The Art of Science Learning

WP4 Assessment Analysis of Goal 4

French Case Study

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FRENCH CASE STUDY

GOAL 4: RRI VALUES

General Framework of the Analysis

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. By Students' attitudes and perceptions towards science we 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. **Gender** is included as a variable of analysis along all these aspects.

Inclusiveness refers to the capacity of the learning process to 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.

Engagement refers to 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 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.

We also addressed **cognitive 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.

Ethic Integration refers to 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.

Finally, our analysis 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.

Methodological Approach

Following the same approach as in Goal 3, these motivations and RRI values **have been explored through** students' inputs provided in the surveys (as a first quantitative approach) and researchers observations of the workshops complemented by students, teachers and ECR's inputs (as a qualitative in-depth approach).

Students' inputs:

We first explored **students' self-perceptions in relation to RRI values** through **a questionnaire conducted twice**: 1) **before the realization of the workshops** (Pre-PERSEIA survey) and 2) **after the workshops** (Post-PERSEIA survey). In order to evaluate whether students' answers were specific to the PERFORM group, we also conducted these questionnaires (pre- and post-PERSEIA) among a group of students who did not attend to the workshops: the control group. In total, the **PERFORM group was composed by 40 students** (19 students in Vauréal and in 21 students Marie Curie) and the **control group by 48 students** (31 students in Vauréal and 17 in Marie Curie).

We analyzed students' answers for both questionnaires (Pre- and Post PERSEIA) independently by looking at the percentage of answers reported by students. We then compared answers from PERFORM group with answers from the Control Group. For PERFORM students, we also analyzed whether there was difference between boys and girls, and between groups of students (as students were divided into two groups in each school).Finally, in order to see **whether students' answers changed between the pre and the post surveys, we calculated the variation for every individual answers for each question**. As most of the questions were answered with a scale of agreement (from 1: totally disagree with the statement to 7: totally agree with it, and 4: neutral), variation was calculated as follows: "Post Survey Answer – Pre Survey Answer". In that sense, a negative individual variation indicates that students' degree of agreement was higher in the pre-PERSEIA survey, i.e. they disagreed more after the performance of the workshops. Similarly, a positive variation indicates that students agreed more with the statement after the development of the workshops. We analyzed then, whether such variations differed between boys and girls, between groups and between the PERFORM group and the control group. To explore whether the differences between PERFORM vs Control group, PERFORM groups, and sexes were statistically significant, we ran Wilcoxon Ranking Tests and ordinal logistic regressions.

We also explored **students' perceptions towards the workshops and aspects related to RRI values**. In this case, since we were not comparing pre and post-survey answers, we included the whole PERFORM group (n=**42 students**[1]- as only one boy from Marie Curie did not answer to the Pre survey). We analyzed whether there was any statistically significant difference either between groups of PERFORM students, or between boys and girls, by running Wilcoxon Ranking tests.

For the sake of clarity, **only statistically significant differences have been reported in this document**[2]. It also implies that specific highlights are present only when the variation of PERFORM students' answers did not follow the same pattern as the control groups.

[1] One student in each school did fill only one questionnaire

[2] This means that if no specific interpretation related to group or to sex of the students is included in the text, the trends described were not different according either to the group or the sex of the students.

Researchers' observations of the workshops

We then analyzed researchers' observations of the workshops in order to explore **how the pedagogical context and related factors of the workshops could have integrated RRI process requirements and fostered learning outcomes**. Most of the results presented in this document rely on the observation of Group 1, which was observed all along the process (the 7 workshops, the final rehearsal and the final PERSEIA), supported also by the observations of Group 2,whichwas observed in three alternative sessions (PW1, PW4 and PW7).

Students, teachers and ECR inputs

All these results **have been complemented with further students' inputs**, collected through: i) a **focus group** with a reduced but representative group of students who participated in the project (9 students in Marie Curie and 10 in Vauréal);and ii)students' answers to a learning chart they filled at the beginning and the end of the project (PW3 and PW6).

Finally, to complete our analysis, we analyzed **teachers'** and **ECR's** perceptions about the fostering of students' transversal skills through the process gathered through **oral interviews** (2 teachers in Marie Curie and 4 in Vauréal) **and written interviews** (2 ECR from each school).

Specific Methodological Approaches

For the analysis of inclusiveness, our observations mostly focused on the implementation of the designed activities and their facilitation (to identify process requirements) and on students' performance and participation throughout the workshops. Most specifically, in terms of process requirements we focused on: i) the number of students by sex in the activity; ii) the provision of specific support to students with special needs, if any; iii) the use of students' previous experiences and knowledge in the activity to include them; iv) students' possibility to make choices during the workshops, v) the relationship that the facilitators established with the students; vi) the type of dialogue between students and science communicators, ECRs and teachers and vii) the use of arts-related and ICT methods in the activity to foster dialogue. In terms of students performance we focused on: i) the number of students by sex in the activity; ii) the type of dialectic interactions among students (only in relation to inclusiveness); iii) students' sharing of tasks and roles during the activity (only in terms of inclusiveness and gender); iv) the type of tasks and roles assumed by gender during the activity; and v) students' affective responses by gender during the workshops. We further explored with students in the focus group their perceptions of the process in terms of their capacity to participate and feel included in the group, and the extent to which they could make decisions. The teachers' interview included a question about students' involvement and participation in the process and the attention to students with special needs when making the groups. We also looked for emerging contents related to inclusiveness in students' learning charts and ECR's interviews.

We analysed students' cognitive engagement in the workshops mainly through observations focused on the capacity of the learning process to foster: i) questioning and reframing, or the promotion of understanding through questions that allowed 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**, such as i) students' predisposition or tendency to respond positively or negatively towards the methods and topics proposed; ii) students' enjoyment or the feelings of pleasure caused by doing or experiencing the workshops; iii) students' 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) students' sense of ability to do things and feeling of acceptance as part or member within a group or learning environment. Teachers were also asked about students' engagement in the process and they were asked to evaluate the different activities conducted through the workshops. We also looked for emerging contents related to engagement in students' learning charts, the open questions of the survey (i.e. what they enjoyed the most and the least; what they learnt) and in ECR's interviews.

Finally, **we analysed ethics integration** through the observation of different process requirements during the implementation and facilitation of the workshops that might facilitate the sharing of the human dimension of science (science as a process). Most specifically, we focused on: i) the contextualisation of STEM topics within societal challenges and/or daily life; ii) the inclusion of ECR's personal stories during the activity; iii) the sharing of contrasting perspectives about science; and iv) the encouragement of students' reflection about ethical behaviours in research practice. We also looked at students' interventions related to their understanding of the nature of science (verbalised perceptions) during the workshops and in the focus group. Emerging contents related to ethics integration in students' learning charts and in ECR's interviews were also included.

Specific Note for the Reader

This document presents the results of the workshops conducted in both schools involved in the PERFORM project in France. As the facilitation of the workshops has been partly led by the same facilitators in both schools, most of the context of facilitation allowing the *mise en place* of RRI values and process requirements has been similar. In that sense, some repetitions occur in this manuscript between both schools.

Overall Highlights

Inclusiveness

- The workshops overall managed to achieve a **high degree of inclusiveness**, with a gender-balanced involvement of students.
- This high participation of students within the workshops has been possible thanks to an **emotional support and fostering dialogue** between students.
- Although **the content of the PERSEIA was mostly led by the facilitators**, students felt they **could overall make choices during** the workshops and the PERSEIA creation process**. However, students' perceptions towards their possibility to make choice largely varies between schools,** with students in **Marie Curie** reporting having **less opportunities for their ideas to be integrated in the PERSEIA.**

Engagement

- **Students were highly engaged in the workshops**, showing a **higher engagement** when working **on theatrical exercises** and the **elaboration of the PERSEIA than** when **participating in the reflection activities** (specifically in Vauréal).
- The workshops **did not seem to reach an optimal cognitive engagement of students,** due to **the format** and **the accessibility of the reflection activities** proposed**,** but also to the **disconnection between reflection activities** and **the research process regarding students' question.**
- **Students' engagement got higher** when they realized **all the activities led to the creation of the final performance**
- **Cognitive engagement through the development of research on students' questions could not reach its optimal potential** as a too little time was devoted to explore students' research questions (especially in Vauréal).

Ethical aspects

- **Ethical issues have not really been approached** through the PERFORM project, and no **precise time was devote to this with students**.
- **Contrasting perspectives when approaching science or a given scientific issues have not been really developed**, probably **due to the lack of depth in the approach to scientific topics**.
- Overall, **gender issues regarding science and science learning were not really approached during the workshops**, as observed through the sessions**.**
- However, the **project emphasized the societal relevance of the topics developed**, by integrating students' research questions, which relied on societal issues, into the creation process, even if they did not really fit into STEM topics.

Recommendations

- In order to **better foster the cognitive engagement** of students during the workshops, it seems **worth focusing on students' own research questions to develop different aspects** (such as gender, societal contextualization, ethics integration and critical thinking) **rather than reflection activities** that are not connected with the questions developed for the creation of the PERSEIA. By integrating RRI values in the process of research on students' questions, it might handle with the potential difficulties for some students to get engaged in more classical activities of reflection (such as reading and elaborating written ideas).

- Cognitive engagement could also be fostered by connecting the STEM-related topics approached through PERFORM with the schooling curriculum, so that students can apply the learning generated in a broader scale.

- Students should **be clearly communicated since the beginning the different steps of the project and their participation in a final event** performing in front of an audience. Opening the choice of the audience could encourage students' participation and appropriation of the process.

- If students' research questions are contextualized within ECR topics, then such questions **should be intimately related to students' concerns and daily life**, for them to feel motivated to get involved in the process of research.

- As research questions brought by students were not precisely related to STEM but could allow to approach different aspects related to RRI values, and also to allow students to be aware of the diversity of disciplines that belong to science, it seemed **relevant not to limit the topics to STEM.**

- The creation **of the groups of students who will participate to PERFORM should be carefully thought**, as the difference between groups of volunteers and groups composed by students who were not wishing to participate largely affected both the process of the PERSEIA creation and students' overall cognitive and emotional engagement.

Collège Les Toupets - Vauréal

The PERFORM Project took place in the school "*Les Toupets*" in Vauréal from January to March. Workshops were led by **two facilitators: one science communicator and one performing arts professional.** Both worked together in a collaborative way, by sharing the management of the workshops and supporting each other's tasks.

It involved a total of 20 students (9 boys and 11 girls) divided in two subgroups of 10 students each. Although all were involved in the final PERSEIA, only 19 students answered to both pre and post-PERSEIA questionnaires.

Highlights

Inclusiveness

- The workshops overall showed a **high degree of inclusiveness**, with a gender balanced involvement of students.
- This high participation of students within the workshops has been possible thanks to an emotional support and thanks to the fostering dialogue between students.
- Although students **could overall made choice during the whole process** of the workshops and the creation of the PERSEIA, although **the content of the PERSEIA was mostly led by the facilitators**.

