The Art of Science Learning

WP4 Assessment Analysis of Goal 4

UK Case Study

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July 2017

European Commission | Horizon 2020 European Union funding for Research & Innovation

This project has received funding from the European's Union H2020 research and innovation program under grant agreement N° 665826

Methodology

As a way to explore how the workshops approached Goal 4 (i.e., including RR values in the participatory learning process and boosting motivations towards science), we focus on three different aspects of **RRI values: i) inclusiveness, ii) engagement,** and **iii) ethics integration.** We also analyze **students' general perceptions and attitudes towards science before and after the workshops** in order to contextualize our analysis and identify potential changes resulting from students participation in the project. **Gender** is included as a variable of analysis along all these aspects.

More specifically, our analysis explores students' feelings towards studying science at school, their predispositions and understandings towards the role of science in and for society, and their motivations for science and studying scientific careers. Furthermore, it is oriented towards exploring to which extent PERFORM workshops facilitated learning spaces integrating process requirements and fostering learning outcomes related to these three dimensions of RRI, and what aspects of the design and implementation facilitated or hindered such integration.

Following the same approach as in Goal 3, these motivations and RRI values **are explored through** students' inputs provided in the surveys (as a first quantitative approach) and researchers' observations of the workshops complemented by students', teachers' and ECRs' inputs (as a qualitative in-depth approach). Thus, data comes from a pre- and a post-questionnaire answered by 19 students (7 girls and 12 boys) of those attending the workshops. We only include responses of those students answering both pre- and post-surveys to be able to compare changes before and after their participation in the workshops, but when reporting answers of questions only included in the post-questionnaire we show the results of the 22 students who provided answers. However, we discarded some of the post-survey answers from one of the students who marked all responses of one of the sides of the questionnaire with the same answer: "4". Due to the small sample size, results are shown in absolute frequencies (percentages could lead to misunderstandings). We compare these answers to those from 13 students (5 boys and 8 girls) from a control group and explore potential associations by using logistic regressions. We also examine potential gender-related associations. Results from these statistical analysis showing significant associations should be taken with caution due to the limited sample in this case study.

Students' answers are then further explored through learning charts they filled in after each workshop and a focus group conducted with a reduced but representative group of students who participated in the workshops (6 girls and 2 boys). Finally, in order to explore how the pedagogical context and related factors of the workshops could have integrated RRI process requirements and fostered learning outcomes, we analyse the transcription of our observations during the whole process. To complete such analysis we explore both involved teachers' and the 7 ECRs' perceptions of the educational process implemented.

Highlights

Students' general perceptions and attitudes towards science

- **STEM related subjects were perceived by students as enjoyable** ways to acquire new knowledge, being **science and design technology the most preferred and mathematics the less enjoyable**. **Learning on IT and computing was more enjoyable for boys than girls**.
- Students in general perceived **positively science education activities and reported feeling comfortable** when doing them. **Girls felt less comfortable than boys before workshops,** a difference that was not found after the workshops, **suggesting that workshops could have reduced such gender gap.**
- The majority of students **perceived that science is related to real-life problems and could help them understand worldwide problems.** Boys **agreed more with such perceptions than girls.**
- Students also perceived that **scientific jobs are important for having a better society and disagreed that men are better scientists than women** and that **scientific jobs are mostly for boys**. Students participating in the workshops perceived the **research profession as more gender balanced** than their peers in the control group.
- In general **students did not have a clear idea about their future studies**. Around half of them **perceived learning science as important for their future success**, **science classes as helpful to get a job** and **would like to study a STEM related career.**
- **Boys perceived learning science as more helpful to get a job than girls**, a difference that was not found after workshops. But workshops did not have an impact on reducing the gender gap in this regard since **boys were more willing to study a STEM career than girls both before and after the workshops.**
- **Around half of the students saw themselves doing science in the future. Boys agreed more with this idea than girls.**

RRI values

- Students **enjoyed working together** through group tasks and practical activities. Overall, they **felt part of the group**, with some exceptions highlighting difficulties in **achieving a balanced participation within subgroups**.
- **Students' interaction was diverse:** some students' asked whatever they wanted to the facilitators whereas the others did not or provided neutral answers. **Gender differences in students' involvement in discussions or asking questions were not clearly observed**.
- Around half of students agreed they **could make decisions about the topic, the research question** and **the content of their busk, but to a lesser extent on acting during the busk**. A similar number of students could choose how **they wanted to participate in their busk.** Gender differences were not clear.
- **Few students felt their work was recognized by the teachers.**
- **Few students really wished to have had more interaction with ECR.** Students complained that ECR talked about useless things and were not interested or not able to help them with their busks. **ECRs in turn noticed that workshops had a rigid structure that did not allow for moments of interaction with the students**.
- **Facilitators and ECR promoted both cognitive and emotional engagement amongst students** during the workshops.
- **Some students really enjoyed the activities while others were uncomfortable or disengaged**. Their **interest and enjoyment increased from the first to the final workshop.**
- Most students **enjoyed contributing with ideas to the design of the busks and practicing or performing them,** although they were **really nervous about performing in front of an**

audience. Others **enjoyed the most talking to the ECRs and doing research by themselves**, as well as **engaging in reflective and discussion activities during workshops**

- Some students **enjoyed the least to perform the busk in front of other students** because they felt uncomfortable. Others **did not enjoy doing the initial tasks and activities because they were not related to the busks** and **interacting with the ECRs** because they were not helpful with their busks.
- **Most students** reported **they improved their learning on the scientific topics of their busks,** although a few students mentioned that the **scientific level of the workshops was lower than science lessons**. **Observations showed that learning about scientific literacy was not well supported by the activities**, which also lacked links to the curriculum.
- Workshops scheduling within the students' timetable **negatively influenced their engagement** since students **missed important science and maths lessons.** Negotiation between facilitators and teachers could prevent similar situations in the future.
- **ECRs suggested giving the props earlier to the students** to generate excitement and engagement and **linking the science busking with students' experience in drama**.
- **Teachers and ECRs suggested to shorten workshops** which did not involve practical activities, **to spend more time in preparing students for the busks**, to **reduce the gap between learning the basics of busking and performing**, and to **shorten the time between the busks performed by facilitators and the workshops.**
- Teachers highlighted that **having an ECR with each subgroup helped in fostering students' engagement.** One of the ECRs **linked the broad topic chosen by the students with her research topic** to be able to work on it and make it more attractive for the students.
- **ECR would have liked to contribute more to the science level of the workshops and to have more time to better prepare STEM explanations** during workshops so as to make them fun to students.
- **Students were able to understand the nature of science both before and after the workshops** so workshops did not have an effect on it. Most students perceived human imagination and creativity are needed for producing scientific knowledge, scientific knowledge is not always certain, and good scientists can fail while doing science.
- According to the teacher, workshops provided a good opportunity for students **to debate ethics in science, which was not part of the curriculum**. But ECRs noticed that some of these activities **could have had the opposite effect than the one desired on students understanding of science and suggested more discussion on the failure of scientists** and more reflection on how to reduce the stereotypes.
- Students and ECRs perceived there was **a disconnection between the ethics content of the workshops and the performance aspects** and **suggested it would be valuable to establish more links**. Also, more efforts should be done to connect activities with students' daily life experiences, as well as to include **ECRs' personal stories so as** to reinforce the human dimension of science.

1) STUDENTS' PERCEPTIONS AND ATTITUDES TOWARDS SCIENCE

Concept and approach

Students' *attitudes and perceptions towards science* refer to their feelings towards studying science at school, their predispositions and understandings towards the role of science in and for society, as well as and their motivations for science and studying a scientific careers.

Students' attitudes and perceptions of science were first approached in the survey and then supported by data collected through students' focus group, observations, and ECR's interviews.

It is worthy to note that students' negative responses to the post-survey regarding their perceptions and attitudes towards science in general need to be taken with caution because some students could have answered these questions more negatively than they actually felt because they did not enjoy the workshop activities. As this boy explained in the focus group when asked for some negative responses in these questions:

"*I think it might be because of the fact that none of us liked the PERFORM project and doing a questionnaire kind of made us feel quite negative about it*" (UK1123).

Indeed, the surveys were implemented by the teacher just after they performed their busks and at the end of the last day of school before holidays, which might lead some students to give non-reasoned answers or even casual answers in order to get it done faster.

Main highlights

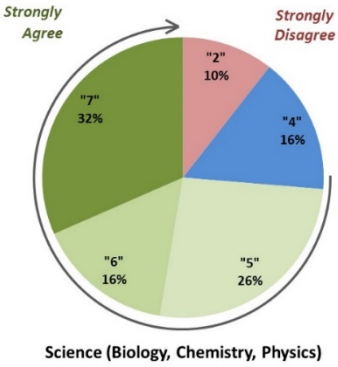
- **Most students perceived STEM related subjects at school as enjoyable ways to acquire new knowledge**, and specifically **those subjects related to science and design technology**.
- **Learning on IT and computing was more enjoyable for boys than girls**, while **mathematics was the subject perceived as the less enjoyable**.
- ECRs **would have liked to have more time to better prepare STEM related explanations** during workshops so as to make them fun and more attractive to students.
- Students in general showed **positive feelings towards science education activities and felt comfortable** when doing science tasks. A statistically significant higher proportion of **girls felt less comfortable than boys before workshops,** a difference that was not found **after the workshops, suggesting that workshops could have reduced such gender gap.**
- Majority of students **disagreed that science has nothing to do with real-life problems and agreed that science can help them understand worldwide problems** and that **scientific jobs are important for having a better society**.
- Before the workshops **boys disagreed more that science is not related to real-life problems than girls**, a significant difference that was not found after workshops. By contrast, **boys were more agreed that science can help them understand worldwide problems than girls after the workshops.**

- **Students participating in the workshops perceived the research profession as more gender balanced than their peers in the control group**. PERFORM students **disagreed that men are better scientists than women** both before and after the workshops, as well as that scientific jobs are mostly for boys.
- In general **students did not have a clear idea about their future studies**. The idea of studying a scientific career was more motivating for a slightly, but not significant, higher number of students after having participated in the workshops than before. However, there were not significant differences in students' motivations for studying a STEM career before and after the workshops: **around half of the students responded they would like to study a STEM related career.**
- Workshops did not have an impact on reducing the gender gap in the willingness to study a STEM career, since **boys were more willing to study a STEM career than girls both before and after the workshops.**
- **Despite this, around a half of students perceived learning science as important for their future success** and **science classes as helpful to get a job**, a proportion that slightly decreased, but not statistically significant, after the workshops.
- **Boys perceived learning science as more helpful to get a job than girls**, a difference that was not found after workshops.
- **Around half of the students saw themselves doing science in the future. Boys agreed more with this idea than girls.**

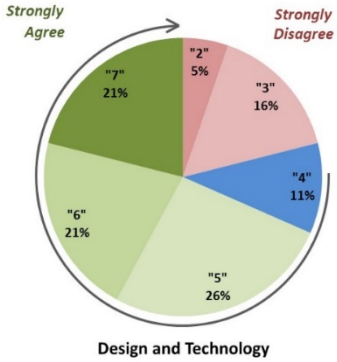
Results description

We first present the results of **students' feelings on science learning at school** gathered through the pre-survey as an introduction to the results related to students' potential changes in perceptions and attitudes towards science and scientific careers and jobs as a result of their participation in the workshops.

