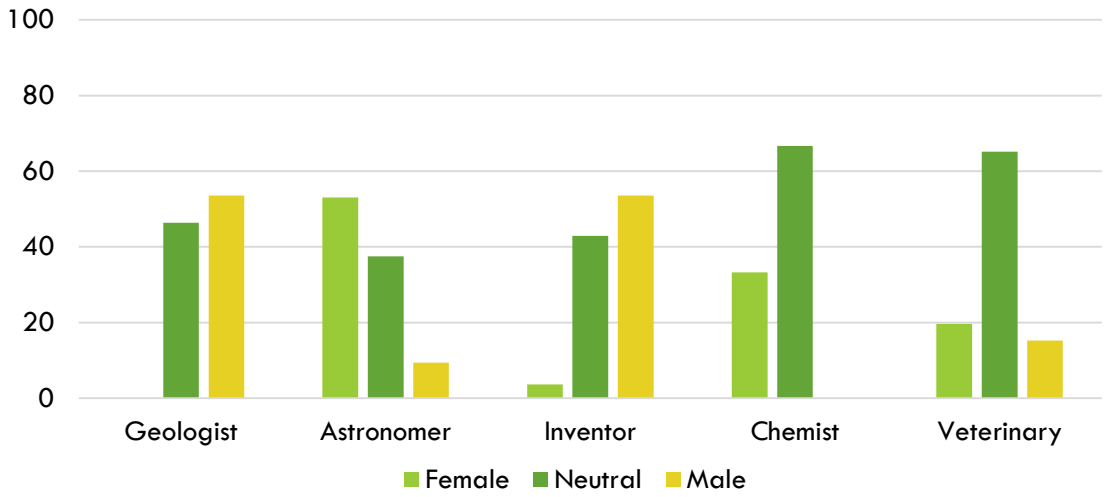


Figure 3.12:STEM Jobs description by country (UK)

2. SPECIFIC GUIDELINES TO GENERATE PERSEIAs

2.1 Guidelines emerged from EW

A series of guidelines and recommendations have been drawn out of the conclusions of the EW's. These guidelines were fine-tuned considering the conclusions of D4.1 (D4.1 "Research report: methodological aspects of science education assessment" that you can find in www.perform-research.eu), local particularities, and the kind of performing disciplines used in PERFORM project (scientific monologues in Spain, clown in France and science busking in UK). The guidelines were collected in the table 4.1 and were shared with TBVT, TRACES and SMS to adapt a performance-based activity into a Scientific Drama-Based Activity.

Table 4.1: Guidelines to Generate PERSEIAs

G1: STEM JOBS
To highlight that science and STEM-Jobs are everywhere:

✓ An excavation, an electoral survey, an architectural studio, a plane, an engineering company, the zoo, a football team, in science communication events
To highlight STEM-Jobs features that young people consider positive: ✓ Travelling, helping others, having a flexible schedule, involving hands-on activities, reducing injustice
To highlight that some well-considered jobs are actually STEM-Jobs: ✓ Architect, airline pilot. Take into account local particularities.
G2: SCIENTIFIC STEREOTYPES
To highlight positive stereotypes of science and scientists: ✓ External recognition, knowledge motivation, long term goal. "Knowledge gives you power: the more you know, fewer lies you will believe" ✓ Imaginative, self-confident
To break negative stereotypes of scientists: ✓ Freaky, nerd, boring, bad couple or parent, social rejection, unable for social relations, always «ON» and in their own world
G3: ETHICS IN RESEARCH
To highlight that scientists do not play to be God, as all new discoveries are under ethical control: ✓ GMO, Artificial Intelligence/Robots, medical advances (cloning, genetic modifications in humans)
To highlight that research is not only conducted to generate useful knowledge from the human being interest point of view. Ethical standards promote research on basic science as: ✓ Improve the environmental quality ✓ Generate basic knowledge to improve nature understanding ✓ Ensure animal rights
G4: EU SOCIETAL CHALLENGES
To use the EU Societal Challenges that students have considered of interest as a hook: ✓ Health, demographic change and wellbeing ✓ Climate action, and environment

✓ Secure societies, freedom and security
To take into account the local particularities: ✓ UK: Health, demographic change and wellbeing ✓ France: Secure societies, freedom and security ✓ Spain: Climate action, and environment
G5: DIALOGUE SCIENCE AND SOCIETY
To highlight the figure of teachers as scientists and as trustable scientific information source.
To include examples of current scientists: ✓ For example: Lynn Margulis, Jennifer Doudna or Emmanuelle Charpentier.
G6: GENDER ISSUES IN STEM
To highlight that STEM-Jobs are not gendered: ✓ The features that define STEM jobs (curious, motivated, hard-working…) are gendered neutral. ✓ Boys can be Astronomer/Veterinary ✓ Girls can be Inventor/Engineer
To give special attention to girls in engineering: ✓ To strengthen girls' self-confidence to pursue engineer/maths studies. ✓ To highlight the social projection of engineering
To give women scientists as role models: ✓ Give special mention to female physicists, engineers and computational scientists.
GENERAL RECOMMENDATIONS (GR)
To use Social Networks (wherever possible): ✓ PERFORM has Twitter and Instagram accounts. Use them to generate dialogue between performers and students. ✓ Social network dialogue can take place during PERSEIA or promoted during PERSEIA to be made afterwards.
To foster students' interaction ✓ To invite students to make questions or to give their opinion during/after the PERSEIA.

To use videos
✓ To show a short video (3 to 5 minutes) talking about a scientific topic.

2.2 PERSEIAs design

Following the integrated methodological protocol defined in the previous section, TBVT in Spain, TRACES in France and SMS in UK adapted a performance-based activity into a PERSEIA. Not all the guidelines could be included in all three PERSEIAs given the different artistic approaches. Table 4.2 collects the guidelines followed in each case study. The PERSEIAs scripts, including those fragments where the guidelines are included, are shown in www.perform-research.eu.

Table 4.2: Recommendations included in each PERSEIA per partner.

GUIDELINES	**PARTNER**		
	TBVT	TRAC	SMS
G1: STEM JOBS			
To highlight that Science and STEM-Jobs are everywhere.	X	X	X
To highlight STEM-Jobs features that young people consider positive.	X	X	X
To highlight that some well-considered jobs are actually STEM-Jobs.	X	X	
G2: SCIENTIFIC STEREOTYPES			
To highlight positive stereotypes of science and scientists.	x	X	X
To break negative stereotypes of scientists.	x	X	X
G3: ETHICS IN RESEARCH			
To highlight that scientists do not play to be God, as all new discoveries are under ethical control.	X	X	X
To highlight that research is not only conducted to	X	X	X

generate useful knowledge from the human being interest point of view. Ethical standards promote research on basic science.			
G4: EU SOCIETAL CHALLENGES			
To use the EU Societal Challenges that students have considered of interest as a hook.	X		X
To take into account the local particularities.			X
G5: DIALOGUE SCIENCE AND SOCIETY			
To highlight the figure of teachers as scientists and as trustable scientific information source.	X	X	X
To include examples of current scientists.	X	X	X
G6: GENDER ISSUES IN STEM			
To highlight that STEM-Jobs are not gendered.	X	X	X
To give special attention to girls in engineering.	X	X	X
To give women scientists as role models.	X		X
GENERAL RECOMMENDATIONS (GR)			
To use Social Networks.	X	X	X
To foster students' interaction.	X	X	X
To use a video.	X		

3. PERSEIAs delivery

PERSEIAswere delivered to students in two different rounds. The first round of PERSEIAS delivery took place while the last EWs were still taking place, as its aim was allowing the three case study science communicators (TBVT, SMS and TRACES) establishing a first contact with the new working methodology. Thus, this first round took partially into account the general results of the EWs.