Engagement

- **Students were highly engaged in the workshops**, with a **higher engagement when working on theatrical exercises and the elaboration of the PERSEIA**, but not really during the reflection activities.
- The workshops **did not seem to reach an optimal cognitive engagement of students, somehow due to overall difficult for the students to approach the topics and develop their ideas, but also to the format and the disconnection between the reflection activities and the process of creation of the PERSEIA.**
- **Cognitive engagement was higher when student were debating than using written supports.**
- **Students' engagement got higher** when they realized **all the activities led to the creation of the final performance.**
- **Cognitive engagement** was **higher** when students were working on **their research questions** but **could not reach it optimal potential** as a too little amount of time was devoted to explore students' research question.

Ethical aspects

- Overall**,** there were **few occasions to bring contrasting perspectives when approaching science, probably due to the lack of depth in the approach to scientific topics**.

- **Reflections about ethical behaviour in science were not frequent.**

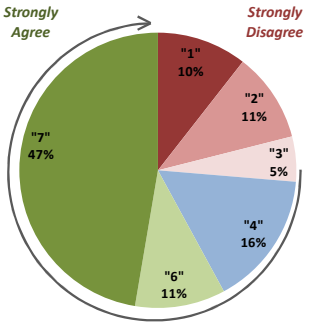
- **The human dimension of science has not been really developed,** especially because the ECR interaction has been really reduced.

- **Ethical issues have not really been approached** during the whole process of the PERFORM project.

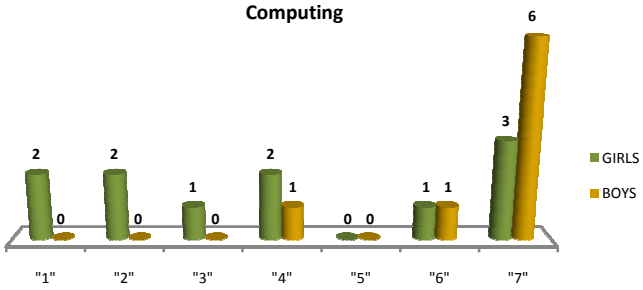
- However, the **project fostered societal relevance of the topics developed**, by integrating students' research questions that relied on societal issues, even if they did not really entered into STEM topics.

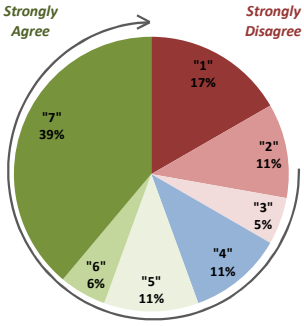
We first present the results of **students' feelings on science learning at school** gathered through the pre-PERSEIA survey as an introduction to the results related to students' potential changes in perceptions and attitudes towards science and scientific careers and jobs as a result of their participation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

Before the beginning of the PERFORM project, students 'appreciation towards learning STEM was not really high and did vary according to the discipline. A little more than half of them reported ***"(they) enjoy acquiring new knowledge in":*** Computing (58% of them), with a significant difference between sexes, as only girls provided negative answers; and Mathematics (56% of them). Students enjoyment was generally lower for the other disciplines, as they reported enjoying acquiring new knowledge in: Physics and Chemistry, only 39% of them; Technology, 37% of them, with a significant higher proportion of girls who reported neutral or negative answers; and to a lesser extent, Biology, 21% of them (more than half reported they did not enjoy learning Biology).

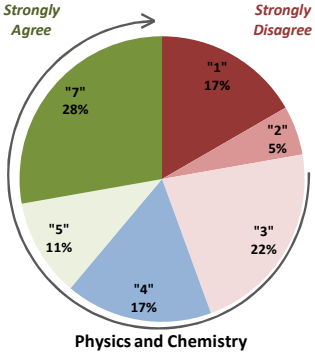


Computing

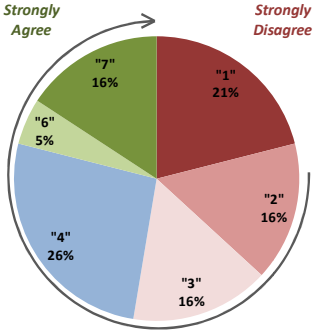




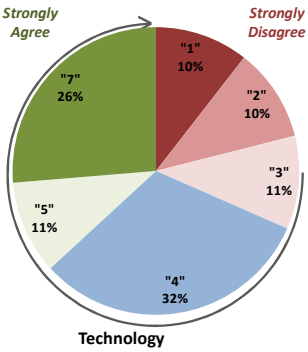
Mathematics



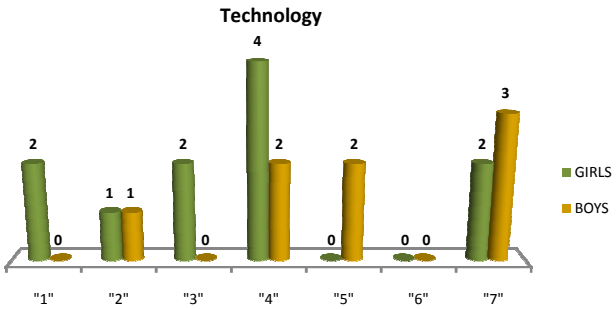
Physics and Chemistry



Biology and Geology

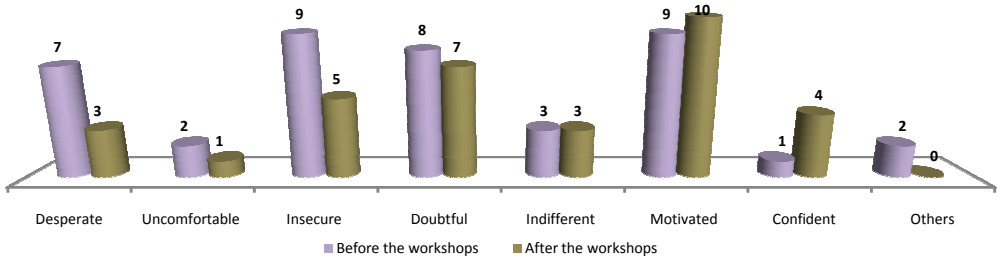


Technology



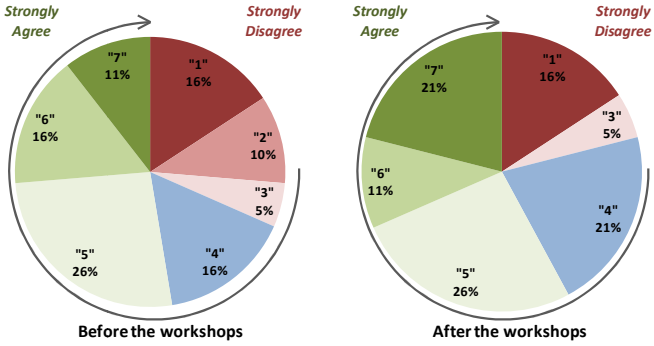
Workshops did not seem to have a significant effect on students' positive or negative feelings towards science education activities at school. In the pre-survey, when asked **how they felt in a science class or**

while doing science-related activities, they provided a diversity of answers. The same proportion of students reported they felt "motivated", "desperate", "doubtful" and "insecure". Indeed, although we can see that less students reported feeling "desperate" or "insecure", there were still 37% of them who felt doubtful, and there was not any significant difference the pre- and the post-PERSEIA surveys. Statistical tests showed no significant between students from PERFORM and control groups, nor between groups or sexes.



"At science class or while doing science related activities, I usually feel"

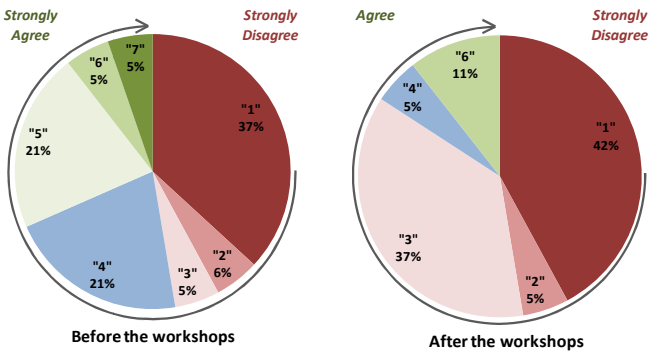
In the same line, **students' confidence while performing activities related to science did not really change** after the workshops. Before the workshops, 52% of the students agreed that ***"they feel comfortable while doing activities related to science",*** what slightly increased after the workshops to 58% of them. These results were significantly different from the Control Group students who were less to report they felt comfortable during the Post PERSEIA survey.



"I feel comfortable while doing activities related to science"

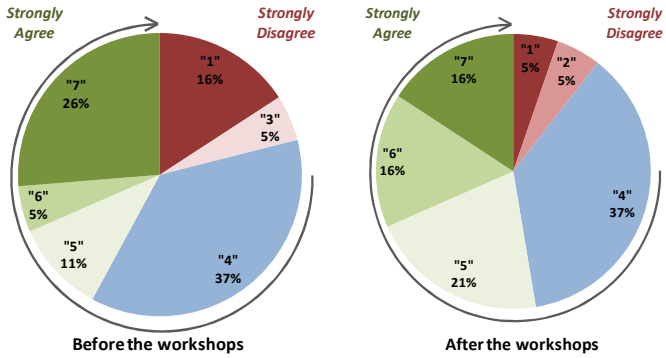
Students were also asked **about their perceptions of the role of science in and for society.** Overall, PERFORM students showed contrasted perceptions towards science with an important part of students who provided neutral answers. This diverse pattern **mostly remained unchanged after the workshops.**

Before the workshops, almost half the students disagreed that ***"Science has nothing to do with real-life problems",*** proportion that largely increased after the workshops. 84% of the students disagreed to the statement in the Post survey, proportion that is significantly different from the Control group (in which only 41% disagreed with the statement).



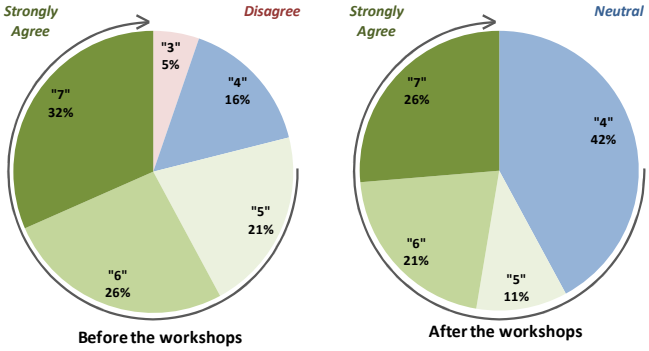
"Science has nothing to do with real-life problems"

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*", as students tended to agree more with the statement after the workshops. Indeed,** before the workshops, only 42% of the students perceived that ***Science will help (them) understand more about worldwide problems",*** proportion that increased to 52% of them after the workshops. However, neutral answers still remained the same, 37% of the students in both surveys. The proportion of answers in the post-PERSEIA survey was significantly different from the control group that provided more diverse answers.