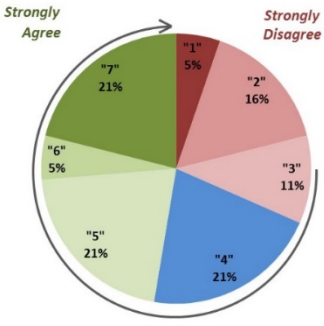
Overall, **PERFORM students perceived STEM related subjects at school as enjoyable ways to acquire new knowledge**, and specifically **those subjects related to science and design technology**. Most of them (14) responded they did enjoy learning science (biology, chemistry and physics) and only 2 did not like it, while 13 students did enjoy learning design and technology and 3 did not. Regarding IT (information technologies) and computing, 9 students did enjoy acquiring new knowledge in this subject and 6 of them did not. There were statistically **significant gender-related differences since boys enjoyed more learning IT than girls** (z=-2.474; p<0.0134). In turn, **students' perceptions regarding learning mathematics were contrasting**: 9 students answered they liked learning mathematics whereas 8 students said they did not. Significant differences were found in this regard between PERFORM and control groups: **students in the control group enjoyed learning mathematics more than those attending workshops** (z=-2.312; p<0.0208).



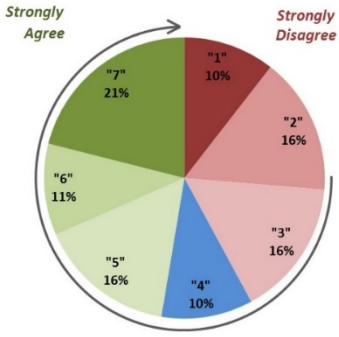
Science (Biology, Chemistry, Physics)



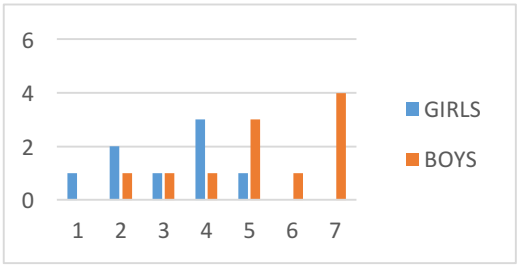
Design and Technology

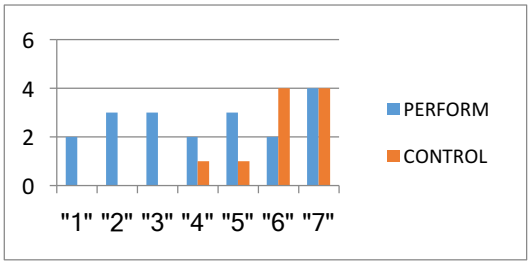


ICT/Computing



Maths



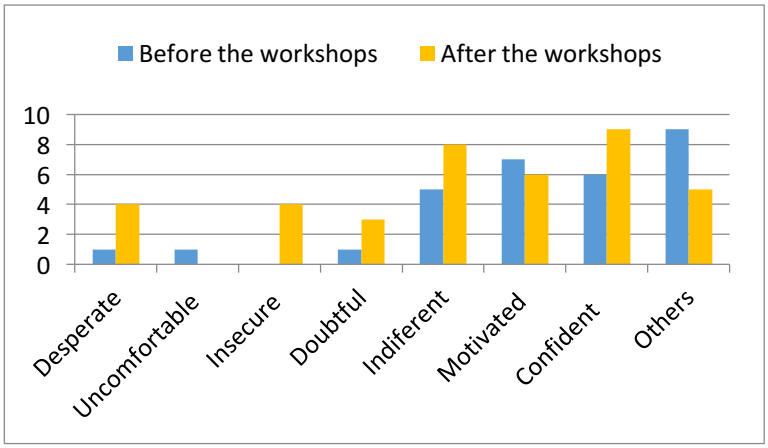


"I enjoyed acquiring new knowledge in…"

Such **disenchantment for learning mathematics at school** was observed during PW3-4 when the video about unconscious bias showed a maths problem about a bat and a ball that many students did not understand. When an ECR went up to explain the problem and did a proof on the board by using x and y symbols, the (male science) teacher said "*algebra! now they will be lost*" and there was a loss of interest amongst students immediately and lots of chat. This reaction suggests students could not have felt able to understand the problem because they were not even motivated to try it. Then the facilitators noticed that a boy was explaining the problem to some students around and invited him up to give his own proof and he managed to explain it in an easier way that was understood by students. **The ECR who tried to explained the problem mentioned during the interview she would have like to prepare her explanation to make it more enjoyable for the students**:

> "*I would have like to have more time to think about how to make it fun as well as like mathematical. I think probably with some more time for preparation I could have done a better job*".
> (ECR, Bristol).

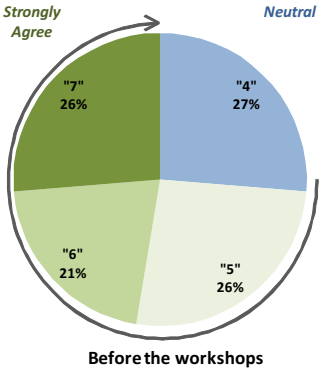
When asked **how they felt in a science class or while doing science-related activities** in the pre-survey, most students answered they felt "motivated" (7 students), "confident" (6) and "indifferent" (5) whereas afterwards they felt more "confident" (9) and "indifferent" (8) but also "less motivated" (6). The number of students showing feelings related to "insecurity" and "desperation" increased after the workshops from 0 to 4 students and from 1 to 4 respectively. Statistical tests showed no significant before and after, nor between students from PERFORM and control groups.



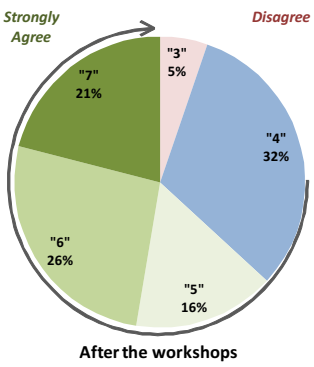
"In a science class or while doing science-related activities, I usually feel..."

Therefore, **workshops did not seem to have a significant effect on students' positive or negative feelings towards science education activities, which were in general positive**. But interestingly, **workshops could have had an impact on girls in this regard**. When specifically asked if they felt **comfortable while doing activities related to science in the pre-survey, a statistically significant higher proportion of girls felt less comfortable than boys** (z=-1.88; p=0,061). **After the workshops this significant difference was not found, suggesting that workshops could have reduced such gender gap.**

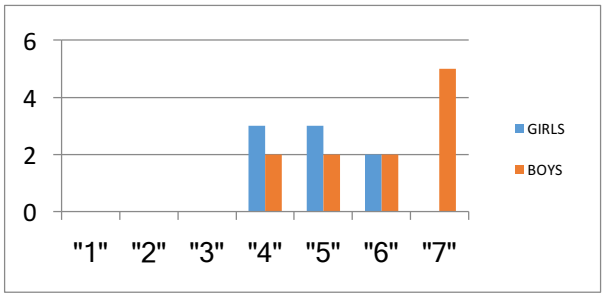
In general, students felt comfortable when doing science-related activities before and after workshops (14 and 12 students respectively). No significant differences existed between students attending workshops and those from the control group, nor before and after.



Before the workshops



After the workshops

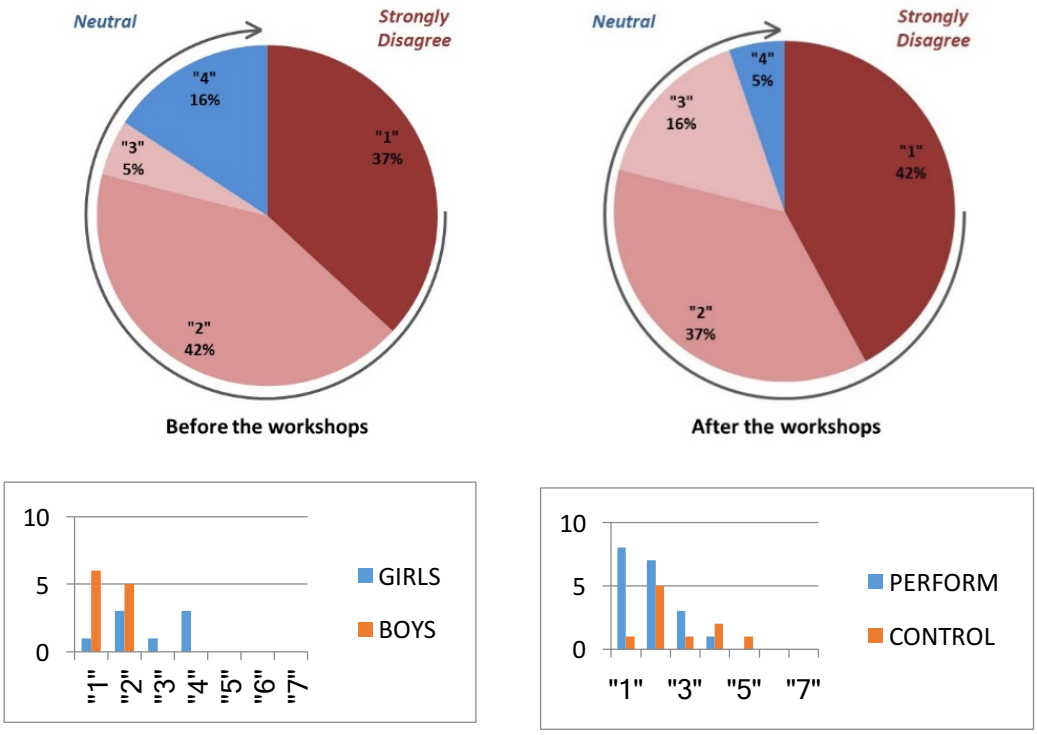


"I feel comfortable while doing activities or tasks related to science"

Students were also asked in the survey for their perceptions about the **role of science in and for society**. In general, **those participating in workshops had a positive perception towards science** that, despite remaining almost unchanged after the workshops**, seemed to be strengthened when compared to the control groups**. Interestingly, **workshops also seemed to have a gender-related impact in this regard**.