The schools that were visited to deliver PERSEIASwere selected according to socio-economic level (the PERFORM project is addressed to low and middle socio-economic level schools) and by order of acceptance. 1,064 students in 12 schools attended PERSEIAs during the first round. Informed consents were also obtained. Schools visited are listed in table 5.3.

Table5.3: Schools visited during the first round of PERSEIAsdelivery.

Case study coordinator	Name of School	Location	Date	Number of students
TRACES	Collège Les Toupets	Vauréal (95), France	14/06/2016	12
TRACES	Collège Marie Curie	Paris, France	10/06/2016	105
TRACES	Collège Jean Zay	Morsang-sur-Orge, France	16/06/2016	46
TBVT	IES Consell de Cent	Castellbisbal, Spain	23/05/2016	49
TBVT	Institut Santa Eulàlia	Terrassa, Spain	23/05/2016	49
TBVT	Institut Europa	Hospitalet de Llobregat, Spain	24/05/2016	132
TBVT	IES Consell de Cent	Barcelona, Spain	25/05/2016	127
TBVT	IES Mare de Déu de la Salut	Sabadell, Spain	26/05/2016	104
TBVT	Institut La Ferreria	Montcada i Reixac, Spain	27/05/2016	66
TBVT	Abat Oliva	Ripoll, Spain	27/05/2016	272
SMS	Fairfield High School	Bristol, UK	30/06/2016	38
SMS	Brimsham Green School	Bristol, UK	14/07/2016	31

Once the guidelines were defined, PERSEIAsdesign was improved and redesigned

accordingly. Resulting new PERSEIAswere hence delivered to 1,426 students from the 18 schools shown in table 5.4. For the evaluation of this second round the Qualia System (see Annex 2 for more information) was not used due to the low rate of response obtained in the first round. Alternatively, a new on-line questionnaire was designed. This questionnaire was completely anonymous and no sensitive data from students were included.

Table 5.4: Schools visited during the second round of PERSEIAsdelivery.

Case study coordinator	Name of School	Location	Date	Number of students
TRACES	EREA Crocé Spinelli	Paris, France	29/09/2016	8
TRACES	Lycée Fénélon	Paris, France	30/09/2016	52
TRACES	Collège La Grange aux Belles	Paris, France	09/11/2016	75
TRACES	Ecole Jeannine Manuel	Paris, France	09/11/2016	20
TBVT	Príncep de Viana	Barcelona, Spain	24/10/2016	62
TBVT	Escola Virolai	Barcelona, Spain	24/10/2016	71
TBVT	IES Júlia Minguell	Badalona, Spain	24/10/2016	79
TBVT	I.P. Federica Montseny	Badia del Vallès (Barcelona), Spain	25/10/2016	83
TBVT	La Salle Montcada	Montcada i Reixac (Barcelona), Spain	25/10/2016	127
TBVT	Institució Montserrat	Barcelona, Spain	27/10/2016	40
TBVT	Maristes Sants-Les Corts	Barcelona, Spain	27/10/2016	193
TBVT	IES Lloret de Mar	Lloret de	28/10/2016	187

		Mar(Girona), Spain		
TBVT	Ramon Coll i Rodes	Lloret de Mar (Girona), Spain	28/10/2016	182
SMS	Birkenhead School	Birkenhead, United Kingdom	14/09/2016	11
SMS	St Michaels CofE School	Chorley, United Kingdom	16/09/2016	19
SMS	Leighton Middle School	Leighton Buzzard, United Kingdom	21/09/2016	25
SMS	Brooklands Middle School	Leighton Buzzard, United Kingdom	21/09/2016	22
SMS	Linslade Middle School	Leighton Buzzard, United Kingdom	22/09/2016	25
SMS	Gilbert Inglefield Middle School	Leighton Buzzard, United Kingdom	22/09/2016	27
SMS	Fullbrook Middle School	Leighton Buzzard, United Kingdom	23/09/2016	21
SMS	The Castle School	Thornbury, United Kingdom	5/10/2016	7
SMS	Broadlands Academy	Bristol, United	20/10/2016	15

		Kingdom		
SMS	Albany Academy	Chorley, United Kingdom	23/11/2016	25

4. PERSEIAs EVALUATION

PERSEIAs delivered to students were assessed in order to test if the specific guidelines to develop performance-based activities were effective in changing students' attitudes towards gender inequality and girls' barriers in STEM, science-related stereotypes, two-way dialogue between scientists and society, ethical issues in scientific research, and the role of entrepreneurial and multidisciplinary research careers in the labour market. For this purpose, *ex-ante* and *ex-post* questionnaires were designed with the assistance of University of Warwick (UoW), Universitat Autònoma de Barcelona (UAB) and Universitat Oberta de Catalonia (UOC).

4.1 Previous considerations

The following assessment of DRAMA-BASED ACTIVITIES's delivery has been carried out beyond the objectives of the PERFORM project stated in the DoA. During the kick-off meeting TBVT, SMS, TRACES, UAB, UoW, and UOC agreed that assessing PERSEIAsdelivery would provide very useful and relevant information to significantly increase the quality and confidence of the integrated methodological protocol to develop performance-based activities. Going further the initial objectives of the project, TBVT as leader of WP2 coordinated the design and implementation of an assessment methodology based on surveys with students and interviews with science communicators. Both, surveys and interviews, which are detailed in the following section, collected enough data to yield meaningful results. Nevertheless, TBVT faced two challenges that were not possible to overcome and that should be taken into consideration:

1. Students perceptions in the first round of PERSEIAsdelivery were assessed through a survey managed through the Qualia system, provided by UoW. This system had not the expected acceptance in schools. Qualia systems required from students that they remember an ID number that most of them forgot and, thus, could not

access to the post-PERSEIASsurvey. Consequently, the number of answers obtained was too low to conduct significant analysis neither cross-sectional nor longitudinally. Nevertheless, data gathered trough this system was analysed by UoW and the results obtained, although being neither systematic nor reliable, are shown in Annex 4.

2. French Case Study Coordinator, TRACES, had great difficulties in collecting students' answers to the surveys forms provided to students after PERSEIAsdelivery. The number of answers obtained in this case study is not enough to provide significant results, both for the first and second rounds. For this reason results coming out of the evaluation of their data are not shown.

4.2 Assessment methodology

The methodological strategy to assess the PERSEIAsconsisted on two main instruments:

1. Pre and post cross-sectional questionnaires addressed to students to evaluate their attitudes towards STEM and their perceptions regarding ethical and gender issues in science and research. Each item in the survey was related to one or more specific guidelines of the integrated methodological protocol to generate PERSEIAsso that each one could assess which of these guidelines were effective. Table 6.1 shows the correspondence between items and guidelines.

Table 6.1: Correspondence between items in survey and specific guideline

Question	EW Guidelines
Scientific knowledge is important for my future career	G1: STEM
If I wanted to, I could be a scientist	G1: STEM
Science is not for me	G1: STEM
Science is irrelevant to my life	G1: STEM
Science is usually boring	G1: STEM

Scientists follow ethical standards to pursue their studies.	G3: Ethics
Ethical standards are essential to pursue scientific research as improving the environment, the rights of laboratory animals or the quality of human beings.	G3: Ethics
Science helps to solve the world's problems	G4: Societal Challenges
Who do you think would do best the following jobs? [Male / Female / Either]	G6: Gender
Write the names of five scientists.	G6: Gender
Showing a video during the performance seems to me a good idea	GR
I actively participated in the performance event.	GR
Did you enjoy the use of social networks to interact with the performers?	GR

In the first round, the system used to collect students' answers was Qualia System. For the second round, the same cross-sectional questionnaires were implemented through online forms. These questionnaires' templates can be consulted in Annex 3. The number of answers collected in the second round is shown in table 6.2.

Table 6.2: Number of students' answers in pre- and post-PERSEIASquestionnaires per country. In both cases, the % of respondents is calculated over the total number of attendants. Between brackets it is shown the absolute number of responses. The % of girls is calculated over the total number of respondents.