Science will help (them) understand more about worldwide problems"

Also, related to students' perceptions of the role of science in and for society, survey results suggest that **students' perception towards the importance of scientific jobs for a better society decreased** after the workshops. Before the workshops, 79% of the students agreed that "***Scientific jobs are important for a better society***", a proportion that decreased to 58% of them. A higher proportion of students were neutral (42% of them).



"***Scientific jobs are important for a better society***"

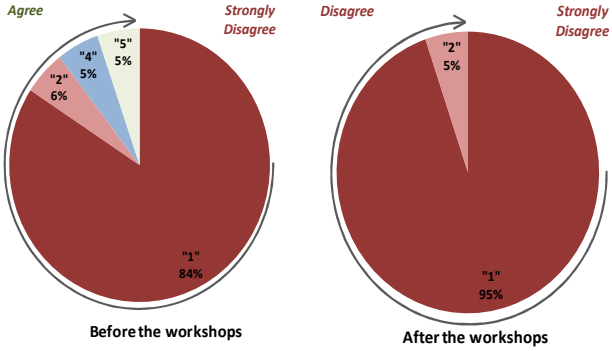
This **overall absence of changes in students' perceptions towards science was also confirmed during the focus group**, in which students clearly reported that it did not change their opinions. Some of them spontaneously said that it might have been possible if they would have had more time to interact with scientists and with science' world.

"*If we have had more time, we could have seen their* (scientists') *world, and thus could have changed our perception towards science*"

(Girl 1, Group 1)

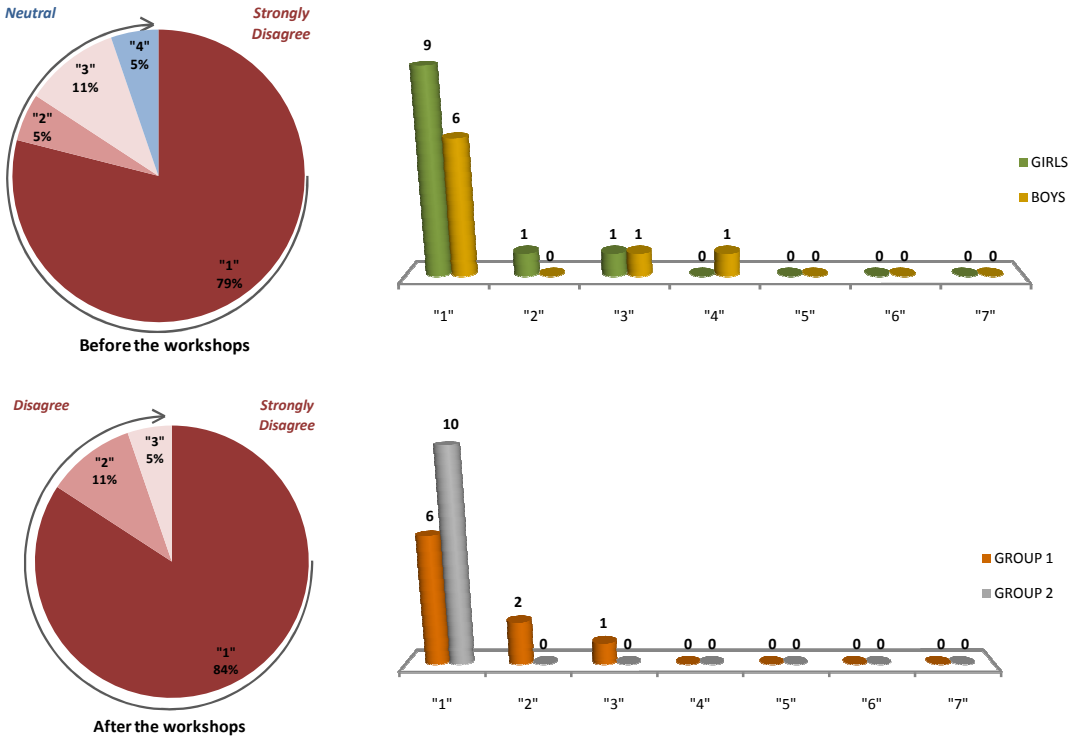
Students also answered questions on their **perceptions about gender-related roles in science**. Surprisingly, before the workshops, 90% of the students strongly disagreed with the item ***"Men are better scientists than women".*** After the workshops, all the students disagreed with the statement. The variation

between pre and post surveys is significantly different from the control group, as this latter tended to provide more positive answers in the post survey.



"Men are better scientists than women"

In the same line, before the workshops 95% of the students who disagreed with the fact that ***"Scientific careers are mostly for boys"***; with a higher proportion of girls who strongly disagreed (some boys were neutral). After the workshops, all the students disagreed with the statement. Moreover, all the students from Group 2 strongly disagreed.



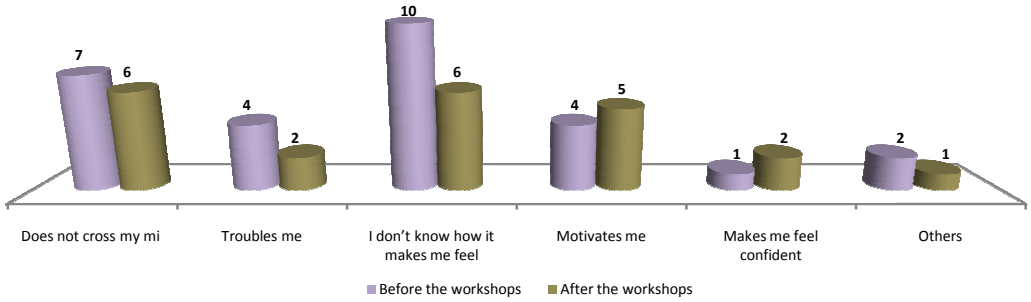
"Scientific careers are mostly for boys"

In that sense, **students did not seem to follow any pattern of gender discrimination** in their perception related to science opportunities and learning.

Finally, **students were asked about their motivations for learning science and studying scientific careers.** Overall**, students' interest towards learning science was low,** and an **important part of them did not have a clear idea about using or studying science in the future.** However**, students' motivation** and **positive perceptions slightly increased** after the workshops.

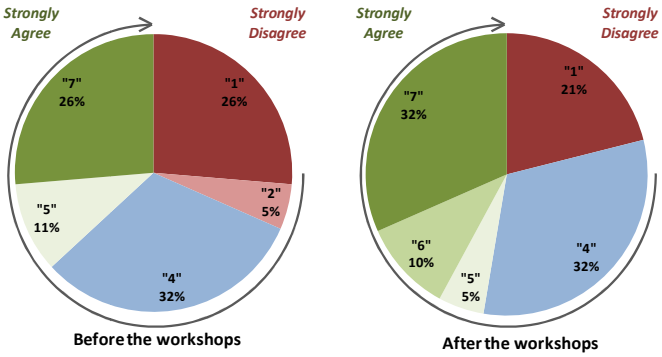
Before the workshops, more than **half the students reported they did not know how** "***The idea of studying a scientific career***" made them feel. Only 5 students reported that it made them feel either motivated or confident. Most students tend not to change their opinion (average variation=0.22). There was not any

statistically significant difference between PERFORM students and the control group, between sexes or between groups.



"The idea of studying a scientific career"

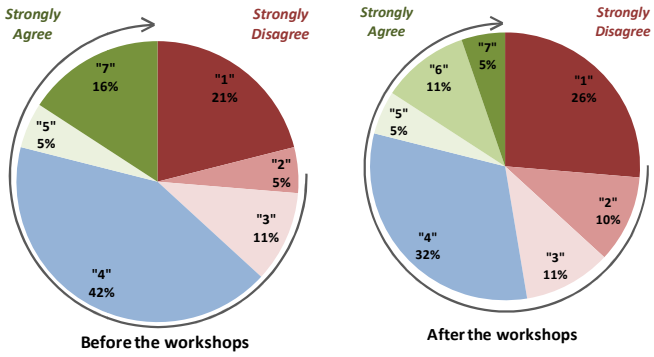
Before the workshops, 37% of the students reported that ***"(they) would like to study a career involving science (like biology, geology, physics, medicine or chemistry), technology, engineering or math".*** Although the differences between both surveys were not significant, students tended to provide more positive answers after the workshops (47% agreed with the statement after). The proportion of neutral answers remained the same: almost 1/3 of the students.



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

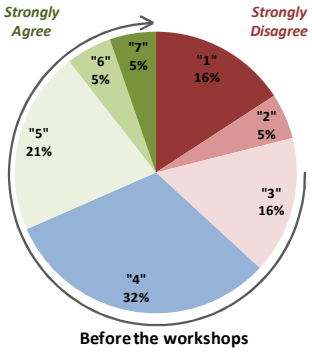
As mentioned in Goal 3, before the workshops, **only 2 students** (12% of them) **considered that "*learning science is not important for* [their] *future success*"**, proportion that did not change after the workshops. A difference however existed between groups, as 70% of the students from Group 2 provided negative answers (vs 33% of students from Group 1) while students from Group 1 gave much more neutral answers (45% of the students, vs 10% in Group 2)(see Goal 3).

Before the workshops, 42% of the students were neutral regarding the fact that ***"(they) do not expect to use science much when I get out of school",*** and 37% of them disagreed with it. After the workshops, neutral answers decreased in favour of a higher proportion of negative answers that reached 46% of them.

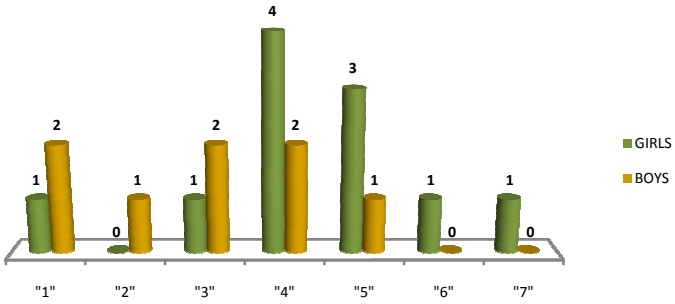


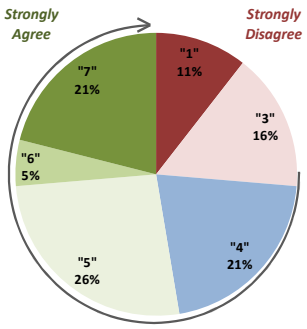
"I do not expect to use science much when I get out of school"

Before the workshops, only 31% of the students reported that **"(they) *can see (*themselves) *doing science in the future*"**. This **proportion largely increased** after the workshops as more than half of students agreed with the statement. In both surveys, girls tended to provide more positive answers than boys.