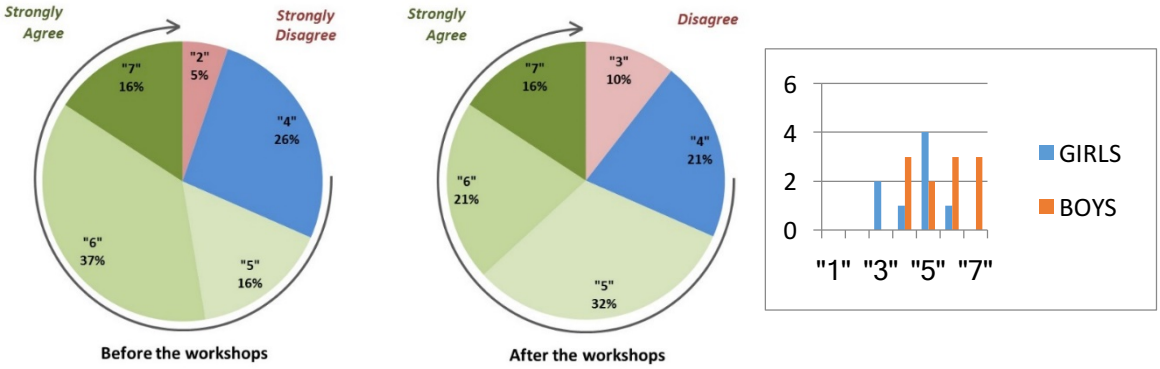
The majority of students disagreed that science had nothing to do with real-life problems both in the pre-survey (16) and the post-survey (18). After participating in the workshops, 2 students changed their opinion from a neutral view to supporting the idea that science was linked to real-life problems, but no statistically significant differences were found in this regard. By contrast, **there was a statistically significant difference between boys and girls before the workshops: boys disagreed more that science is not related to real-life problems than girls** ($Z=2.52$; $p<0.01$). This significant difference was not found after the workshops, suggesting that girls might have changed their perception after participating in the workshops.

Also, students' involvement in the workshops seemed to have an effect on their perceptions since in the post-survey significant differences were found between PERFORM students and those from the control group: **PERFORM students disagreed more with the statement that science has nothing to do with real-life problems than the control group** ($z= -1.89$; $p<0.06$).



"Science has nothing to do with real-life problems"

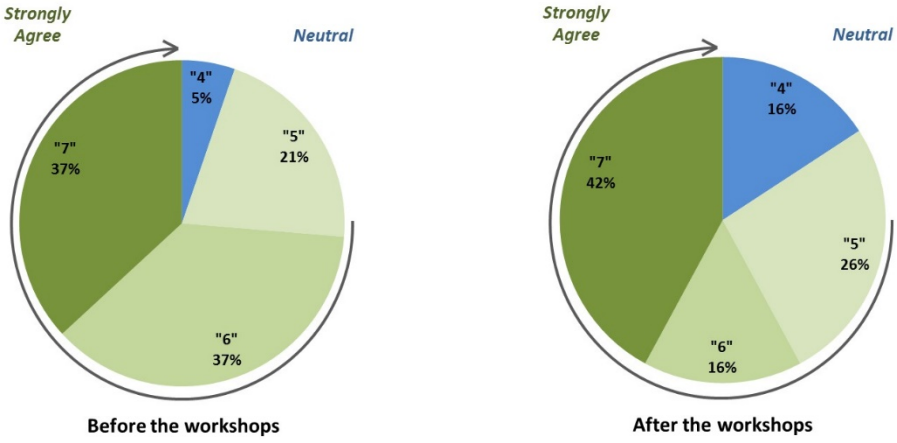
Such general perception about the connection of science with societal challenges was also supported by **students' responses to the question "*science will help me understand more about worldwide problems*" since most of them agreed with it in the pre- and post-surveys** (13 out of 19 students). Although not statistically significant, the number of students who thought that science could not increase their understanding of worldwide problems increased from 1 to 2 after the workshops and those giving neutral answers decreased from 5 to 4. There were not significant differences between PERFORM students and the control group. Interestingly, and similarly to the question before, we found significant differences in relation to gender: **after the workshops, more boys agreed more that science could help them understand worldwide problems than girls** (z=-1.697; p<0.0898).



"Science will help me understand more about worldwide problems"

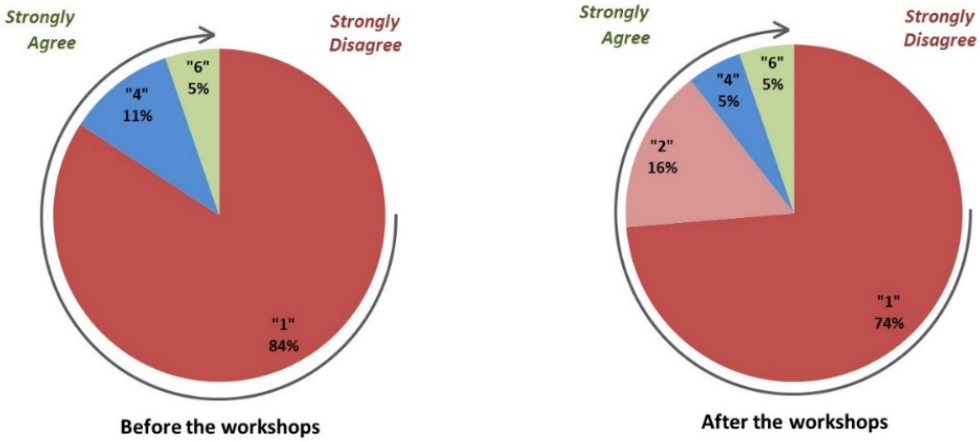
Also related to the students' perceptions of the role of science in and for society, **overall both girls and boys perceived that scientific jobs are important for having a better society both before and after the workshops** (18 and 16 students). Although two girls changed their opinion

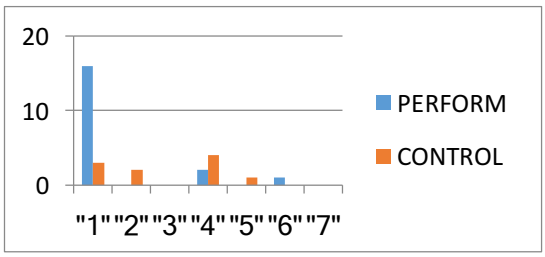
from positive to neutral responses in the post-survey, there were not significant differences between girls and boys, nor in their responses in the pre- and post-surveys.



"Scientific jobs are important for a better society"

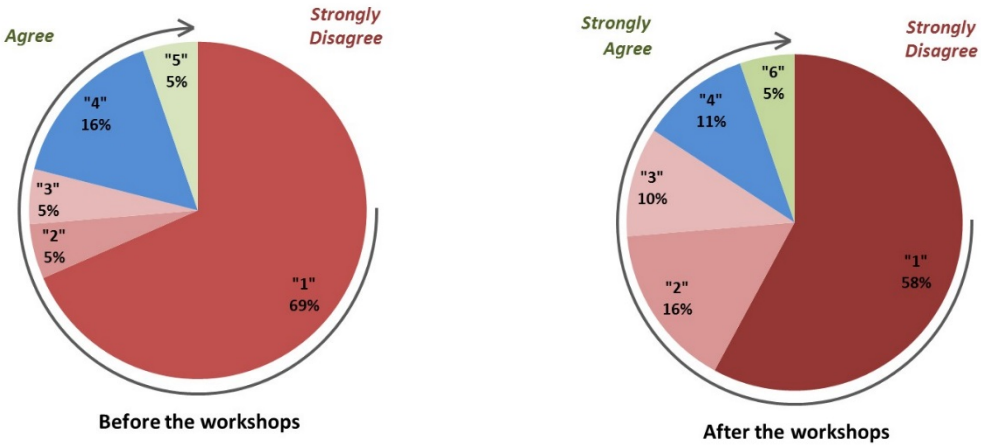
Students also answered questions on their **perceptions about gender-related roles in science**. **Overall, students disagreed that men are better scientists than women both before and after the workshops** (16 and 17 students respectively). One of the students who provided a neutral answered in the pre-survey changed his opinion and disagreed with the statement afterwards. Only one boy perceived that men are better scientists than women both before and after the workshops. **Significant differences were only found between PERFORM and control students before the workshops, being PERFORM students more disagreed with the statement than those in the control group** ($z=-2.559$; $p<0.0105$), which suggests that students participating in the workshops perceived the research profession as more gender balanced than their peers.