		PRE-PERSEIAS		**POST-PERSEIAS**	
	Attendants	Respondents	% Girls	Respondents	%Girls
Spain	1024	76.6% (785)	50.8	47.9 (490)	49.8
UK	197	95.4% (188)	47.9	55.8% (110)	47.3
France	135	41.2% (64)	41.2	12.9 (20)	65.0

2. Structured interviews to performers to gather their perceptions after the PERSEIAsdelivery. Their experience in delivering the PERSEIAscomplemented the

information obtained through cross-sectional questionnaires. The structured interviews transcripts are showed in Annex 4. The number of interviewees per country is shown in table 6.3.

Table 6.3: Number of performers interviewed per country.

	Performers	Interviewees
Spain	3	3
UK	1	1
France	3	1

4.3 Results

4.3.1 Students' STEM perceptions

To analyse students' perceptions towards STEM careers, the questionnaire incorporated two Likert scales with three items each: one for positive and another for negative attitudes (check Annex 3 for further information). In this sense, levels of agreement and disagreement of both scales were measured as indicators of the increase or decrease in the positive and negative attitudes towards STEM. Figure 6.1 shows the data for the positive attitudes scale in Spain and UK.

As shown in figure 6.1 all three indicators were slightly higher in the Spanish case study after the delivery of the Drama-Based Activities. On the contrary, science busking in UK achieved the goal of increasing positive attitudes just for some of the indicators: agreement and disagreement for "Science knowledge is important for my future career" decreased after delivering the DRAMA-BASED ACTIVITIES, meaning that students fell into neutrality; disagreement to the sentence "If I wanted to, I could be a scientist" increases after seeing the DRAMA-BASED ACTIVITIES. These two considerations should be taken into account for other groups working with science busking and reinforce positive attitudes.

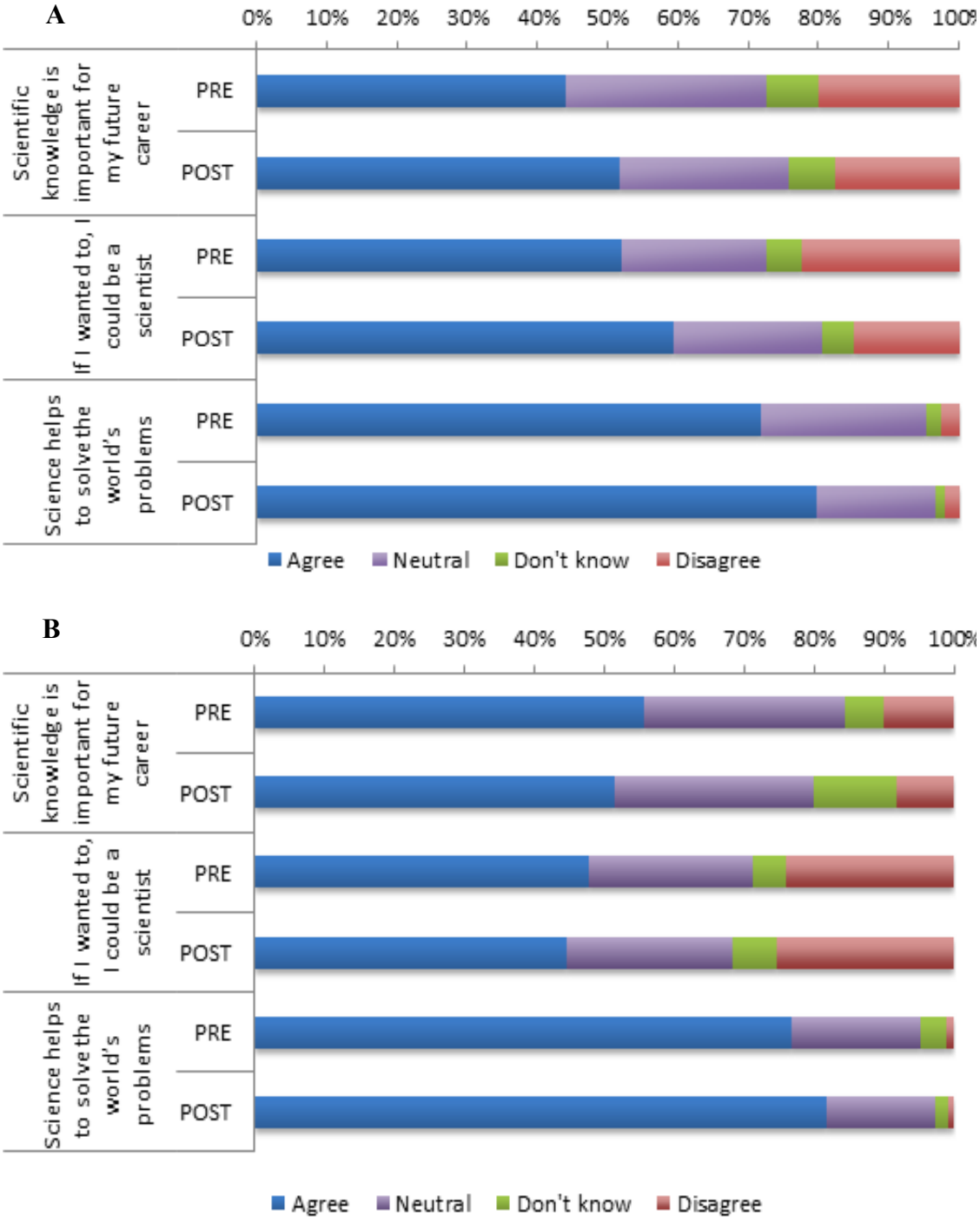


Figure 6.1: Graph showing the percentage of agreement, disagreement, and neutrality towards positive attitudes to STEM pre- and post-PERSEIASin Spain (A) and UK (B).

Both case studies results were analysed by gender to see whether there were meaningful differences among boys and girls in relation with positive attitudes towards STEM subjects and jobs. In Spain (table 6.4) there were no meaningful differences but for the indicator “Scientific knowledge is important for my future career” in which boys experienced a much higher increase than girls (12% vs. 3.3%). This fact suggests that major efforts should be put into action in further PERSEIAsto highlight the value of STEM for girls' careers.

In the UK case (table 6.5) a remarkable difference among boys and girls in their attitudes towards STEM careers can be appreciated. For the indicator “If I wanted to, I could be a scientist”, girls’ degree of agreement decreased in 11.7% while boys’ increased after the PERSEIAS in 4.7%, i.e. there is a difference among them of more than 15%. As in the Spanish case, major efforts should be put into action in further PERSEIAsto highlight the value of STEM careers amongst girls.

Table 6.4: Agreement, disagreement, and neutrality by gender towards positive attitudes to STEM in Spain.

		Agree			Disagree			Neutral		
		PRE	POST	DIF	PRE	POST	DIF	PRE	POST	DIF
Scientific knowledge is important for my future career	ALL	43.9%	51.6%	**7.7%**	20.2%	17.7%	**-2.5%**	28.6%	24.1%	**-4.5%**
	BOYS	42.8%	54.8%	**12.0%**	15.0%	14.4%	**-0.6%**	34.9%	25.9%	**-9.0%**
	GIRLS	45.1%	48.4%	**3.3%**	25.2%	21.1%	**-4.1%**	22.4%	22.3%	**-0.1%**
If I wanted to, I could be a scientist	ALL	51.8%	59.4%	**7.6%**	22.5%	15.1%	**-7.4%**	20.7%	21.0%	**0.3%**
	BOYS	54.4%	60.7%	**6.3%**	22.6%	14.7%	**-7.9%**	19.3%	18.9%	**-0.4%**
	GIRLS	49.4%	58.1%	**8.7%**	22.4%	15.3%	**-7.1%**	21.9%	23.2%	**1.3%**
Science helps to solve the world's problems	ALL	71.7%	79.5%	**7.8%**	2.6%	2.2%	**-0.4%**	23.4%	17.0%	**-6.4%**
	BOYS	70.5%	77.5%	**7.0%**	1.8%	1.6%	**-0.2%**	25.6%	18.8%	**-6.8%**
	GIRLS	73.1%	81.4%	**8.3%**	3.5%	2.9%	**-0.6%**	21.1%	15.3%	**-5.8%**

Table 6.5: Agreement, disagreement, and neutrality by gender towards positive attitudes to STEM in UK.