Before the workshops





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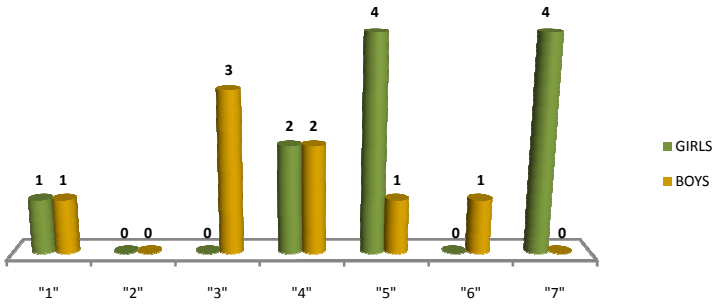


"I can see (*themselves) *doing science in the future"

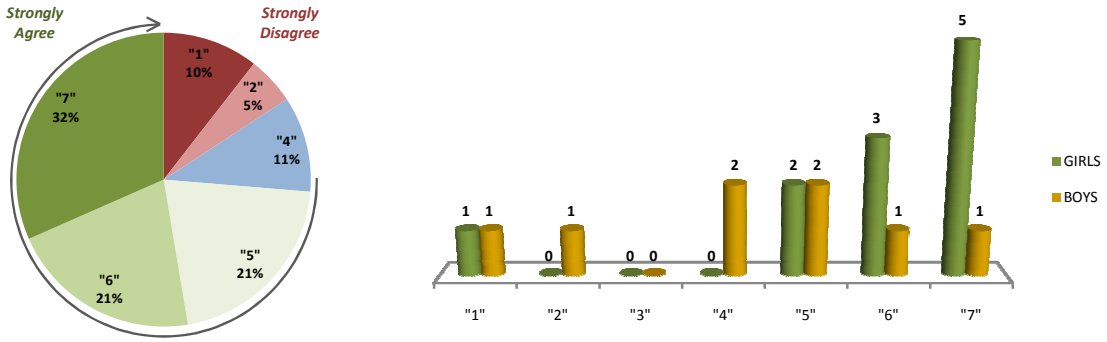
INCLUSIVENESS AND GENDER

As already developed in Goal 3, we could see that the majority of the students reported that **they "*actively participated in all the group tasks during the workshops*"**; and all the students agreed to say that they "***shared different tasks within their group during the workshops***". For both questions, a **higher proportion of girls than boys answered they strongly agreed**. During the focus group, students confirmed to us that they **liked to be engaged in the workshops** and that they felt they participated actively.

Teachers also acknowledged that **students were active and engaged in the workshops proposed by the facilitators.** Furthermore, teachers highlighted that some students who were generally inactive in class surprised them by being really active and involved in the activities proposed during the workshops.

All along the workshops, from researchers' observations, we could report that there **were no precise tasks assumed by specific students**, but rather group and individual participation when asked during the different exercises. As already highlighted in the Analysis of Goal 3, **students' participation differed** mostly **during activities in subgroups**, **according to the specific composition of the group.** Moreover, all the students **participated to the activities in a similar way, without any clear difference between genders.** The groups formed in Vauréal were composed by 11 students in each group, with a **balanced representation of boys and girls** (respectively 4 and 5 in Group 1 and 6 girls and 5 boys in Group 2). There was neither **any clear pattern of division of tasks nor roles according to the gender.**

This balanced participation of students during the workshops was allowed by different aspects of the **facilitation that fostered dialogue among students.** Indeed, as reported by students, almost 3/4 of the students agreed to say that "***during the workshops*** **[they]** ***asked the facilitators whatever*** **[they]** ***wanted to",*** with a significant difference between boys and girls: as girls (except 1) agreed whereas boys provided more diverse answers.

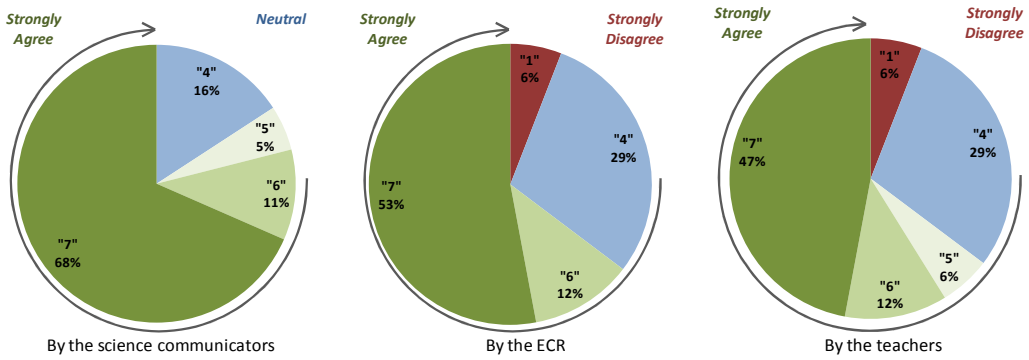


"***During the workshops I asked the facilitators whatever*** **[they]** ***wanted to"***

Facilitators provided a climate of trust since the beginning of the workshops, by **creating a horizontal relation with students**, allowing them to interact without **norms used in authority adult/teacher-students**, such as raising hand to talk. Facilitators also watched out that students who tended not to speak frequently could participate by giving them the speech, inviting them to share their ideas.

The context of inclussiveness was also settled thanks to the emotional support provided to students. Overall, as reported in Goal 3, students felt mostly confident during the workshops. In the same line, they felt they were prepared to perform the final PERSEIA. **When exploring students' perception on exterior consideration,** students reported that they felt their work was recognized by the different facilitators and actors. Indeed, they **felt their work was recognized by**: i)the **science communicators, for more than 82% of them** (only 3 boys reported neutral answers) ; ii) by **the ECR for 65%** of them with a stronger position among girls, with 1 student who did not agree and 29% of them who provided neutral

answers; and iii) by the **teachers for 55% of them**, with 1 student who did not agree and 29% neutral. Among the three statement, a higher proportion of girls reported stronger agreement. There was not any statistically significant differences between groups.



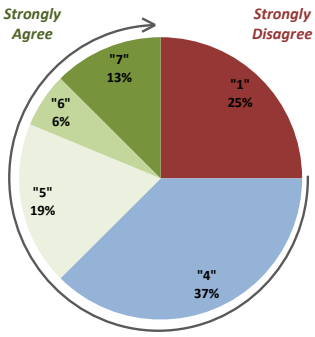
"I felt my work was recognized by..."

Such students' positive perceptions might have been largely due to the relation established by facilitators. Indeed, since the first workshops, both facilitators established a **fluent dialogue with students and** were really **inclusive and attentive to the needs and demands of the students**. For instance, in PW2, in Group 1, when entering in the use of the voice and the body, one girl went out the circle and sat. The facilitators respected that and left the girl quiet. Then, before beginning the last part of the theatrical activity, facilitators asked her if she wanted to participate in a way the girl went out of her moment of shyness of discomfort and came back to the activity. In general, the dynamics were **enthusiast, in a good mood**.

The context of inclusiveness was also fostered by giving space to students **mobilize their own experiences and knowledge** all along the workshops. It occurred **for both the reflection activities and theatre exercises**. During the work in subgroups (during PW1, PW3 and PW4) and the common debate that implied with the whole group, facilitators invited students to refer to their own experience and knowledge. For instance, during the presentation of the project on societal challenges (PW1), facilitators and the ECR were asking them to develop their ideas and asked why they elaborated such project, what they already knew about this, what they could have learnt before. Thanks to that, students tried to connect their own research and thought developed through the cards-game with life and their experience. However, it also occurred that **students used spontaneously their own experience in order to argue what they were saying. Students' mobilization of their previous experiences** also occurred through **the exercises of performing arts.** Facilitators were asking students to use their body, to be creative, to invent and create scenes, situations and improvisations all along the workshops about different topics, including the topics of their own research questions. Because it was not related to schooling knowledge and competences, most students could mobilize their own embodied and lived experience**. Students were really reactive to these exercises and most students who were not that comfortable with speaking during the debate were more involved when they had to act, to improvise or to perform**. In this sense, it allowed all the students to get involved, independently of students' ease to reasoning on scientific topics.

Despite of this context of inclusiveness among students, the format of the workshops did not **reach a real context for fostering dialogue with other actors**, especially with the young researchers (see Analysis of the Goal 1). This situation was also reported by students, as **63%** of them agreed they "***wish I could have had more interaction with the researchers***" (see Goal 1).

Moreover, although the use of the Moodle was initially thought to better foster dialogue between the different participants, it seemed it could not be really developed all along the project. Really few students did use the Moodle platform and all the students disagreed that "***the use of the platform helped* (them) *to participate more in the project",*** except 21 % who provided neutral answer***.***

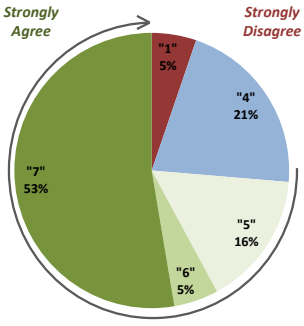


"The use of online platforms helped me participate more in the project"

Finally, exploring how the workshops dealt with inclusiveness intimately relates to the way students could make choices all along the process. Three different contexts have been specifically explored in order to see how student made choices: i) their participation into the activities; ii) their research question and the topic developed for the PERSEIA; and iii) the content of the PERSEIA and their role in it.

Regarding their overall participation during the activities, the way the different workshops have been conducted by the facilitators generally **allowed students to make their own choices** and thus **be somehow drivers of the activities**, as students could clearly choose to participate or not. Facilitators provided them the possibility to get involved how they wanted to. For instance, in PW2, in Group 1, during one activity, one girl did not want to participate when performing the infernal machine, what was respected by the facilitator. Overall, during the exercises, students formed the groups by their own according to their desires to get involved with some or other peers. In this regard, students recognized that overall, all along the workshops, their capacity to make choices highly relied on their own wishes, as one of the student said during the workshops: « *basically, it depended if we were taking our places or not."*

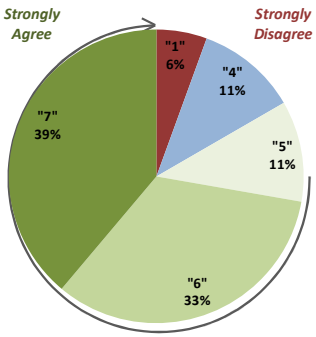
Regarding the topic they would have to develop during the project, students were invited to choose a topic they would like to explore during the project. During the first workshops, facilitators asked during a whole group session, to list all the subjects they would like to explore. Students were reactive and almost 2/3 provided ideas. Then, during PW3, students were asked to choose the topics they will develop all along this project. To do so, the facilitators used the tool "moving debate" where student were asked to go in either right or left side of the room (not agree - agree) with every topic they previously listed in workshop 1. Each student was also asked to find one specific question for the three main topics they chose. The dynamic was thus inclusive and was also confirmed by students, as 74% of them reported that they could make choice on their own research question (4 were neutral and 1 disagreed).