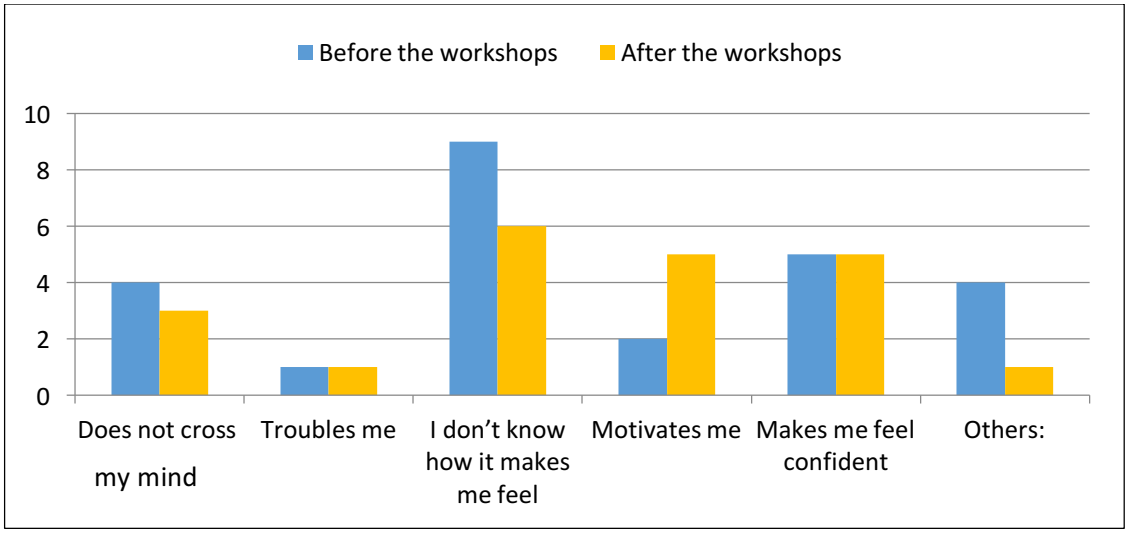
"Men are better scientists than women"

Similarly, most students disagreed that scientific careers are mostly for boys: 15 and 16 students before and after the workshops. Again only one boy agreed with it. No significant differences were found between groups.



"Scientific careers are mostly for boys"

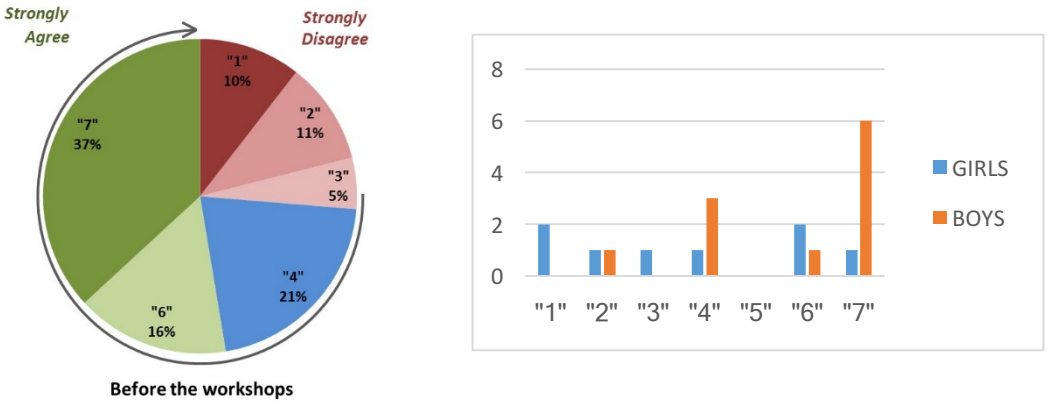
Finally, **students' were asked for their motivations for learning science and studying scientific careers. In general students did not have a clear idea about their future studies before the workshops** since almost half of them (9) answered they did not know how they felt thinking about studying a scientific career. This number was reduced to 6 students after the workshop. Also, the **idea of studying a scientific career was more motivating for a slightly higher number of students after having participated in the workshops** (5 students) than before (2 students), but there were not significant differences in this regard. 5 students responded they felt confident when thinking about studying a scientific career both before and after the workshops.

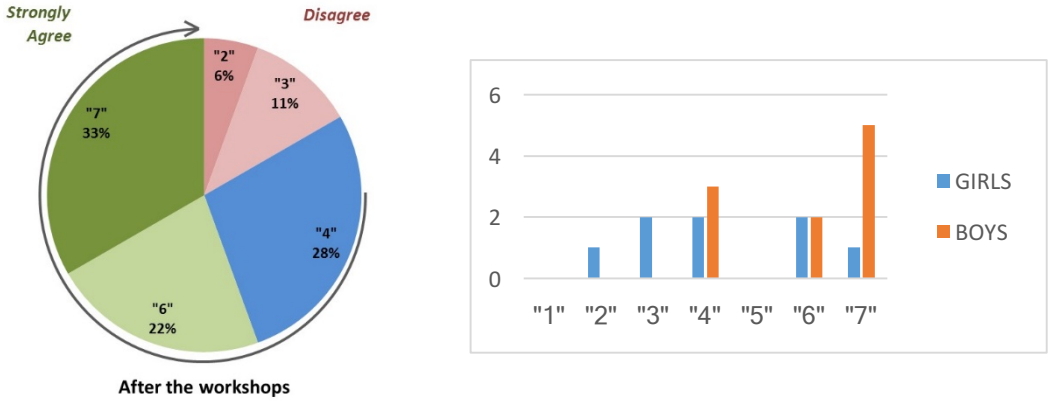


"The idea of studying a scientific career…"

Around half of the students (10 out of 19 students) responded in the pre- and post-survey that they would like to study a STEM related career. **Boys were more willing to study a STEM career than girls**, as statistically significant differences related to gender were found in students' answers to the pre-survey ($z=-1.96$; $p<0.05$) and post-survey ($z=-1.98$; $p<0.05$). No significant differences were found before and after the workshops, which suggests that **workshops did not**

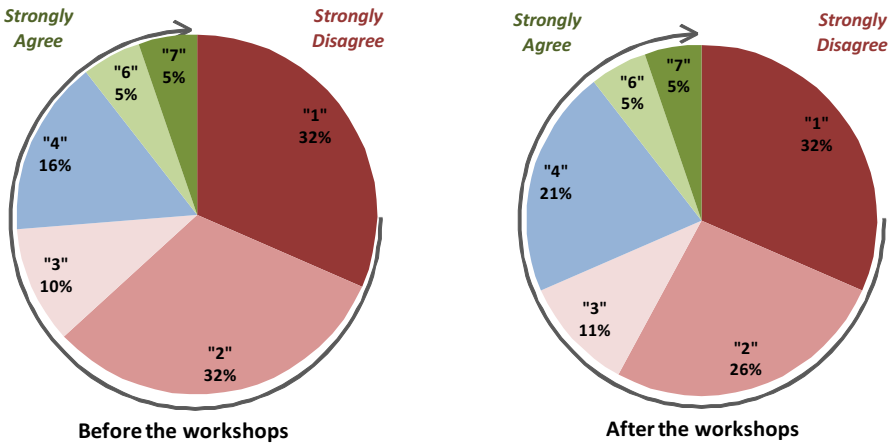
have an impact on students' willingness to study a STEM career, and specifically in reducing the gender gap.





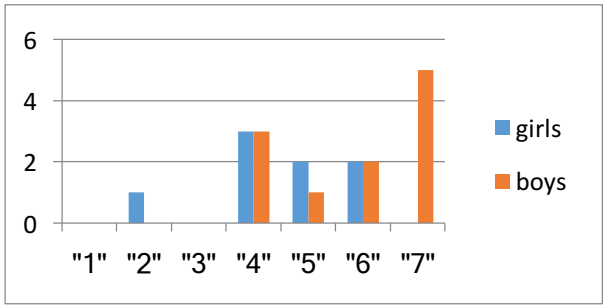
"I would like to study a career involving science (like biology, geology, physics, medicine or chemistry), technology, engineering or mathematics"

Despite these results, **students did value learning science as relevant for their future success with 2 exceptions who agreed with the statement *"Learning science is not important for my future success"*.** Statistical tests neither showed significant differences between boys and girls on how they value learning science. Also, answers given by these students did not differ either from the control group, in both surveys (pre and post).

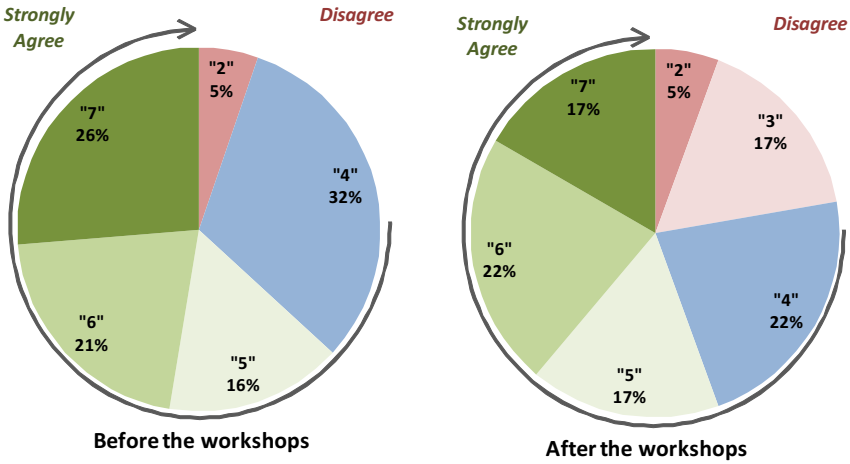


"Learning science is not important for my future success"

Significant differences did exist between boys and girls before the workshops when answering the statement "*What I learn in science class will help me to get a job*" with a higher number of boys providing positive answers than girls (Z=-1,92; p=0,055). These gender differences were not found in the post-survey, which suggests that **workshops might have reduced this gender gap**.

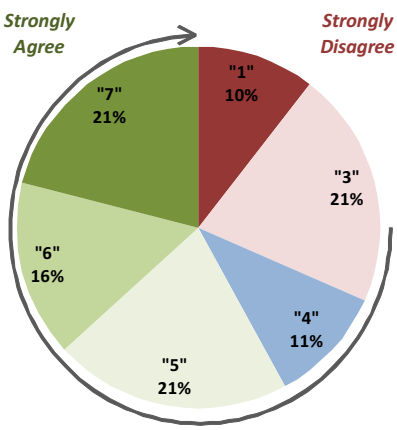


However, the overall number of students who agreed that what they learn in science class would help them to get a job slightly decreased after the workshops (from 12 to 10 students). Also, a higher number of students gave negative answers in the post survey (1 student before and 4 after). These differences were not significant.