		Agree			Disagree			Neutral		
		PRE	POST	DIF	PRE	POST	DIF	PRE	POST	DIF
Scientific knowledge is important for my future career	ALL	55.7%	51.3%	**-4.4%**	10.2%	8.3%	**-1.9%**	28.6%	28.4%	**-0.2%**
	BOYS	59.4%	51.7%	**-7.7%**	7.3%	8.6%	**1.3%**	28.1%	29.3%	**1.2%**
	GIRLS	51.7%	51.0%	**-0.7%**	13.5%	7.8%	**-5.7%**	29.2%	27.5%	**-1.7%**
If I wanted to, I could be a scientist	ALL	47.6%	44.5%	**-3.1%**	24.0%	25.4%	**1.4%**	23.5%	23.6%	**0.1%**
	BOYS	41.8%	46.5%	**4.7%**	25.5%	25.9%	**0.4%**	27.6%	25.9%	**-1.7%**
	GIRLS	54.0%	42.3%	**-11.7%**	22.5%	25.0%	**2.5%**	19.1%	21.2%	**2.1%**
Science helps to solve the world's problems	ALL	76.6%	81.7%	**5.1%**	1.1%	0.9%	**-0.2%**	18.6%	15.6%	**-3.0%**
	BOYS	77.5%	86.3%	**8.8%**	2.0%	0.0%	**-2.0%**	16.3%	12.1%	**-4.2%**
	GIRLS	75.6%	76.4%	**0.8%**	0.0%	2.0%	**2.0%**	21.1%	19.6%	**-1.5%**

As in the case of positive attitudes, indicators for negative attitudes towards science increased in Spain after delivering the Drama-Based Activities. The negative attitudes were reduced in all three indicators of the scale (Fig 6.2-A). In contrast, in UK the indicators for negative attitudes increased except the indicator "Science is usually boring" (Fig 6.2-B). Following the insight stated previously, these considerations should need further analysis and need to be taken into account by other groups working with science busking.

Case studies results from Spain and UK were disaggregated by gender to examine whether there were meaningful differences among boys and girls in relation with negative attitudes towards STEM subjects and jobs. In Spain (table 6.6), all three indicators showed that negative attitudes decreased for both genders, but more intensively among boys than girls. Actually, girls' level of disagreement with regards to the negative indicator "Science is not for me" decreased in 4.7% after having participated in the DRAMA-BASED ACTIVITIES.

In the UK case study (table 6.7), on the other hand, only the level of agreement with the indicator "Science is usually boring" decreased after delivering the PERSEIAS, while the other two negative indicators increased instead of hindering. In this case, girls were less prone to diminish their negative attitudes than boys. These results suggested that science busking PERSEIASneeded further revision.

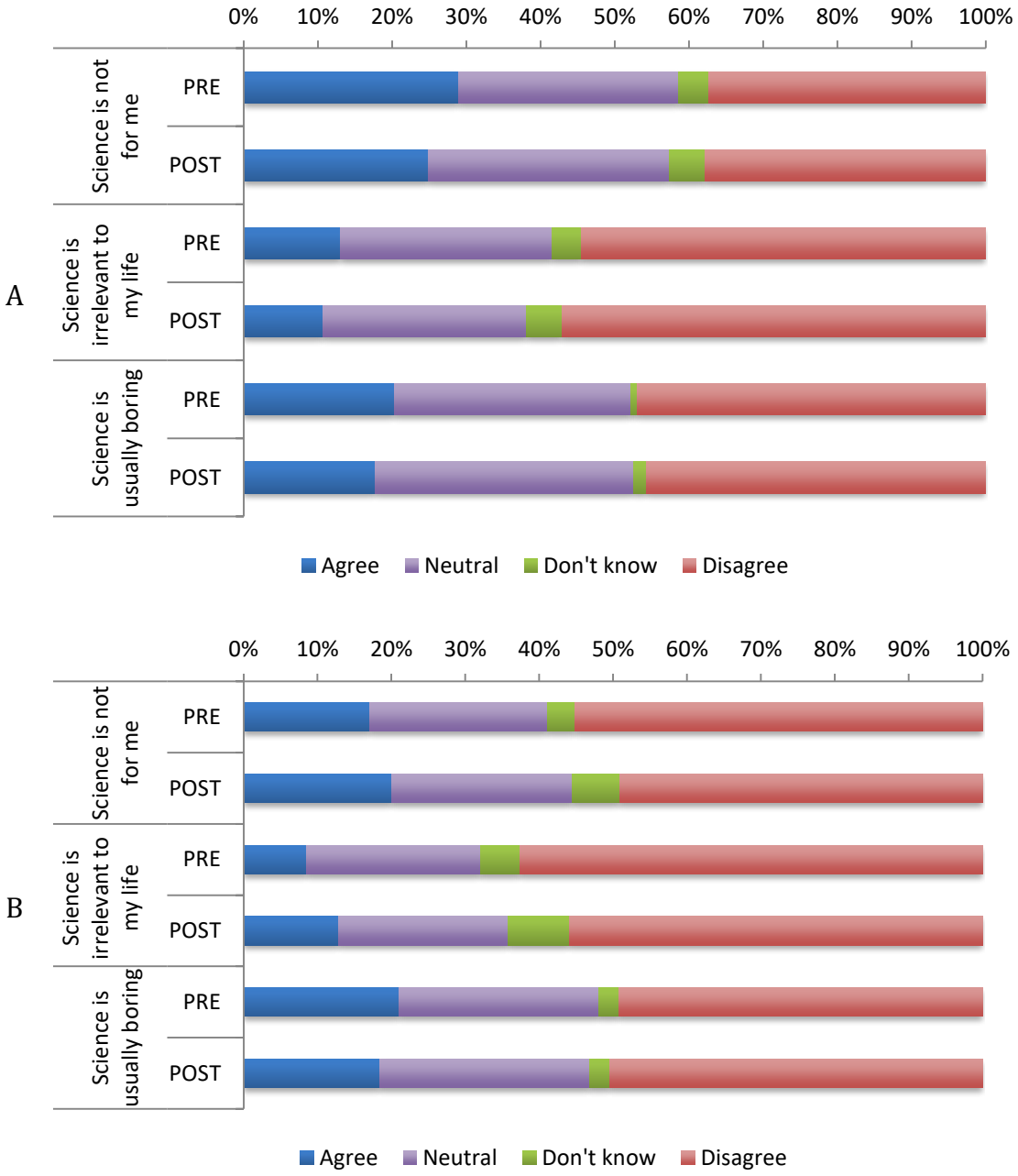


Figure 6.2: Percentage of agreement, disagreement, and neutrality towards negative attitudes to STEM pre- and post-PERSEIASin Spain (A) and UK (B).

Table 6.6: Agreement, disagreement, and neutrality by gender towards positive attitudes to STEM in Spain.