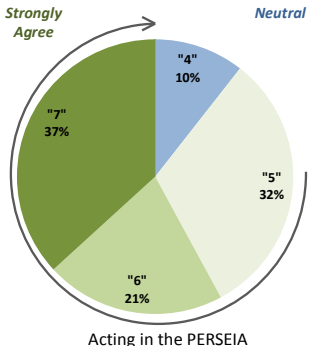
The Research Question

"During the creation of the PERSEIA, I could make choice on the research question"

Finally, regarding **to the PERSEIA**, except one girl and two boys who provided neutral answers, all the students agreed to say that "**[they]** ***could choose how I wanted to participate in the PERSEIA".*** In the same line, all the students reported **they could decide their role play** during the PERSEIA.

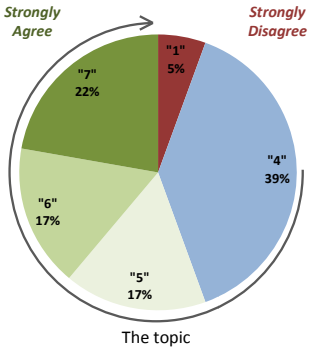


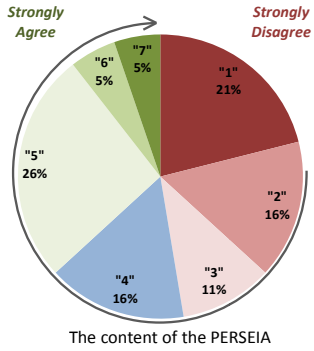
"I could choose how I wanted to participate in the Perseia"



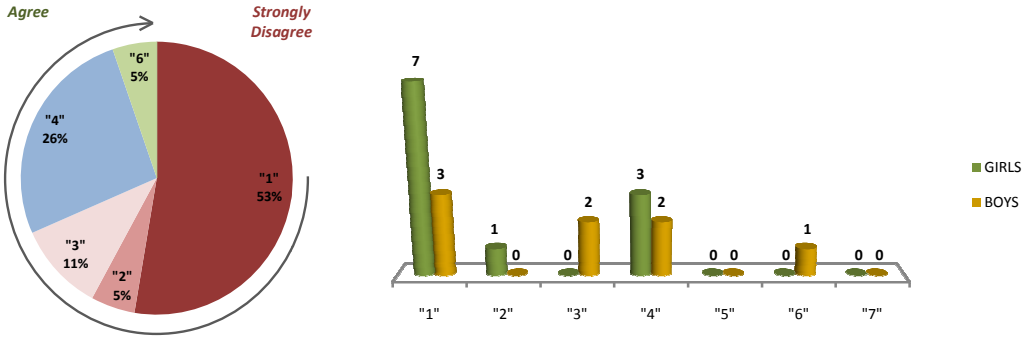
"During the creation of the PERSEIA, I could make choice on my acting"

However, students reported **to a lesser extent that they could make choice regarding the content of the PERSEIA,** as more than **half the students agreed they could make choices about the topic** developed during the PERSEIA. However, regarding the specific content of the PERSEIA, **almost half the students disagreed that they could choose the content of the PERSEIA**. This feeling was also confirmed by another item, "***the PERSEIA did not include their ideas***", which gathered 68% of students' disagreement, especially from girls who tended to provide stronger answers.





"During the creation of the PERSEIA, I could make choice on …"



Our [PERSEIA] did not include my ideas

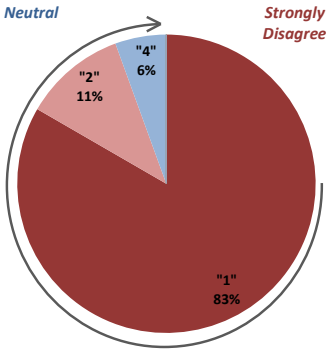
When asking student during the focus group why they perceived they could not make choices on the content of the PERSEIA, **some of them reported that they had missed the session in which the research question and topics were selected** (from Group 2).Moreover, students complaint that although some of them did get involved in looking for answers to their own research questions, such information was not used afterwards. One student reported however that even if he was absent the time they decided which topic would be part

of the PERSEIA, "*he could make choices on how to act on the topics that were decided*". It is worth mentioning that when asking students whether this situation of not being totally the ones who decided the content of the PERSEIA would have frustrated them or made them feel less motivated, they all answered that **it did not affect their motivation.**

Such unconvinced feelings towards students' possibility to decide on the content of the PERSEIA might be explained by the way the creation of the PERSEIA was realized. Indeed, based on the research questions proposed by the students, facilitators invited them to perform improvisations and theatrical exercises related to these topics. By seeing student's performance during the improvisations, facilitators could identify some specific ideas students provided to keep them for the final PERSEIA. Then, facilitators wrote the script of the sketches and shared it with students. However, no time was devoted precisely to write the script with students. Moreover, although students were invited to read the script all together, **no time could be really devoted to discuss with students its exact content.** Therefore, although **the final product of the PERSEIA was partly selected by students,** this might be one of the reasons why students had the feeling their ideas were not all included in the PERSEIA.

ENGAGEMENT AND CRITICAL THINKING

Except one neutral answer, all the students disagreed with the fact that "(**they) *found it of little interest to get involved in the creation of their PERSEIA"***



*"**I found it of little interest to get involved in the creation of our PERSEIA"***

This interest of students for the creation of the PERSEIA seemed coherent as it was the main reason why they got involved into the PERFORM project. Indeed, as the creation of the PERFORM group was initially based on own students' wish, and because most students did get interested by the project for the theatrical part.

"it is above all the theatre that made students get engaged or not in the project; some of them did not want to do theatre and did not participate, but for some other, it was clear that the theatrical part was the driver of their implication into the PERFORM, especially because they had in mind above all the idea of theatre and not specially the idea of science."

(Teacher 2, Group 2)

In this line, when asking students on what they did **like the most and the least during the project**, more than half of them reported they liked the most was to perform the scenes, to do theatre. Students also added during the focus group that they really liked the workshops mostly because it was funny.

We also observed **affective responses to the methods or activities proposed emerged among students** (e.g. **behavioural reactions that could be noted during the activities)**. Overall, the **students' enjoyment during the theatrical exercises was higher than in the other activities**. For instance, during PW4, when the facilitators presented the aim of the interview role-play game, one guy said "*yeah, like in The voice*". They really enjoyed the activities of recruitment; they were active, laughing a lot. They were very excited and took the role-play very seriously, and some even said "*already one hour passed*?!" and some others were really happy and engaging themselves actively in the activity.

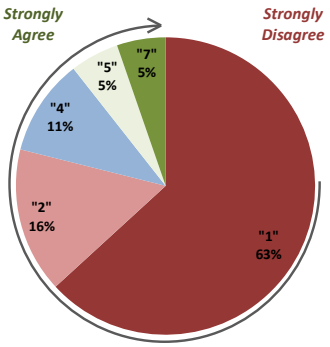
They were in general enthusiast and shared easily their happiness to perform different exercises and the warming up, and specifically the "*samurai*" game, which has been even reported by students as the thing they preferred during the workshops. As developed in Goal 3, students easily shared with the facilitators when they were not comfortable with some exercises and asked for further explanation. In these cases, both facilitators, and sometimes teachers, answered to these worries and guided student to get more trust, what allowed students to stay involved in the activities, and to be more confident all along the process (as highlighted in Goal 3).

Students were invited by the facilitators to explore and express their emotions through the realization of different theatrical exercises (further details in Goal 3), but also to reflect through/upon their emotional responses. Facilitators frequently **opened a space to discuss about students' feeling after the development**

of some exercises. Moreover, they were **encouraging and congratulating students** during the different activities of the workshops, and recognized the difficulties students might encounter. They devoted time for students to express their feelings about how they played those roles. During the theatrical exercises, facilitator very often appreciated and recognised when students managed to perform the task asked. During the **rehearsals** and the final PERSEIA, when the stress was higher for students, facilitators were guiding the scenes, working with students by encouraging them when they were performing and helping them to improve what students found more difficult.

Overall, we could **not observe any kind of excitement or amusement explicitly related to learning science or the topic**. They were laughing more in relation to other peer's jokes, and amused by the different theatrical exercises proposed by the facilitators.

However, although the scientific aspect of the project was not the reason of the presence in the PERFORM group for several of the students, and despite the low amount of students who reported to enjoy learning science topics (see above), almost all the students disagreed that "(**they**) ***found it of little interest to get involved in the reflection activities and group discussions (cards activity, articles activity, interview role play and art and science activity".***



"I found it of little interest to get involved in the reflection activities and group discussions (cards activity, articles activity, interview role play and art and science activity."

However, despite of such self reported interest towards reflection activities, observation of the workshops and further exploration on students' inputs highlighted students cognitive engagement depended on the context (whole group vs subgroup) and on the way the activity was led (see Goal 3).

Students' engagement differed between the activities related to reflection (PW1, PW3) where students had to read, write and think around a table, and the theatrical activities and exercises. In general, in Group 1, students were generally **less comfortable when they had to work on reflection activities than on theatrical exercises and were less engaged when working on papers than when discussing during the debate.** For instance, during PW3, when reading the articles, not all were really active and they did not look really enjoyed by this activity. Then, during the debate, almost half the students was really involved and participated a lot; the rest was active but did not talk that much. Therefore, the workshops did not reach all the students to be cognitively engaged, and two different students explicitly **reported that what they liked the least of the workshops were the reflection activities and the work on papers. Teachers also reported the limitation some of the reflection had towards the engagement of the students within the workshops. One of them explained:**

"When they had to work on the articles, they did not understand why they had to work on this whereas they were supposed to do theatre. Maybe in this session was too disconnected and not enough prepared, anyhow, students got bored, and this is a negative criteria, as it demotivated some of them. I guess they did not what the project was about and whether they really would create a scene."

(Teacher 3, Group 2)

Therefore, because of this disconnection between reflection activities and PERSEIA creation, cognitive engagement has not been totally fostered during such activities. Consequently, as reported by both students and teachers**, students' engagement got higher when they realized that all the results of their improvisations and research would be part of the final PERSEIA.** Although facilitators presented the idea of the project and that all the activities would lead to the creation of a final PERSEIA, students apparently did not realize its implications before late in the project.

Furthermore, **it seemed overall difficult for the students to approach the topics and develop their ideas**. For instance, in Group 1, during PW1, when students were presenting their project (on societal challenges), it was hard for them to develop their ideas and to answer the questions the facilitators and the ECR asked to them. The ECR brought elements of contextualization and reflection about the way science is realized and how we can or not trust what is referred as "science". However, students seemed not to totally understand his approach. As reported in Goal 3, this might be also due to the schooling abilities in this specific group, reason why, as teachers highlighted, such reflection activities might have not reached their full potential. In Group 2, students' cognitive engagement seemed indeed to be higher. For instance, during small group work about students' research question (on optical illusions), students could get involved in the reasoning of what the facilitators proposed quite easily. However, some students might have been somehow less comfortable with the terms used, as they reported during the focus group that they would have liked to be more helped during the workshops. This was also reported by teachers, who highlighted the fact that sometimes, the explanations and the vocabulary given by the facilitators were somehow too complex for students.