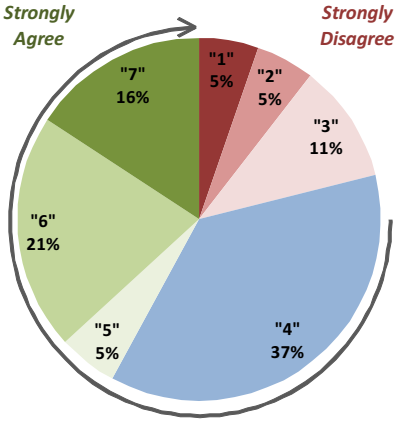


"What I learn in science class will help me to get a job"

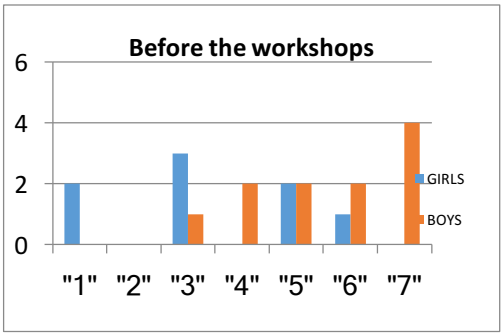
Similar results were found when asked **if they could see themselves doing science in the future:** 11 and 10 students agreed with the statement before and after the workshops respectively. The number of students providing neutral answers largely increased from 2 to 7 students, suggesting that some of these students (mostly girls) could have slightly reduced their disinterest in science due to their participation in the workshops, although significant differences were not found in this regard. We did find **significant differences between boys and girls, being girls those providing more negative answers than boys** both before (Z=-2.39; p=0,017) and after the workshops (Z=-1,75; p=0,08).



Before the workshops



After the workshops



"I can see myself doing science in the future"

2) INCLUSIVENESS

Concept and approach

We addressed *inclusiveness* here as the capacity of the learning process reach diverse students' profiles and learning styles. This has been approached through three criteria: i) balanced participation, as the inclusiveness and involvement of all students, making sure that each one has the opportunity to contribute to the process in an active way; ii) fostering dialogue as the capacity of the process to build learning upon students' mutual exchange of ideas and opinions so as to integrate different perspectives and work together; and iii) students' acceptance of process/ outcomes, as the degree to which participants accept and feel ownership of the different learning outcomes and processes involved in the activity.

Furthermore, although a gender perspective has been transversally addressed in all the evaluated aspects, we have also included in this section some specific items related to: i) gender balance in participation, that is, participation differences according to gender and ii) gender differences in students' engagement, reactions to the methods and topics proposed and interactions among them.

We addressed theses aspects mainly through students' surveys and the focus group as well as observations, but also through teachers' and ECRs' interviews.

Main highlights

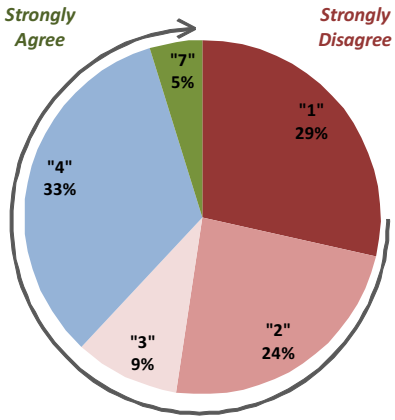
- Some students reported in their learning charts **they enjoyed working together** through group tasks and practical activities. Enjoyment when working in groups was possible because overall students **did feel part of the group** during workshops, with some exceptions highlighting difficulties in **achieving a balanced participation within subgroups**. However, few students **complained about the way teachers formed subgroups** because of their lack of confidence when working together with other students ended up leaving aside them.
- **Students' experiences about their interaction with the facilitators were contrasting**: some students reported that they asked whatever they wanted to the facilitators during workshops whereas the others did not or provided neutral answers.
- **Gender differences in students' general involvement throughout the workshops were not clearly observed**.
- **Overall students could make decisions about the topic, the research question** and **the content of the busk, but only a few agreed** they could **make decisions on acting during the busk**.
- A similar number of students reported **they could choose how they wanted to participate in the busk and they could not.** There was **not any significant difference between boys and girls** in this regard.
- **Students felt their work was more recognised by the ECRs than by the facilitators** maybe because students thought facilitators were also researchers.
- **Few students felt their work was recognised by the teachers whereas around half of them did not have such feeling.**
- **Few students really wished to have had more interaction with ECR.** Students who did not enjoy interacting with ECR argued that **ECR talked about useless things and were not interested or not able to help them with their busks**. **ECR also noticed that workshops had a rigid structure that did not allowed for moments of interaction with the students**.

Results description

As reported in the Goal 3 report, **around half of the students responded they actively participated in all tasks** (12 out of 22) **and shared different tasks within their subgroup** (13 out of 22). In this regard, some students reported in their learning charts **they enjoyed working together** through group tasks and practical activities. As this girl wrote when asked how she learnt duing workshops:

> *"Through performing, group tasks and activities. I liked how we wrote on the sheet the ideas we had and we rotated to different groups to write on their sheets. That made planning our busks easier because we had input from others."*
> (Girl, UK1110)

Such enjoyment when working in groups might be explained because overall students' **did feel part of the group** during workshops (13 out of 21). Only 1 did not and 7 provided neutral answers to the question.



"I did not feel part of the group during workshops"

The female teacher created students subgroups "*not taking account of friendship groups/science classes that I was aware of but tried to have some mix of gender*". She perceived that the students worked well together in this way and specifically referred to the case of a shy girl who did well working with two boys: "*She (the girl) wasn't phased about working with two males and being the only female*". However, some students in the focus group **complained about the way teachers formed subgroups** because their lack of confidence when working together with other students who were not their friends ended up leaving aside some of them. As a result, in some cases, few people within the group ended up doing the tasks:

> *Instead, it's not like a group it's like two people would be doing all the work and the rest would just not do anything*
> (Boy UK1123).

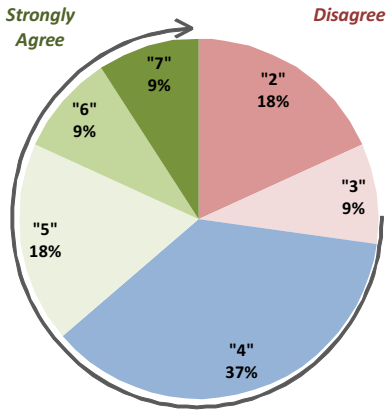
Indeed, in the first workshop facilitators realised one girl was disengaged and looked bored and upset in her subgroup so she was invited to move to another subgroup.

Difficulties in achieving a balanced particiation within subgroups were also highlighted by some students in the focus group by explaining their experience on the activity for choosing their topic. As a girl explained, this activity forced students to wait until another student agreed on the chosen topic, so a student could not do a topic unless another student had previously

agreed upon it. As a result, in one of the subgroups students finally chose a topic that was less interesting for them, as this boy explained:

> *"Everyone wanted to do their own thing and then we ended up doing something really random that everyone kind of wanted to do… but no one really did* (…) *a bit of help choosing a topic that was a actually interesting instead of what everybody wanted to do*"
> (Boy UK1123).

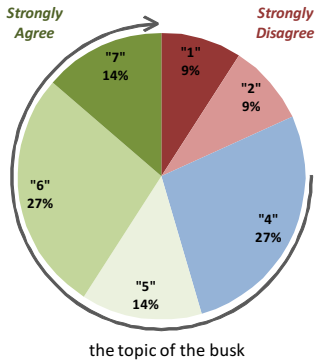
Facilitators used videos and power point slides, as well as little performances (one of them played by an ECR in PW3-4) which seemed to promote interventions and discussions among some students while others did not participate. In this regard, **students' experiences about their interaction with the facilitators were contrasting**: 8 students acknowledged that they asked whatever they wanted to the facilitators during workshops whereas 6 did not and 8 students provided neutral answers.



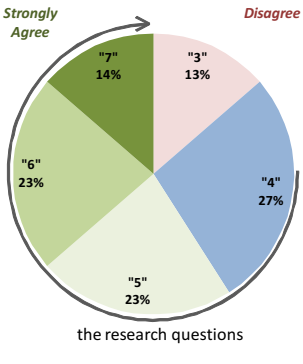
"During the workshops I asked the facilitators whatever I wanted to"

Therefore, some students were more active in asking and answering questions, as well as participating in discussions, **but gender differences in such involvement were not clear**. For instance, in PW1-2 some boys seemed to be very focused whereas girls were paying attention and contributing to the discussion but also demonstrating at some points a level of disengagement, which might be a simulation to capture more attention from their peers. In turn, in PW3-4 girls seemed to be more enthusiastic in the discussion of the "science is a girl thing" video than boys, but were mostly boys who took the initiative of presenting the results of the discussions in the subgroups to the large group. Differently, in both breaking news and storytelling exercises, boys and girls took the lead to present the work done in their subgroups.

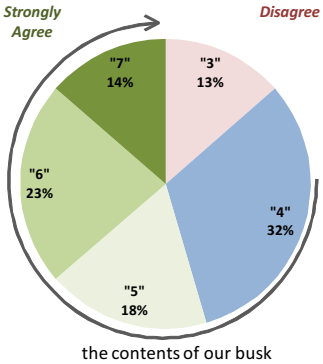
Regarding their capacity to intervene in the creation of their busks, **only 4 students disagreed that they could make decisions about the topic while 12 students agreed**. **A similar number reported they could decide on the research question** (13 students agreed and 3 disagreed) and **the content of the busk** (12 students agreed and 3 disagreed). Our observations showed that students could also decide who presented or performed the different tasks during activities, and in the last workshop they could also decide what props to use for their busks, always supported by facilitators and ECRs. However, when asked if they could **make decisions on acting during the busk, only 9 of them agreed**.