		Agree			Disagree			Neutral		
		PRE	POST	DIF	PRE	POST	DIF	PRE	POST	DIF
Science is not for me	ALL	28.9%	23.2%	**-5.7%**	37.3%	35.2%	**-2.1%**	29.7%	30.2%	**0.5%**
	BOYS	31.2%	23.5%	**-7.7%**	36.9%	37.1%	**0.2%**	28.0%	31.3%	**3.3%**
	GIRLS	26.7%	22.8%	**-3.9%**	37.9%	33.2%	**-4.7%**	31.1%	29.0%	**-2.1%**
Science is irrelevant to my life	ALL	13.1%	10.7%	**-2.4%**	54.6%	57.1%	**2.5%**	28.5%	27.4%	**-1.1%**
	BOYS	14.7%	10.2%	**-4.5%**	50.0%	54.7%	**4.7%**	31.7%	30.6%	**-1.1%**
	GIRLS	11.6%	11.3%	**-0.3%**	59.1%	59.6%	**0.5%**	25.3%	24.2%	**-1.1%**
Science is usually boring	ALL	20.3%	17.8%	**-2.5%**	47.0%	45.8%	**-1.2%**	31.9%	34.8%	**2.9%**
	BOYS	22.6%	18.6%	**-4.0%**	44.5%	43.0%	**-1.5%**	31.3%	36.8%	**5.5%**
	GIRLS	18.2%	17.0%	**-1.2%**	49.5%	48.6%	**-0.9%**	32.3%	32.8%	**0.5%**

Table 6.7: Agreement, disagreement, and neutrality by gender towards positive attitudes to STEM in UK.

		Agree			Disagree			Neutral		
		PRE	POST	DIF	PRE	POST	DIF	PRE	POST	DIF
Science is not for me	ALL	17.2%	20.0%	**2.8%**	55.7%	49.1%	**-6.6%**	24.3%	24.5%	**0.2%**
	BOYS	20.8%	22.4%	**1.6%**	57.3%	48.3%	**-9.0%**	20.8%	24.1%	**3.3%**
	GIRLS	13.4%	17.3%	**3.9%**	53.9%	50.0%	**-3.9%**	28.1%	25.0%	**-3.1%**
Science is irrelevant to my life	ALL	8.5%	12.8%	**4.3%**	62.5%	55.9%	**-6.6%**	23.5%	22.9%	**-0.6%**
	BOYS	9.2%	12.0%	**2.8%**	68.4%	56.9%	**-11.5%**	19.4%	22.4%	**3.0%**
	GIRLS	7.8%	13.7%	**5.9%**	56.2%	54.9%	**-1.3%**	28.1%	23.5%	**-4.6%**
Science is usually boring	ALL	21.1%	18.4%	**-2.7%**	49.2%	50.4%	**1.2%**	27.0%	28.4%	**1.4%**
	BOYS	18.6%	17.2%	**-1.4%**	47.4%	48.3%	**0.9%**	29.9%	31.0%	**1.1%**
	GIRLS	23.8%	19.6%	**-4.2%**	51.1%	52.9%	**1.8%**	23.9%	25.5%	**1.6%**

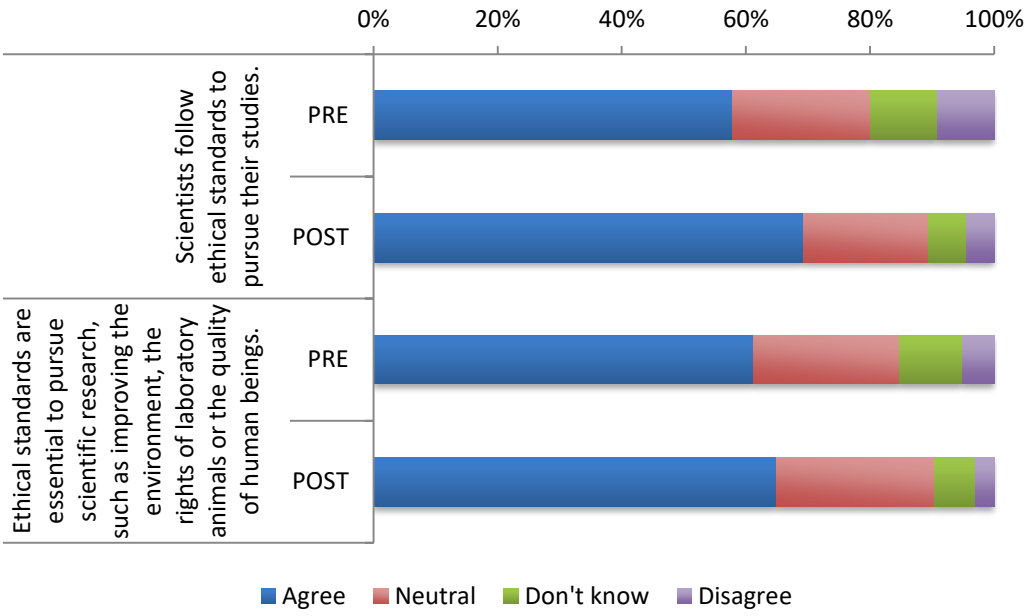
4.3.2 Students' perceptions of science-related ethical issues

In order to address how students see and perceive ethical concerns related to the scientists' work, the questionnaire included a 2-items Likert scale. As in the previous scales, figure 6.3, show the degrees of agreement and disagreement with those items in the two case studies analysed. In this case, the option "Don't know" is included, as its results are relevant for the study.

In the Spanish case study, both indicators are enhanced after delivering the Drama-Based Activities, specially "Scientist follow ethical standards to pursue their studies", which has been enhanced more than 10%. It is also remarkable that those answering "Don't know" are decreased by a rate of 5%. There are no meaningful gendered differences in the perceptions of ethical concerns regarding the scientific practice.

In UK ethical perceptions are also enhanced after delivering the Drama-Based Activities. In this case, though, the ratio or respondents for the option "Don't know" was higher than in Spain and was increased by the DRAMA-BASED ACTIVITIES, reinforcing the idea that the science busking show, as a tool for transmitting RRI values, must be reformulated. There are no meaningful differences between girls and boys in their perceptions of ethical concerns.

A



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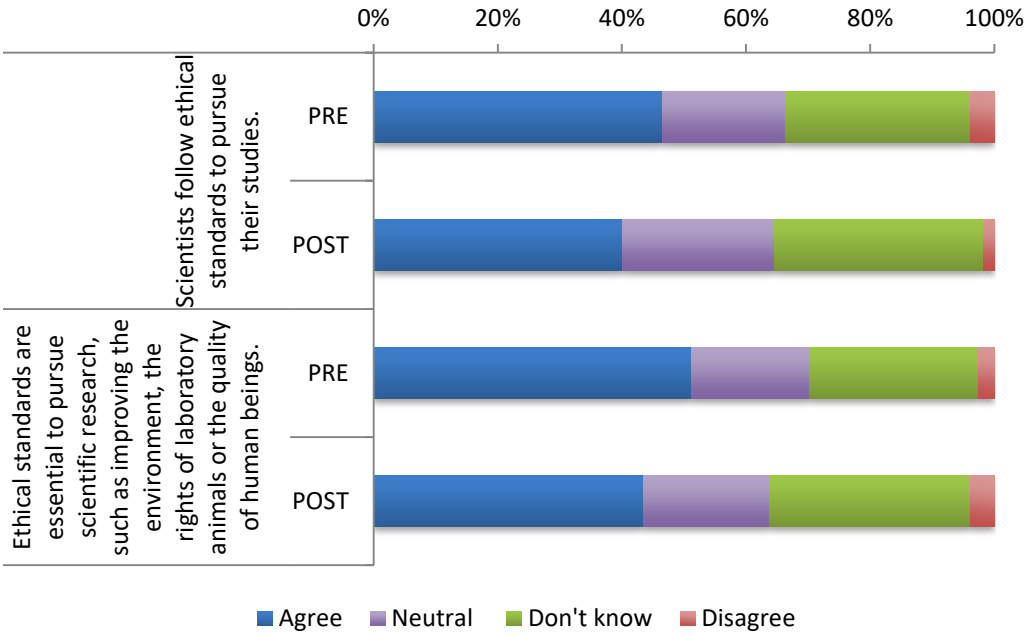

Figure 6.3: Graphs showing the percentage of agreement, disagreement, neutrality and "Don't know" option towards ethical issues concerning science pre- and post-PERSEIAS in Spain (A) and UK (B).