However, **students were curious and really dynamic when they were in whole group debating about their different ideas**. They were able to use their own experience and knowledge and tried to understand the different issues related to the topic. For instance, during the debate after the articles in PWX, they were trying to understand how they could know the "truth". They were curious and with the desire to understand. However, in general, the different **debates and argumentations that appeared all along the workshops were not really deeply developed.** For instance, during the creation of the scene about animal conservation, in Group 1, students were asked to create two groups: one with people pro conservation and the other against it. Students had then to perform, by giving ideas of argumentation from both sides for the conservation or not of a specific animal. Although many ideas emerged from students, several were totally disconnected from the real and fell into prejudices. However, no more time was devote to explore, deconstruct or think about what emerged from them and somehow, the conclusion of their debate stayed with a lot of misunderstanding. In Group 2, during PW4, there was not much reasoning or arguing during the plenary. The conversation was mostly descriptive of characteristics they saw and only in a couple of moments there was disagreement (e.g. because of the consequences of girl 1 having kids, the lower salary of boy 3), but there was no debate as no time was dedicated to discuss aspects of disagreement.

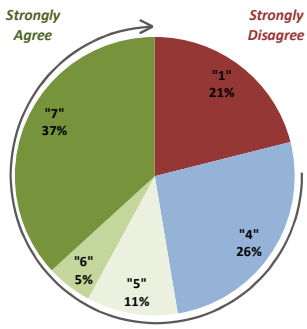
Related to this, **the contextualization of STEM topics within daily life and societal contexts was not really developed**. It occurred few times mostly during the debate of PW1, PW3 and PW4. For instance, in Group 1, during PW3, STEM topics were contextualized when facilitators led the debate by joining together the different topics of the three articles to include them in a broader approach in this current context of making science and economy/politic strategies of business. During PW4, during the speaking round about students questions, facilitators invited a girl to consider her question in a more global way by comparing the situation (in this case violence caused by the police) in other countries and regimes. Overall, **few occasions occurred where questions were put in a broader context and used to highlight ethical questions or allow students to develop a critical thinking about it.** However**,** as **students brought research questions intimately related**

to social context (on police, violence, etc**), such topics could be explored with a broader lens,** even if no much time could be dedicated to it.

In the same line, although **critical thinking was developed during reflection activities** of PW4 and also during the different discussions about student's PERSEIA related to their own questions, the workshops **did not seem to allow students to acquire this concept**. Indeed, when students asked on the meaning of critical thinking during the focus group, no one could really answer. They mostly reported that critical thinking meant "*to criticize a person*", "*to give positive and negative comments*" or "*to give a feedback to someone*". Among the surveys, only one student reported that she could learn thanks to the project "*to do research on questions I am wondering. And to not believe on one idea presented by a researcher rather on ideas presented by several researchers*". Moreover, the **workshops did not foster any critical approach towards gender** in relation to science or science learning. The only occasion in which it could be approached was during PW4through an activity that specifically related to stereotypes and gender. However gender issues were only lightly evoked by the facilitators during the debate that occurred after the interview role-play. Regarding their perception and attitude towards the gender issue, there was no much explicit talking about it. In Group 2, two girls explicitly mentioned having kids as a disadvantage and one boy mentioned during the role play that for him was not a problem to have kids because he "*has a wife*" (the woman is the one who takes care of children). Facilitators did not explore some of these interventions to foster debate. Maybe because students were already out of gendered stereotypes they did not evoke such aspects during the debate. However, no more time was dedicated to talk about such issue during the workshops.

Finally, **students' cognitive engagement was higher when working on their own research questions**. As reported by a girl during the focus group "*in contrast with the other works on articles or with the cards, when we were working on our different thematic, like on the technology, the police, the animals, honestly, it was awesome, it made us think*."

However, students' engagement was quite reduced while out of the workshops. Indeed, in relation to their perception regarding **the process of learning for the realization of the PERSEIA**, more than half of the students (10) considered that **"*The Perseia could have been done without homework*"**; 5 provided neutral answers and only 4 students considered the Perseia could not have been done without homework.



"The [PERSEIA] could have been done without homework"

Although students **reported they could have realized their PERSEIA without homework**, students reported during the focus group that some of them did performed homework, but not all.

Teachers confirmed to us that **most students did explore their research question** out of the workshops. Indeed, two teachers devoted a 2 hours session with PERFORM students in order to guide them in their research. However, teachers also highlighted that students might have not really integrated the importance of doing homework and look for answers to their research questions, but rather as a facultative option.

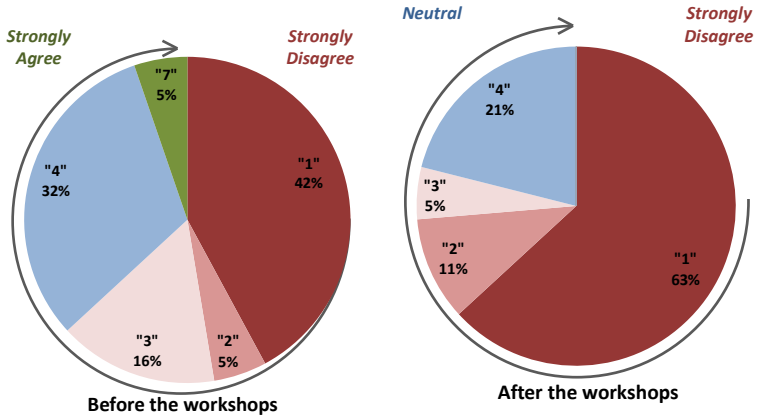
Students, according to their words, students did not spontaneously go for extra work at home and are not really autonomous.

Furthermore, **one of the main reason why students might have perceived this issue** might be, as also said by students during the Focus Group, that a **really little amount of time was devoted to the sharing of student's results** on their research and that **not all the questions raised by the students were used for the PERSEIA**. In that sense, students might have felt homework were useless because their research questions were not all selected for the creation of the PERSEIA.

THE NATURE OF SCIENCE: ETHICS INTEGRATION

Finally, we approached the understanding of the nature of science, both through the perceptions of students, and through the capacity of the project and the activities designed, to include ethical aspects of research and share science also as a process

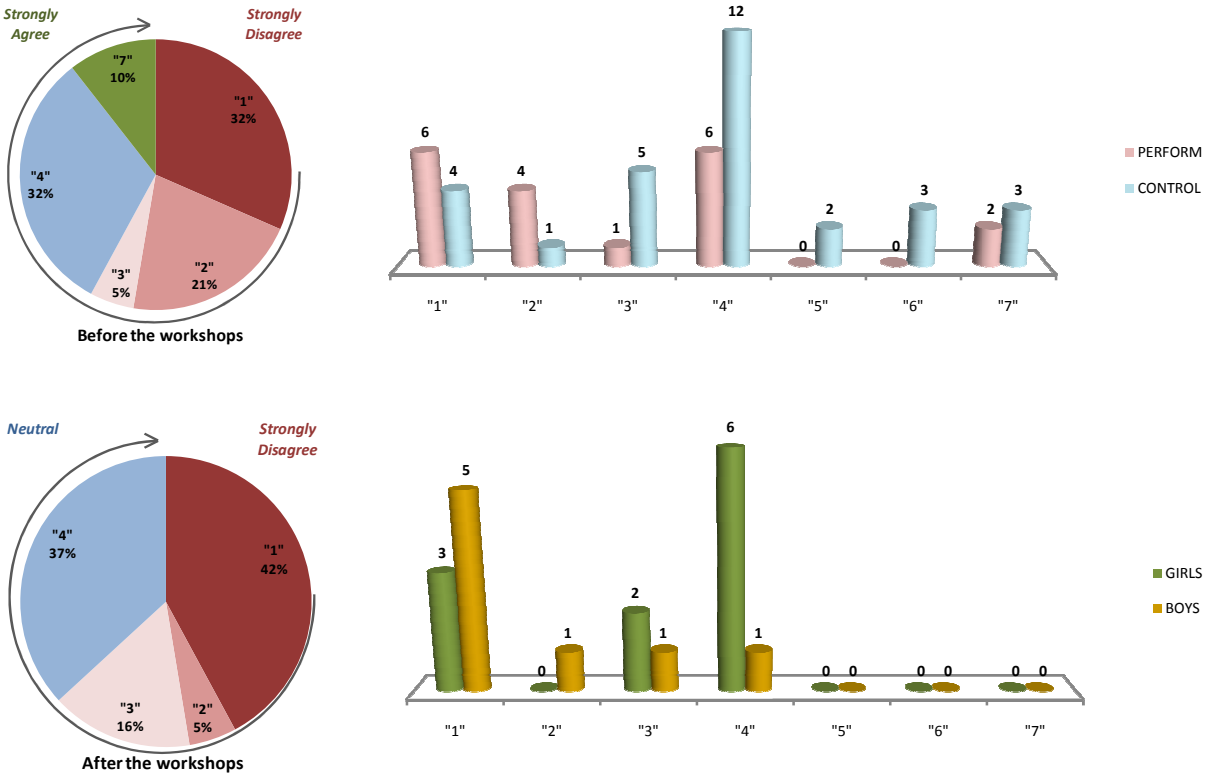
When asked about the nature of scientific knowledge, 63% of the students **did not think that scientific knowledge is always certain** before the workshops. Although the variation of students' answers did not differ significantly between both questionnaires, such **understanding tended to increase after the workshops** as 78% of them disagreed with the statement, while the rest of the students provided neutral answers.