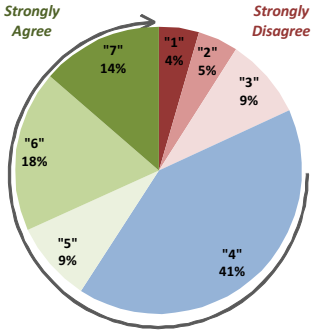
the topic of the busk



the research questions



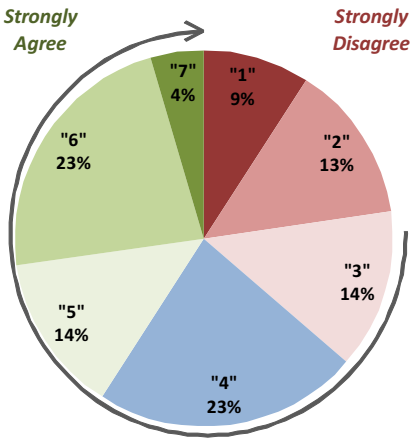
the contents of our busk



acting in our busk

"During the creation of our busk [they] could make decisions about…"

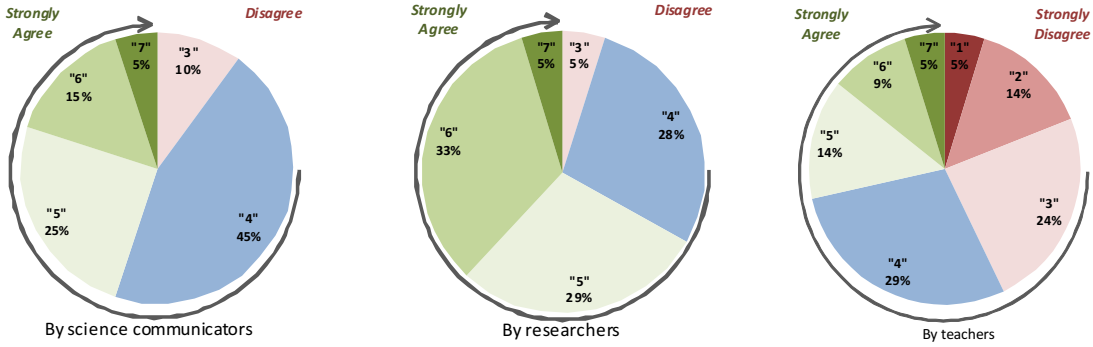
A similar number of students **reported that they could choose how they wanted to participate in the busk (9) and they could not (8).** 5 provided neutral answers. **There was not any significant difference between boys and girls in this regard. Gender differences in students' answers were neither evident when they explained their role when performing the busks in the post-surveys.** 4 girls and 3 boys explicitly mentioned they had an active participation by "*speaking*", "*introducing experiments*" and/or being the "*leader*". Most of them also mentioned that "performing" was what they enjoyed the most during workshops, which suggest that having such a prominent role in the busk was a positive experience for both these boys and girls. As one girl highlighted: "*Good, I had a speaking part and I enjoyed it*" (girl, UK1130). By contrast, one boy and one girl reported "*not doing much*".



"I could choose how I wanted to participate in the PERSEIA"

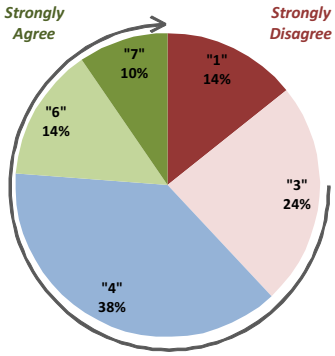
When asked who they felt their work doing the busks was recognized by, **10 students (out of 21) said their work was recognized by the facilitators or science communicators** (9 students reported neutral answers and 2 provided negative answers). This low number might be

explained because students got confused with facilitators, who they thought were also researchers. **Indeed, more students (14) felt their work was recognised by the ECR** (6 students gave neutral answers and only one student disagreed). In the case of teachers, **only 6 students felt their work was recognized by the teachers whereas 11 did not have such feeling** (6 provided neutral answers), maybe because they were not really involved in the workshops as it was observed. There was not any statistically significant differences between girls and boys.



"I felt my work was recognized by…"

While **a minority of students really wished to have had more interaction with ECR (5)**, most students did not mind (8) or did not wish to have increased their interaction with ECR (8). Three of them did not wish to increase their interaction with ECR at all.



"I wish I have had more interaction to the ECR"

These results might be explained by at least two reasons. First, and as reported in Goal 1 report, in the focus group, students who did not enjoy interacting with ECR argued that **ECR talked about useless things and were not interested or not able to help them with their busks**. Second, **ECR noticed that workshops had a rigid structure that did not allowed for moments of informal conversation with the students**, to ask questions about science or chat with them about their motivations for attending the workshops or to get their feedback on the topics discussed (on gender and ethics). ECR also noticed that students **did not have the opportunity of sharing their busking experience after the performance** at the hall with the ECR, which, they said, it would have been useful for them to share feelings about the process.

3) ENGAGEMENT

Concept and approach

We understand engagement as the capacity of the process to foster students' active involvement in science and scientific research. We have approached this both as i) e*motional engagement,* that is, students' *a*ctive involvement in the activity or project, related to intrinsic motivation, affective reasons and/or interest; and ii) c*ognitive engagement,* as students' *s*ustained, engaged attention during a task or process requiring mental effort. We also refer here to RRI values, such as, critical thinking, as students' ability to actively conceptualise, analyse, apply and evaluate information and knowledge.

We addressed engagement mainly through observations and students' learning chart and focus group, but also through students' surveys and teachers' and ECRs' interviews. Specifically we looked at the learning process capacity to foster i) questioning and reframing, or the promotion of understanding through questions that allow students complex thinking and the possibility to see the issues approached in new or different ways; ii) systems thinking, or the holistic approach to analysis that considers the interactions between the constituents of a system; iii) connecting topics with experience, or the contextualisation of the issues approached within their broader societal context and connection with participants' experience; and iv) seeking other points of view, or the consideration of different perspectives and points of view in students' discourse.

We also collected data on emotional aspects related to the acquisition of knowledge, such as i) students' predisposition or tendency to respond positively or negatively towards the methods and topics proposed; ii) enjoyment or students' feelings of pleasure caused by doing or experiencing the workshops; iii) emotional awareness and reflexivity or student's capacity to identify or express emotions associated with the topics addressed and to reflect upon and through their emotional responses; iv) body and spatial awareness or students' body movement and expressiveness, sensual awareness, and relation with the physical space, and v) empowerment and sense of belonging or students' sense of ability to do things and feeling of acceptance as part or member within a group or learning environment.

Main highlights

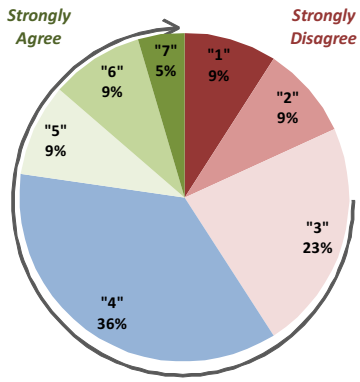
- **Facilitators and ECR promoted both cognitive and emotional engagement amongst students** during the workshops. **Facilitators were recognised by teachers to be very good at engaging the pupils**.
- **Some students really enjoyed the activities while others were uncomfortable or disengaged**.
- **Students' interest and enjoyment in the activities increased from the first to the final workshop.**
- Most of them **enjoyed contributing with ideas to the design of the busks and practicing or performing them,** although they were **really nervous about performing in front of an audience**.

- Some students **enjoyed the most talking to the ECRs and doing research by themselves**, as well as **engaging in reflective and discussion activities during workshops (e.g., unconscious bias activity)**.
- **Some students enjoyed the least to perform the busk in front of other students because they felt uncomfortable. Other students enjoyed the least to do the initial tasks and activities because they were not related to the busks**. Some of them explained that their expectations were not met since they expected to do more performance and less science.
- Some students did not enjoy to talk or listen to the ECR, and a few noticed they were not helpful with their busks.
- One of the ECR **linked the broad topic chosen by the students with her research topic** to be able to work on it and make it more attractive for the students.
- The way workshops were scheduled within the students' timetable negatively influenced their engagement since students **missed important science and maths lessons.** Negotiation between facilitators and teachers could prevent similar situations in the future.
- **Few students compared the workshops with the science lessons**, concluding that the scientific level of the busks was lower than science lessons and that these lessons were funnier than workshops.
- Observations showed that **learning about scientific literacy was not well supported by activities, which also lacked links to the curriculum.**
- Despite some students did not find the workshops interesting, **most of them** reported in their learning charts **they improved their learning on the scientific topics of their busks.**
- **ECR suggested giving the props earlier to the students** and using them in the first workshops because they generated more excitement and engagement than the planning and reading activities.
- **Teachers and ECR suggested to shorten workshops which did not involve practical activities**, as well as **to spend more time in preparing students for the busks** to be showed in public, to **reduce the gap between learning the basics of busking and performing**, and to **shorten the time between the busks performed by facilitators and the workshops.**
- Teachers highlighted that **having an ECR with each subgroup helped in fostering students' engagement.**
- **ECR would have like to make more scientific contributions** throughout the different tasks so as to be able to engage students' more in learning about science.
- ECR also suggested the **possibility of linking the science busking with students' experience in drama** (students did two years of drama at secondary school).

Results description

In general, our observations suggests that **facilitators and ECR promoted both cognitive and emotional engagement amongst students during the workshops**. ECRs also noticed that **in general students were enthusiastic** during most part of the workshops, and sometimes **excited**. **Students' reacted positively to the topics related to science and the scientific practice approached**, most of the time they were listening and/or contributing with respect. Students **gained confidence with facilitators and ECR** throughout workshops while **facilitators were recognised by teachers to be very good at engaging the pupils**.

Students' answers to the surveys as well as ECRs' and teachers' perceptions showed that **some students really enjoyed the activities while others were uncomfortable or disengaged**. **Such contrasting views amongst students about their cognitive and emotional engagement in the workshops** were reflected in their answers to the question *"I found of little interest to get involved in workshops"*: 5 of them did not find workshops interesting whereas 9 students did found them interesting. The others (8) provided neutral answers.