4.3.3 Students' perceptions of science-related gender issues

In order to know to what extent students perceive science as gendered, pre- and post-surveys included two indicators. One of them addressed how many female scientists they knew so both pre and post-surveys included an open question about scientists they knew. Out of them, the names of "real" female scientists were counted. The second indicator evaluated how gendered they understood six different professions related to science: veterinarian, computer programmer, theoretical physicist, nurse, astronomer, and engineer.

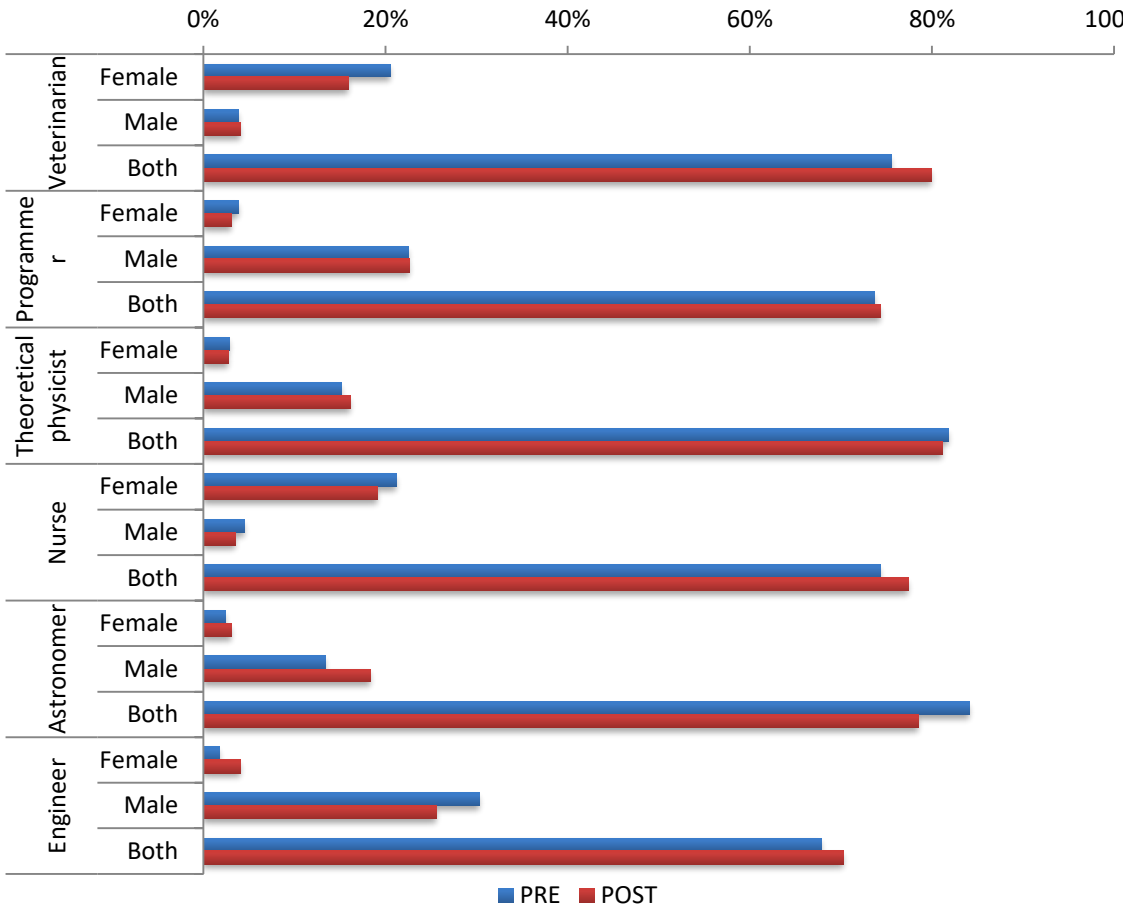

Figure 6.4: Gendered perceptions towards six scientific professions in Spain.

In Spain, 85.1% of the students taking the pre-PERSEIAS survey did not know any female scientist, and this rate decreased to 82.9% after delivering the PERSEIAS. Regarding to how gendered they perceived each one of the six professions, figure 6.4 shows that in general they perceived all of them as being able to be performed by both men and women. Anyway, veterinarian and nurse were slightly attributed to women whereas programmer, theoretical physicist and astronomer were more perceived as a men's job. After the DRAMA-BASED ACTIVITIES, the perception that these professions could be carried out by both men and women increased for all cases but for the astronomer, which was even more related to men.

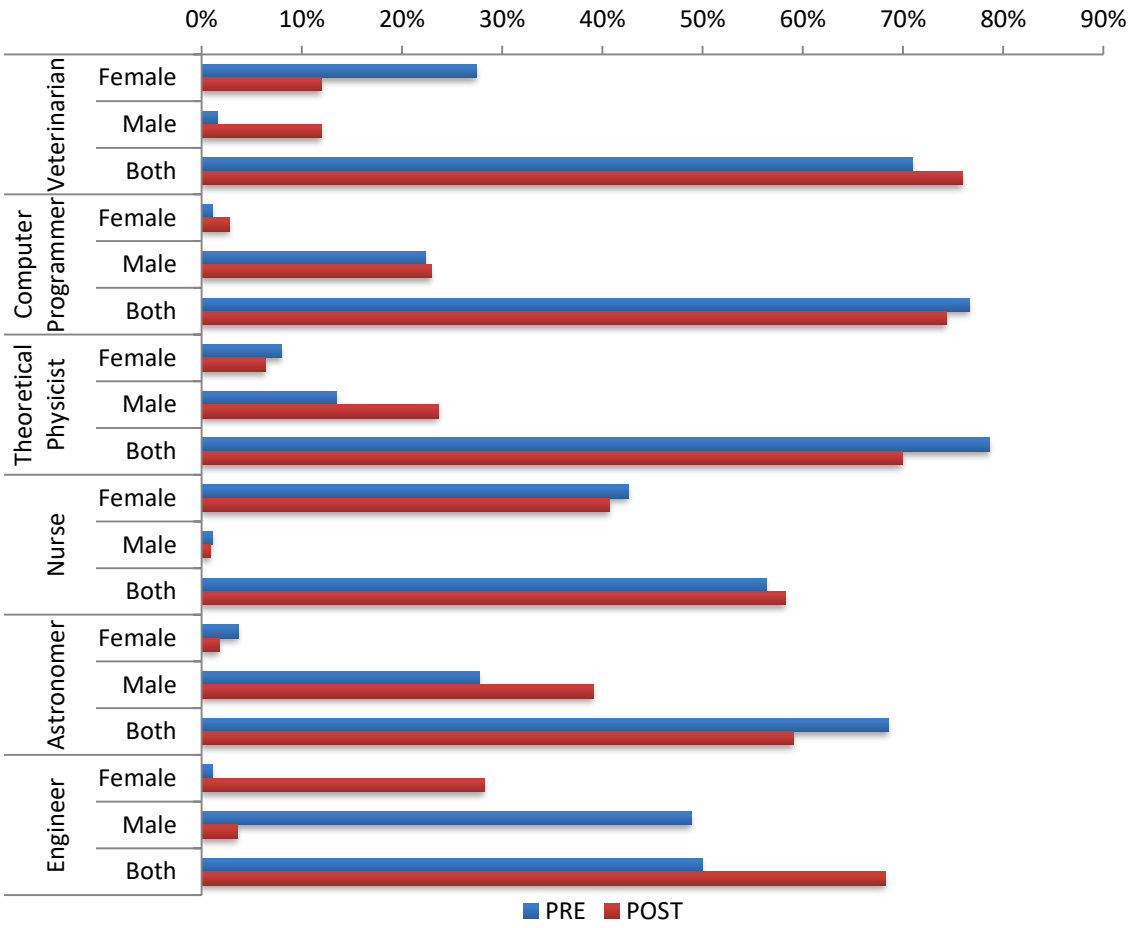

Figure 6.5: Gendered perceptions towards six scientific professions in UK.