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

However, **we did not observe a global approach from the facilitators to embed contrasting perspectives when approaching science or a given scientific issue, probably due to the lack of depth in the approach to scientific topics**. It was **mostly done during PW3**, in which the whole activity was about developing critical thinking and thus highlighting contrasting perspectives. By allowing students to question what they were reading, they could share and think about the different issues related to science and business, the conflict of interest between research and market as well as the processes of knowledge creation within science. However, **no more occasions really occurred to bring contrasting perspective on science, and it could not be really developed when working on students' own research question.**

Regarding the impacts of science in the society, in the pre-survey, **more than half** of the students reported they **disagreed** that **science only has good impacts on people**, whereas 32% of the students gave a neutral answer. There was a significant **difference between PERFORM and control group students**, as most of the control group students provided a neutral answer. Although variation between both surveys was not significant, after the workshops, there was not any student who agreed with the statement. Most of the neutral answers were provided by girls (significant difference between sexes)



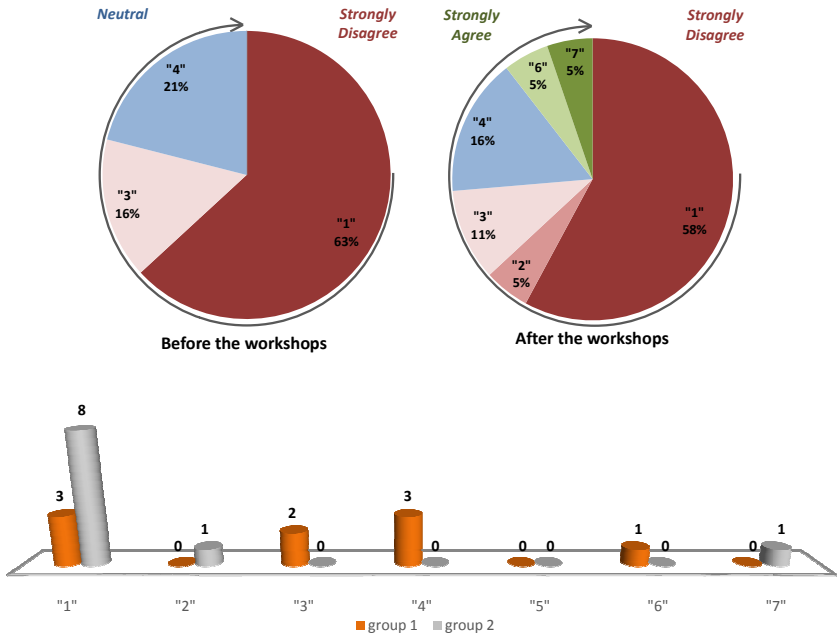
"Science only has good impacts on people"

During the workshops, an effort was done to contextualize science and its social relevance, by the integration of social and ethical aspects of research in the activities. Indeed, because **students proposed several questions that were not intimately related to STEM topics** as their own research question for the creation of the PERSEIA, it somehow challenged the framework of the project, aiming to assess STEM topics. Indeed, as observed also in Marie Curie, some students brought relevant questions embedded into societal challenges, such as the use of violence by the police, the way justice is done among the police and the discrimination and racism in our current context. In that sense, such questions were not directly related to any STEM topics, but **facilitators kept these questions and tried to explore them with students and could be presented during the PERSEIA. In that sense, it allowed students to integrate the potential link between doing research and its potential impact into the society. However, as already mentioned, it could be only superficial approached, and few occasions allowed to develop on these aspects.**

Similarly, and probably due to the same reason, **reflections about ethical behaviour in science were not frequent.** We observed, however, some moments in which they were introduced. For instance, it occurred during the debate in PW4, in which they quickly talked about the fact to recruit someone with babies or not, but such debate did not explore very deeply stereotypical issues. When the person recruiting said something about the fact that the chosen guy has children, he said he has also a wife. The others laughed and the facilitators let the students arguing, but they directly shift to other topic. However, **at the end of the debate, facilitators did not explore much more about stereotypes.**

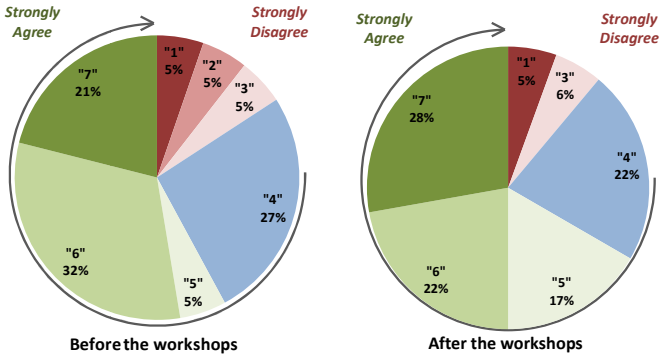
Finally, students seemed **to already hold a perception on science production that does consider science as a process embedded in human qualities,** as more than half of them consider science as a product of imagination and creativity and that good scientists can fail in doing science. As some students spontaneously reported when facilitators opened a discussion about the nature of science, *"scientists are human beings also!"* and *"to err is human!"*

Before the workshops, more **than 3/4 of the students disagreed to say that good scientists do not fail while doing science before the workshops; this proportion remained almost the same,** although some students agreed with the statement in the post-PERSEIA survey. Significant **differences existed between both groups**, as almost **all the students from Group 2 strongly disagreed** with the statement whereas **students from Group 1 provided more diverse answers**.



"Good scientists do not fail while doing science"

Before the workshops, more than all half the students 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 positive answers after the workshops (from 58 to 67% of them).



The production of scientific knowledge involves human imagination and creativity

However, the inclusion **of the human dimension of science could not be really developed**, as for instance, the inclusion of personal stories of the ECR could not really happen. Indeed, although the ECR could share ideas and thoughts about different topics, **his personal experience was not approached during the workshops.** In that sense, as also reported in Goal 1, **the contact with ECR did not foster students to get a view on the personal and human side of science**.

Despite these key aspects to improve, when asked about changes in their perception of their relation to science, several students commented that although **their global perception of science had not really changed, the project allowed them to get a broader their view on it**. For instance, they reported that they were afterwards aware that **science also includes much more disciplines than only the ones related to STEM**, and that a lot of different types of scientists do exist.

Collège Marie Curie Paris

The workshops were led by **two facilitators: one scientific communicator and one professional of performing art.** Different from Vauréal, one of the scientific communicator also had experience in performing arts (Group2). For each group, both worked together in a collaborative way, by sharing the management of the workshops. It involved a total of 22 students (10 boys and 12 girls) divided in two subgroups of 11 students each. Although only 18 students performed PERSEIA, 21 students to both the Pre and the Post PERSEIA questionnaires.

Highlights

Inclusiveness

- The workshops overall showed a **high degree of inclusiveness**, with a gender balanced involvement of students.
- This inclusiveness has been settled thanks to **the fluent communication established and the emotional support** facilitators provided to students.
- The possibility for students to **make choice was high** in relation to their **participation** to the activities and the PERSEIA; although some **students perceived they would be liked to be more consulted in relation to the content of the final PERSEIA.**

Engagement

- **Students were highly engaged in the workshops**, when **working both on reflection activities and the different exercises leading to the elaboration of the PERSEIA**.
- Overall, **students' engagement got higher when they realized they would have to present** their results in front of others by **creating a PERSEIA** (final performance).
- **Emotional engagement was high** within PERFORM group, with a **great enthusiasm towards theatrical exercises** and all the process of the creation of the PERSEIA, fostered by facilitators who invited students to express their feelings all along the workshops.
- The workshops **did not seem to reach an optimal cognitive engagement of students (even if more than in Vauréal), mostly due to the disconnection of the reflection activities and the creation of the PERSEIA**.
- **Cognitive engagement through the development of research on students' question could not reach it optimal potential** as a too little amount of time was devoted to explore students' research question.

Ethical aspects

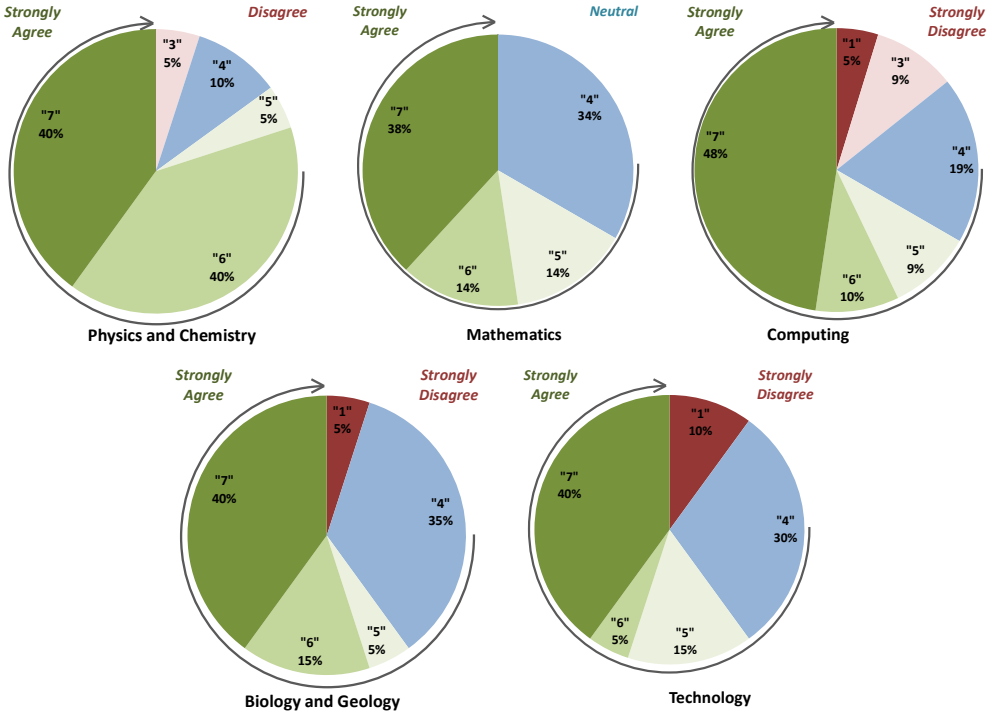
- **Ethical issues have not really been approached** during the whole process of the PERFORM project, as no **precise time was devote to this with students;** but some issues emerged when working on students' own research questions.

- **Contrasting perspectives when approaching science or a given scientific issues have not been really developed**, probably **due to the lack of depth in the approach to scientific topics**.
- However, the **project fostered societal relevance of the topics developed**, by integrating students' research questions that relied on societal issues, even if they did not really entered into STEM topics.

STUDENTS' PERCEPTIONS AND ATTITUDES TOWARDS SCIENCE

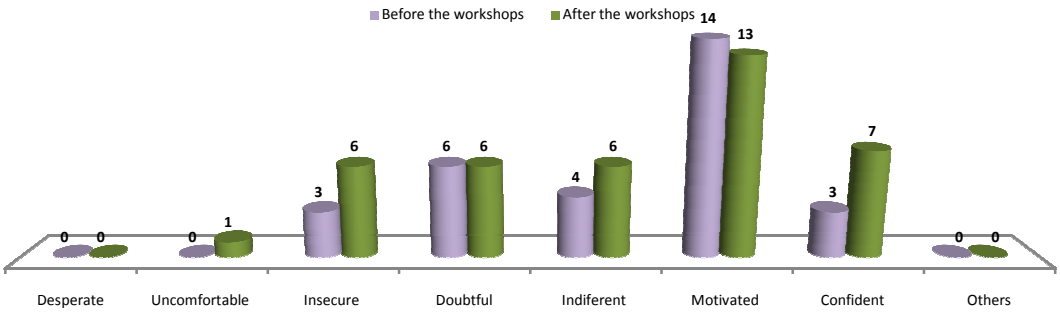
We first present the results of **students' feelings on science learning at school** gathered through the pre-PERSEIA survey as an introduction to the results related to students' potential changes in perceptions and attitudes towards science and scientific careers and jobs as a result of their participation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

Before the beginning of the PERFORM project, students' appreciation towards learning STEM differed according to the discipline. A large proportion of students reported that ***"(they) enjoy acquiring new knowledge in" Physics*** and Chemistry (for 85% of them). Then, they reported to a lesser extent enjoying acquiring new knowledge in Mathematics (for 67% of them), Computing (for 66% of them) Biology and Geology, and also Technology (for 60% of them). For this latter, a higher proportion of girls reported neutral or negative answers.