"I found it of little interest to get involved in the workshops"

Our observations showed that **students' interest and enjoyment in the activities increased from the first to the final workshop**. Although most of them seemed to enjoy the activity of self-selection of the topics in PW1-2, there were some pupils who looked disengaged and students' attention seemed to waver from time to time during the tasks. In the next workshop, PW3-4, they started attentive but very quiet and passive (only 3 girls and 2 boys answered and asked questions during activities conducted with the large group) and afterwards when working in subgroups almost all actively participated in the two activities conducted. In the last workshop students experienced surprise when the facilitator attached a glove to a tube and blew in, making a tremendous boom noise to demonstrate vibration. **They also enjoyed creating their busks by using the props**. As an ECR said:

> *"Kids became really comfortable in the final session with props which I feel like is when they finally felt like performers. It was interesting to watch the team dynamics and how different kids reacted and how the audience engaged with them when they actually did their performance."*
> (ECR, Bristol)

Also in the post-survey, when asked for **what they enjoyed the most**, most of them (11 out of 19) mentioned **they enjoyed contributing with ideas to the design of the busks and practicing or performing them**. As mentioned by one boy in the focus group, students in general were scared about performing the busk in front of their peers but also noticed that such feeling disappeared when they did the busk:

"*When we were going, once we actually did, it was fine*"
(Boy, UK1123)

The ECR and the teachers also realised students were really nervous about performing but, as an ECR said, they "*weren't as scary as I thought they'd be*" and **they really engaged in creating the busk.**

Other students referred in their answers that what **they enjoyed the most was to talk to the ECRs and doing research by themselves**, as well as **engaging in reflective and discussion activities during workshops**. As this boy wrote down in his questionnaire:

"*The activity when you had to choose who to give money to. A good way to overcome stereotypes*" (Boy UK1119)

Our observations confirmed that **students were excited and surprised with the results of such unconscious bias activity** that engaged students in reflecting about how stereotypes may influence the way that people make most of decisions. Such discussions rarely emerged spontaneously from students, and worked better when working in subgroups. In this regard, the female teacher noticed that: "*provoking and discussion activities at the beginning of the project worked well to generate interest about scientific issues*". The ECRs also referred to these activities that they perceived engaged students in reflection and discussion:

"Also I found it really good because they had really good discussions and raised good points and were really engaged with it. So that was really cool. Also, it was good to know the video was also ridiculous to school kids, not just academics."
(ECR, Bristol)

When asked about **what they enjoyed the least during workshops** students provided diverse responses. 7 of them mentioned they **did not enjoy to perform the busk in front of other students because they felt uncomfortable.** Indeed, in the last workshop, it was observed that students' motivation decreased when they realized they would have to perform their busks in front of other students in the school hall. This was previously announced by facilitators and also received by the students with a lack of enthusiasm in the previous workshop (PW3-4), but it seemed that they did not realized about it until the last workshop. When facilitators asked students to rehearsal in the hall, many students expressed their discontent: "*are we going to stand up and go to people? Can't they (ECR) go to us? So embarrassing…*". Facilitators worked with students on how to get the attention of the audience (e.g., expressing interest in people in the audience, using humour), what not to do (e.g., looking down, reading script), but some students remained afraid and disengaged. This was shown at the end of the workshop when facilitators asked students to put their hands up if they were looking forward to their busks and only students from three subgroups put their hands up. Moreover, in general students in the focus group agreed that they felt ignored when performing at the school hall. As a boy said:

"*Well a couple of people we like knew came about to see what it was, a part from that everyone just kind of left us; everyone just sat there, not really doing anything*"
(Boy, UK1114).

4 students also mentioned they enjoyed the least **to do the initial tasks and activities because they were not related to the busks**. In the focus group, one boy and one girl, complained about the disconnection between sessions on critical thinking, gender and ethical issues and the creation of the busk. They mentioned that these initial sessions did not include relevant content for creating the busks, and consequently they perceived them as a "*waste of time*" because they

would have appreciated having more time for working on the busk. In particular, the boy did not find the gender session had any value:

"*There was one two-hour session, that was like four-hour session that was just on like feminism and science. I don't understand. I don't really see the point of us learning about that was, anything to do about busking and stuff.*"
(Boy, UK1114).

The same students in the focus group explained they did not find workshops engaging at all partly because **the activities did not meet their expectations and the activities were not fun**. Students explained that they were initially motivated about the idea of doing or creating a performance with science because it was supposed to be fun, but when attending the workshops they realised it was not what they expected. As two girls explained:

"*And then when we joined it was like something completely different, it was more science than perform stuff*"
(Girl UK1103)
"*We did this one on like ethics. It wasn't really like that fun, cos we knew we had to get through three loads of them and it wasn't really like engaging"*
(Girl UK1118)

Such misunderstanding partly resulted in **3 students dropping out** (workshops started with 14 girls and 15 boys and ended up with 15 girls and 12 boys). The male teacher also noticed that these students could be disappointed of workshops because they expected more scientific content. As he explained: "*they were put off by the performing side and or the actual science activities*".

3 students also reported in the post-survey they did not like to listen or talk to ECRs. One of them said it was because ECRs made him feel nervous. Students' also discussed about the role of ECRs in engaging them during workshops. One of the girls explained her subgroup was lost since the beginning, as well as the ECR who they expected to get help from:

"*She* (ECR) *didn't really know a lot about what we were doing*"
(Girl UK1118)

By contrast, one of the boys of another subgroup **mentioned their ECR did help them a lot with the busk**, but he also mentioned that the process of creating the busk was challenging:

"*I think it's because we wanted to do, we had to do stuff that like proves some kind of science and that is not always fun trying to think of something that is fun to watch but also explains some kind of topic. And then, kind of our group couldn't think of anything and it wasn't that fun*"
(Boy UK1123).

During the ECR interviews, a female explained to the other ECRs how **she managed to engage students in the scientific topic for the busk.** She decided to link the broad topic chose by the students with her research topic to be able to work on it and make it more attractive:

"*I found that my group quite disengaged at the beginning and then once we found a topic that we agreed on, and I thought about the topic and I ended up picking a topic that was research from my laboratory which meant that I knew more about it so*

that I could relay the knowledge back. And I was passionate about it so they could pick up from my thoughts about it".
(ECR, Bristol)

Two students responded in the post-survey that **they did not like to miss their favourite lessons**. In this regard, one of the girls participating in the focus group complained about workshops because she lost "*important lessons such as science and maths*" (Girl, UK1118). A couple of students in the focus group also mentioned they wanted to sign out of the workshops at some point because they **were missing on important lessons from other teachers who got angry and they were doing another project on engineering and did not have enough time** for the two projects. Indeed, the teacher noticed that **the way workshops were scheduled within the students' timetable negatively influenced their engagement**. As she explained:

"*I had arranged the workshops to be on the same day each time in the students' timetable as I thought it would help them remember which day their workshops were on and these were the days that it did not impact on mine and Scott's teaching of our GCSE classes. I realised after that the students did not enjoy missing the same lesson each workshop if they enjoyed it which is why we had some students drop out of the process.*"
(Female teacher, Bristol)

Negotiation of timetables between facilitators and teachers (those involved and the others) could prevent similar situations in the future.

One of the boys in the focus group specifically **complained about the scientific level of the topic of the busk**, which he perceived as not really interesting. In comparison to the science lessons it was too basic, as he said:

"*Cos in like science lessons you will go and you will do like a practical something and you will do some burners and stuff. But when you come down to the actual science workshop you spend hours and hours just doing about the same thing and at the end you just, it's totally, you have to do something on sound. Like trying to learn something but it's like primary school science that you are learning. Our whole thing was about sound causes vibrations but like you learn that in year 7*"
(Boy, UK1114)

The two boys and some girls in the focus group agreed that science lessons were funnier than workshops because they could "*do experiments, we've got lots of stuff to do, like this chemicals and all this kind of stuff*" (Girl UK1118), and they could learn about things that they "*can use in real life*" (Boy UK1123).

Despite some students did not find the workshops interesting, **most of them** (20 out of 29) reported in their learning charts **they improved their learning on the scientific topics of their busks.** As these students wrote when asked to complete this sentence at the end of the last workshop *"What I have learnt is…"*:

"That dust is made up from dead skin cells"
(Girl, UK1126)
"DNA is made up of amino acids, that in your busk you should make sure it is relatable and funny"
(Girl, UK1117)

"Miracle berries come from a fruit; a jelly bean taste test could work quite well; everyone can be bias unconsciously, we all also make bad decision based on our unconscious reactions"
(Boy, UK1109)

Regarding the **pedagogical approach of the workshops and its engaging capacity**, teachers and ECRs highlighted opportunities and challenges. On the one hand, they **valued those workshops that included kinaesthetic activities and using props and materials because they generated excitement and engagement more than the planning and reading activities**. In this regard, ECR suggested to **give the props earlier to the students**, not just the concepts, so as to engage them in **using the props to explain the science behind by putting in practice their imagination and creativity**. As these ECRs discussed:

"*I think, yeah, you needed to give them the science but then you needed to say, "Work with that." Like give them the prop, give them the science and then say, "You create something*""
(ECR1, Bristol)
"*I think we had already worked on the words and the concepts a bit, and if they had the props before…"*
(ECR2, Bristol)
"The props made such a difference"
(ECR1, Bristol)

On the other hand, they recommended **to shorten workshops not involving practical activities** and **reduce the density of the schedule.** Some ECR perceived students' attention decreased a lot during the last part of the workshops and that particularly the last one was too dense because students had to create the whole busk in only two hours:

"*I think we had a bit too much in the schedule for the kids to learn for the time we had given to them. Because there was a lot to absorb. Even just busking, learning busking and performing it, I think just maybe a full session – the last session wasn't really a full session, a session and a half, I think it was maybe a bit dense*".
(ECR, Bristol)

In this regard, they suggested **to spend more time in preparing students for the busks** to be showed in public as well as to **reduce the gap between learning the basics of busking and performing**:

"*I think this was a bit negative on them as well because they did kind of maybe forgot what they were supposed to do and then they got excited but then they again realised what they were supposed to do and they just didn't do it maybe even. This could have been better if they were doing like a bit closer to each other."*
(ECR, Bristol)

As mentioned above, they also suggested **shortening the time between the busks performed by facilitators and the workshops** so as students can get inspired by professional busks easily:

"*The frequency of the workshops was too far apart. A number of students were not expecting that something they'd started in yr8 would continue in yr9."*
(Teacher, Bristol)

Teachers also highlighted that **having an ECR with each subgroup helped in fostering students' engagement.** ECRs expressed they enjoyed working with students, particularly with the

subgroups because all felt more comfortable, although some **ECR would have liked to contribute more to the science level of the different tasks** to be able to engage students more in the learning process. For instance, one of them referred to the critical thinking activity, for which she did not have time to look at the papers before, and felt she could not contribute to the discussion. By the answers provided by some students in the focus group, they connected the concept of critical thinking with the session about discussing news but it is not clear if they completely understood it. In this regard, **observations during this workshop showed that learning about scientific literacy was not well supported by the activities, which also lacked links to the curriculum.**

Finally, ECR also discussed during the interview the **possibility of linking the science busking with students' experience in drama** (students did two years of drama at secondary school).