In UK, 88.8% of the students taking the pre-PERSEIASsurvey did not know any female scientist, and this rate was very slightly increased to 89.2% after delivering the DRAMA-BASED ACTIVITIES. The genderization pattern was also very similar to Spain with more than 70% of students agreeing on the six professions being performed by both women and men equally. Nevertheless veterinarian and nurse were perceived as more related to women than men, in the latter with more than 40% seeing it as a women's job, whereas the other four were perceived as more related to men. These patterns did not change much after delivering the PERSEIASbut for the engineer, which increased by 25% its perception of women being engineers. Results are shown in figure 6.5.

4.3.4 Performance styles' assessment

Besides the analysis of RRI values and STEM perceptions showed below, the PERSEIAsevaluation strategy included an assessment of the performances styles through the post-PERSEIASsurvey using three different scales: positive perceptions, negative perceptions, and general recommendations. The former scale assessed the impact that the general recommendations of the guidelines had over the general development of the PERSEIAsdelivery. These scales were complemented by structured interviews to the performers.

In Spain, all indicators for positive perceptions had a level of agreement of more than 60%. Nevertheless, students agreed in less than 40% that attending the PERSEIASwas positive for their learning of science. In the case of negative perceptions, the level of disagreement was higher than 60% in all cases, even though the scientific monologues were more confusing for boys than for girls. In Spain, only 6.7% of the students did not enjoyed the PERSEIAS (figure 6.6), what is consistent with the results obtained in the statement "The performance was boring", which was agreed by 12.4% of the students, and with "The activity was a waste of time" that was agreed only by 8.7% (figure 6.7). The use of monologues to talk about science did not adversely affect the image that students have of the performers, as only 7.8%

of the students did not consider the performers as scientific experts. In the same line, a reduced 4.8% of the students did not trust in the scientific information given during the performance and 13.1% considered it confusing, while 42.0% considered the performance important for their scientific learning (figure6.6).

Showing a video was a good idea for more than 65% of the respondents, especially for girls (figure 6.6). Even more, almost 30% of the students attending the Spanish PERSEIASagreed on having actively participated in the event. Actually, 27% of the students attending the event talked directly to the performers during the event (data not shown). This confirms that an important effort has been made to reach the goal of making an interactive DRAMA-BASED ACTIVITIE, as stand-up comedy shows normally low interaction with the audience. The use of social networking applications was moderate, with less than 50% of the audience having used them to interact with the performers (data not shown). All these results are showed in figure 6.6.

In the UK, two of the indicators for positive perceptions ("I have enjoyed the performance" and "I trust the scientific information in the performance I attended") had a level of agreement of almost 80%. Nevertheless, only 50% of the students agreed on "The performers are scientific experts". In the case of the negative perceptions, the level of disagreement was higher than 70%, even though many boys positioned themselves neutrally when considering the science-busking event as confusing. The level of interaction with the audience was higher than in the Spanish case, with almost 50% of students admitting having spoken with the performers and having actively participated in the event. This fact could be due to the fact that busking is delivered with smaller audiences than stand-up (table 5.4). Only 40% of the students were engaged with social networks. All these results can be checked in figure 6.7.

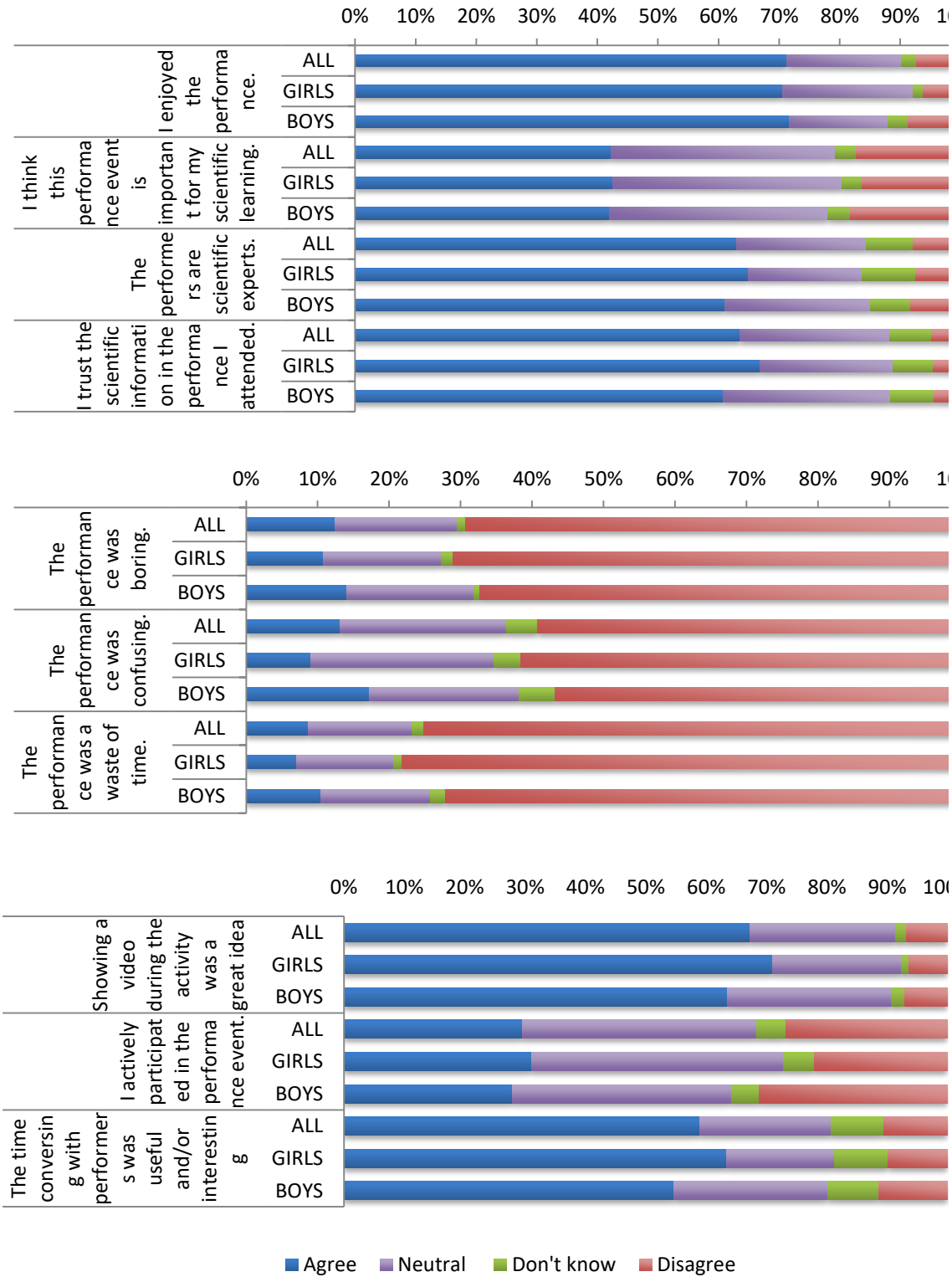

Figure 6.6: Evaluation of stand-up comedy style performance in Spain, by gender.

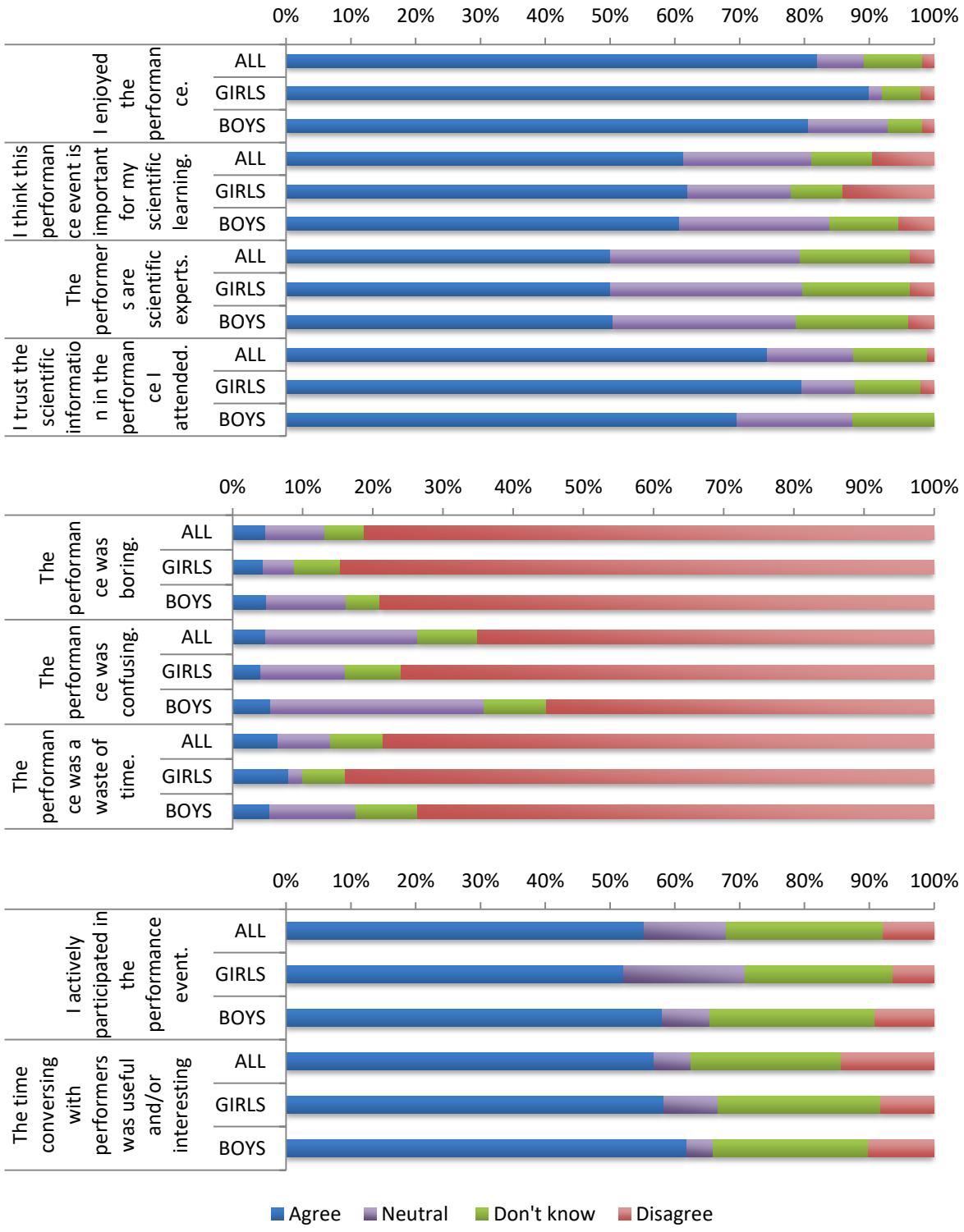

Figure 6.7: Evaluation of science-busking style performance in UK, by gender.

These quantitative results are compared to the answers given by the performers delivering the PERSEIAsin both cases through structured interviews that are included in Annex 5. In the Spanish case, students' perceptions that the performance was fruitful for their learning process was moderately high (42.3%). According to TBVT performers, PERSEIAsmediated by stand-up comedy worked because humour enhances attention.

> *"As I observed, [the elements that worked best] were passages in the text that required low concentration and offered proximity (not necessarily humour) and lively nonverbal communication." [ES_performer1]*

> *"Monologues used familiar situations. Besides, it is always great to see your mates participating in the activity." [ES_performer3]*

Other elements that helped students to better understand the DRAMA-BASED ACTIVITIES, according to the performers, was delivering it outside the common classroom, incorporating rap music or using a video. This last question has been also evaluated through the post-PERSEIASsurvey, as showed before, and showed an agreement degree of 65%.

> *"It helps a lot if the performance is not inside the classroom. If possible, it is better moving to the school auditorium or to a nearby theatre. […] This makes students behave better and teachers get more involved in the show." [ES_performer2]*

> *"The use of video is a great tool. It is awesome to observe how students stay quiet and contemplating the video very concentrated." [ES_performer2]*

> *"The final rap worked very well. Rap speaks in their language."*

[ES_performer3]

Even though these elements worked well, a moderate proportion of the students admitted having participated actively in the Spanish performance (30%). The performers, who claimed that they were not able to make participate students attending the DRAMA-BASED ACTIVITIES, confirmed this appreciation. They asserted that the final round for questions usually did not work well, and that sometimes they would need some help from teachers. They admitted, in addition, that the most dense and narrative parts of the performance did not make students participate correctly. All these elements should be taken into account to better improve stand-up PERSEIASin the future.

> *"Sudden demand of collaboration, if voluntarily don't work, is tricky, so as to attracting attention by force, using clichés and overacting."*
> *[ES_performer1]*

> *"Sometimes, the questions round does not work properly, especially if they are going to the playground or home just after the performance. In those moments, the collaboration of teachers is crucial, but they usually "disappear" from the show." [ES_performer2]*

> *"Moments in which the structure was more narrative and serious did not work well at all at engaging audience." [ES_performer3]*

In the UK case study, students' perception that the activity was useful for their scientific learning was higher than in the Spanish case study. As the performer indicates, science busking showed that it worked well because the performer knew very well the audience. For this, it was necessary to listen what they said during the show and to wrap the busking show with familiar stories close to their context.

"[…] listening to your audience before and as you commence to busk. If we listen hard enough are audiences will nearly always tell us (whether they mean to or not!) how best to deliver material to them. The mobile phone routine was especially useful for this and the performer could feel the difference when time constraints sometimes prevented this element of the busking set from being deployed." [UK_performer1]

"The mobile demo is so very interactive, pupils really bought into the Harry Potter idea, with science being allied to magic in popular culture." [UK_performer1]

In addition to being useful for their learning, students actively participated in the busking. The performer, who affirmed that participation is the most important variable to make a science busking show successful, confirmed this claim.

"This mixture of wonder through participation lies at the heart of many successful science busking demonstrations" [UK_performer1]

"Questioning remains one of the most effective techniques for involving an audience in any busk. Even closed questioning can very much have its uses for engaging an audience in your subject matter at its relevance to that audience." [UK_performer1]

Considering all these results, it can be concluded that science busking artistic discipline was more appealing for students than stand-up comedy. Nevertheless, the latter showed better results to transmit RRI values and to increase STEM attitudes in secondary school students. Having these preliminary results in mind makes it even more necessary the collaboration among different groups working in performing arts and science.

In the French case study, one of the most important appreciations the TRACES performer had is that clown PERSEIAs worked so well because teenagers feel represented by the characters:

> *"I think the teenagers recognize themselves, and adults they live with, in some part of the show. They laugh and comment some scenes." [FR_performer1]*

TRACES performer admits that using EW to adapt their performance has allowed them to better connect with teenagers.

> *"The fact we used the real material of the workshops we did in the classroom with teenagers worked well. What job make them dream, what vision they have about scientist? Etc..." [FR_performer1]*

As in the Spanish case, one of the main problems of TRACES PERSEIAS was the interaction with the audience. In this sense, French and Spanish PERSEIAS need to further review their performances to include some participation of teenagers.

> *"It's not easy to answer this...because they didn't talk about what they didn't like after the show (in front of us!)" [FR_performer1]*

> *"[It would have improved the show] taking more time in the sessions to really let the discussion grows up, and let us be surprised by what young teenagers have to say!!" [FR_performer1]*