4) ETHICS INTEGRATION

Concept and approach

We consider as ethics integration the capacity of the learning process to address ethical aspects of science and research and foster reflection with students. Specifically these include: i) *understanding of the nature of science* (NOS) as sharing with students key principles and ideas, which provide a description of science as a way of knowing, and the characteristics of scientific knowledge; ii) the *social relevance of the topics addressed*, that is, the degree to which the scientific issues approached are connected to relevant broader social contexts and challenges; and iii) *connecting scientific topics with values*, that is, the identification and exploration of the diverse values and normative aspects behind scientific practice and knowledge.

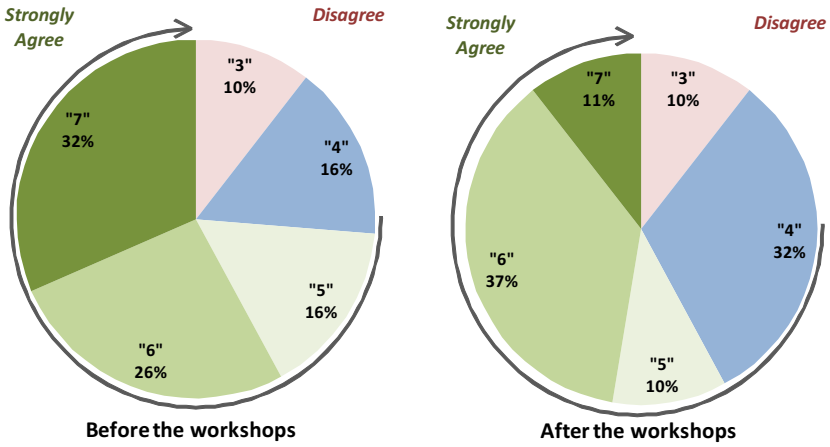
Students' surveys, as well as observations and interviews with teachers and ECRs allowed us to approached these issues.

Main highlights

- **Students held an understanding of the nature of science both before and after the workshops** and workshops did not have an effect on it.
- **After the workshops, a higher number of students disagreed that science only has good impacts on people, but this difference was not statistically significant.**
- The teacher highlighted the workshops provided a good opportunity for students **to debate such a variety of "*ethical and moral issues in science*** *that were not included in their usual curriculum*".
- There was **a disconnection between the ethics content of the workshops and the performance aspects** so it was **suggested it would be valuable to establish more links**.
- **Some students perceived the content of science lessons was more relevant for their daily life than the scientific topics chosen for the busks**. More efforts should be done to connect activities with students' daily life experiences.
- **Students engaged in and enjoyed reflections about ethical behaviour during ethics and gender activities but** ECR noticed that some of these activities **could have had the opposite effect than the one desired on students understanding of science and suggested more discussion on the failure of scientists** and more reflection on how to reduce the stereotypes.
- **ECRs' personal stories were rarely included and should be** to reinforce the human dimension of science.

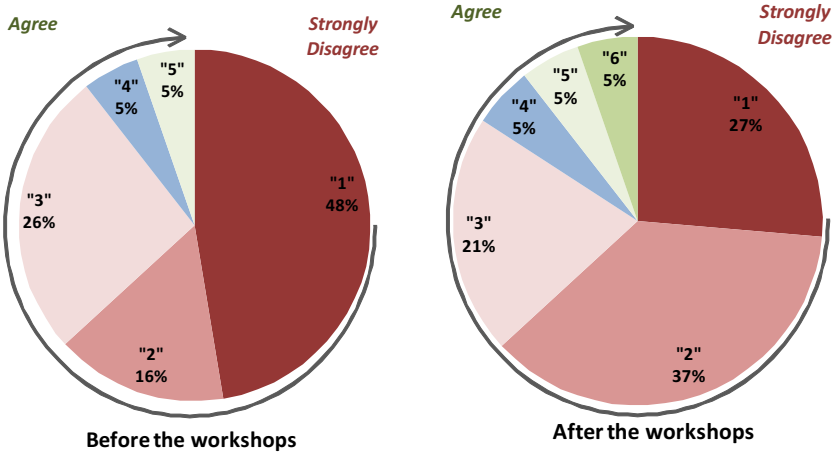
Results description

Overall, **students' answers to the surveys showed they held an understanding of the nature of science both before and after the workshops**. Although little changes were observed, there were not statistically significant differences due to attending workshops. For instance, most students (14 students out of 19) **agreed that human imagination and creativity are needed for producing scientific knowledge**. Although the variation of responses between the pre- and the post-survey is almost null, a higher proportion of students provided neutral answers after the workshops (from 3 to 6 students).



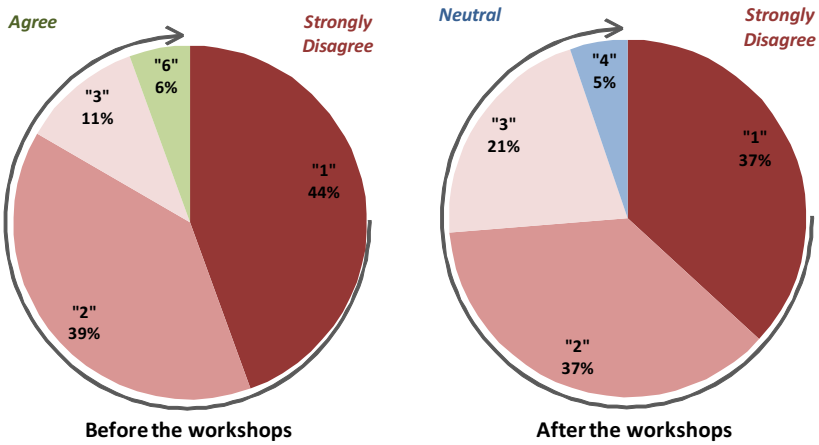
"*The production of scientific knowledge involves human imagination and creativity*"

Almost all the students (17 out of 19) did not think of **scientific knowledge as always certain before the workshops**. Such general understanding remained after the workshops.



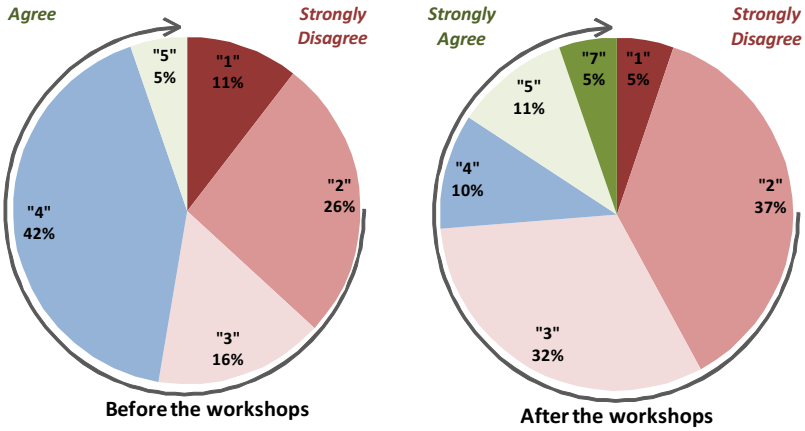
"Scientific knowledge is always certain and therefore never changes over time"

Similarly, most students (18) reported in the pre- and post-surveys they perceived **good scientists do fail while doing science**.



"Good scientists do not fail while doing science"

When asked for their perception of the impact of science in society, **around half of the students (10 out 19) reported they disagreed that science only has good impacts on people** before the workshops, whereas **in the post-survey a higher number of students disagreed with the statement (14)**. However, there were not significant differences between their responses before and after the workshops, nor between girls and boys.



"Science only has good impacts on people"

Regarding how the project integrated ethical issues in their approach to science and research, the female teacher highlighted the opportunity the workshops provided for students **to debate such a variety of "*ethical and moral issues in science* that were not included in their usual curriculum"**, and perceived **those activities worked well**.

However, as mentioned above (engagement section), some students in the focus group mentioned **they did not like the workshops on ethics because it was not connected to the busks**. ECRs also noticed there was **a disconnection** between the ethics content of the workshops and the performance aspects and **suggested it would be valuable to establish more links**.

Despite there were attempts to **engage students through their daily life experiences** in the selection of topics during PW1-2, by using the cards on real life STEM topics within societal challenges, some students in the focus group **perceived the content of science lessons was more relevant for their daily life than the scientific topics chosen for the busks**.

Students also **engaged in a little reflection about ethical behaviour** focused on how people use to judge other people based on stereotypical ideas when doing the unconscious bias activity, which they enjoyed. Links between STEM careers and jobs and gender were also introduced for further discussion and facilitators showed contrasting perspectives about science and gender by showing first the video "science is a girl thing" and then a related protest video making fun of it, which made **students smile and laugh**.

However, ECR noticed that some of these activities **could have had the opposite effect than the one desired on students understanding of science**, through the following examples:

> "*When we watched that film about – the terrible one, where some of the people we talked with actually said it had made them want to do science less. I'm not sure whether the stuff we talked – the reflective work we did around it, whether that was enough to counterbalance it.*"
> (ECR, Bristol)

> *"We showed them quite contradictory video and then we said you (students) have to question – we told good things, but maybe we didn't emphasise enough that scientists are doing also good things. It's not just like they have to be questioned because they may produce some nonsense on the news, but they are doing valuable things as well."*
> (ECR, Bristol)

> "*They (students) were particularly put off in our group because there were some statistics that someone said, like forty-one percent are women, and they were like, "That's rubbish, I don't want to do science if…" like they were all quoting the things that we'd said beforehand, which was supposed to inspire them. Instead they were like, "Oh no." And then the video kind of put the nail in the coffin*".
> (ECR, Bristol)

ECR thus **suggested more discussion on the failure of scientists**, showing the statistics, and more reflection on how to reduce the stereotypes to reinforce the idea that researchers are "*normal people so you can be one*" would help students to better understand how science works.

In this regard, observations showed that **ECRs' personal stories were rarely included** to reinforce the human dimension of science. Only one of the ECRs told students about how he got interested in his subject, and one ECR explained her experience of being a woman doing a Ph.D. The first one highlighted the training he received on gender and ethics was very useful to responsibly interact with students and motivate them during workshops:

> "*How do I present myself in a way that is meant to be open and to encourage everybody in a room to want to go and do science, and to be able to practise using gender neutral pronouns and to express the fact that science is for everyone, and that we can be enthusiastic together and to overcome issues around nerdiness and geekiness and whatever. I see those should be the main barrier, not like who you are, we should be working on normalising science, for lack of a better descriptor".*
> (ECR, Bristol)