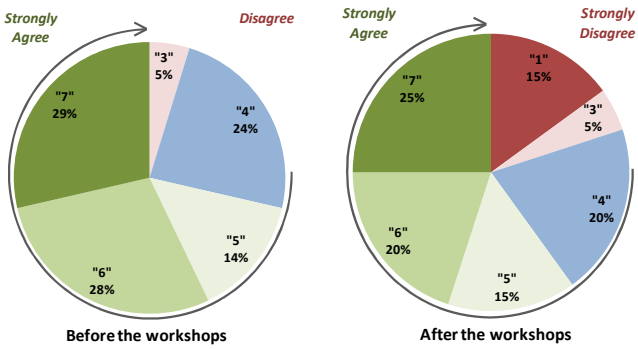
"I enjoy acquiring new knowledge in:"

Overall, before the workshops, a large amount of students (14 out of the 21) seemed to feel motivated *"**At science class or while doing science related activities, I usually feel**"*. Similar to Vauréal, the w**orkshops did not seem to have a significant effect on students' positive or negative feelings towards science education activities at school**. Indeed, most students tended to not to change their opinion (average variation=0), after the workshops, although there was a lower proportion of motivated and higher proportion of insecure and confident.



"At science class or while doing science related activities, I usually feel"

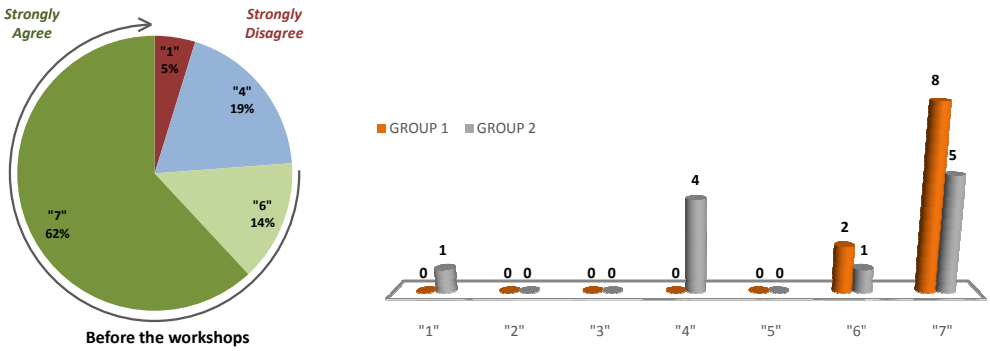
Coherent with the previous question, almost **3/4 of students were agree with the statement *"I feel comfortable while doing activities related to science"*.** Although there was no significant difference between the Pre and the Post surveys, we can see that after the workshops, the proportion of students who disagreed with the statement largely increased. The **variation in students' answers differed according to the sex of the students**, with girls' answers showing a positive variation (1.09) while boys' a negative one (-0.05).

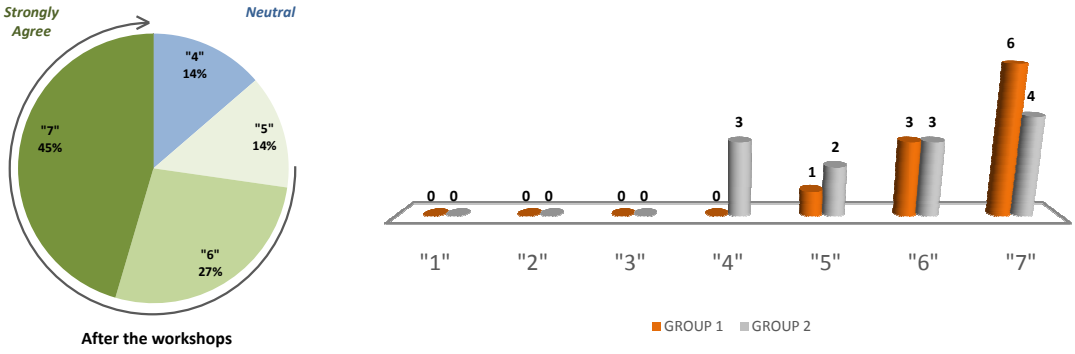


"I feel comfortable while doing activities related to science"

Students were also asked about **their perceptions about the role of science in and for society.** Overall, **more than 3/4 of the students** considered **science as important for a better society** and **almost half of them** considered **science has embedded in real life** and **helpful to understand the worldwide problems.**

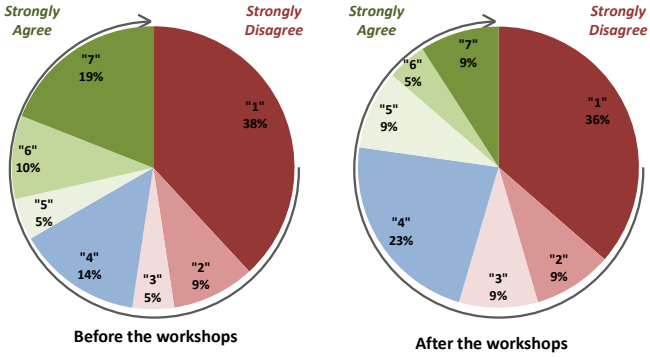
Survey results suggest that **students' perception towards the importance of scientific jobs for a better society slightly increased** after the workshops. Before the workshops, more than ¾ of the students agreed to say that "***Scientific jobs are important for a better society***". After the workshops, even if variation was almost null (0.05), the proportion of students who provided negative and neutral answers decreased. In both surveys, there were **significant differences according to students' groups**, as only students from Group 2 tended to provide more negative and neutral answers.





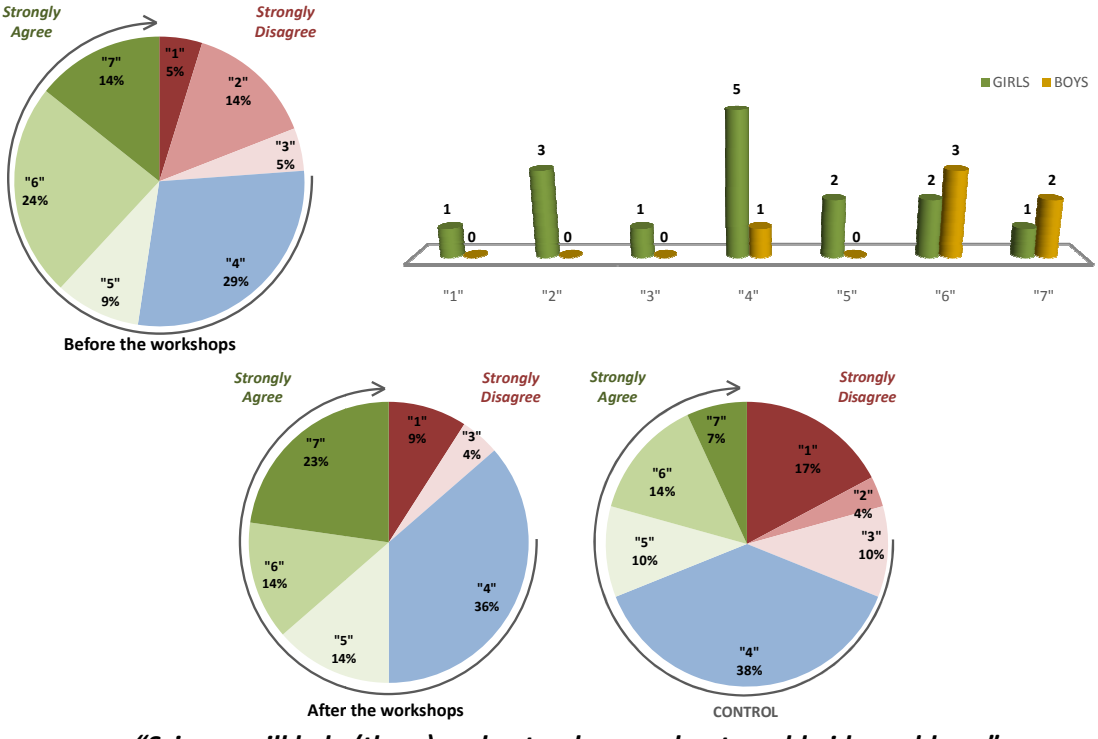
"Scientific jobs are important for a better society"

Moreover, before the workshops, half the students disagreed that ***"Science has nothing to do with real-life problems",*** proportion that stayed almost the same after the workshops, although the proportion of students who agreed with the statement decreased.



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

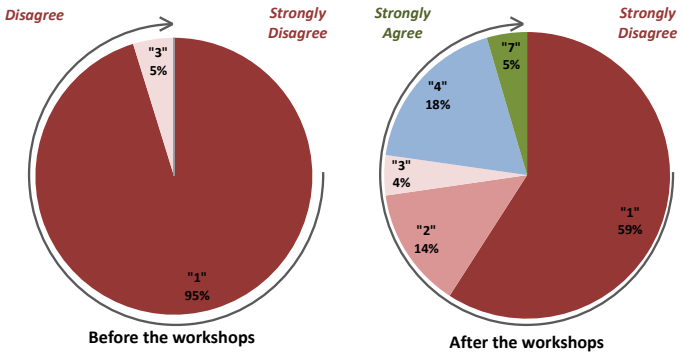
Before the workshops, less almost half the students agreed to say that ***"Science will help (them) understand more about worldwide problems",*** with a significant difference between boys and girls as **only girls disagreed with the statement**. After the workshops, the proportion of answers did not change but there was a higher proportion of neutral answers. **PERFORM students' answers significantly differed from the control group** that showed a more diverse pattern of answers.



"Science will help (them) understand more about worldwide problems"

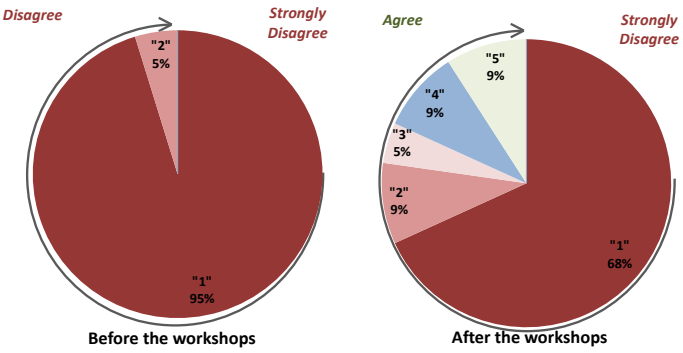
Students also answered questions on their **perceptions about gender-related roles in science**, whose results showed a **noticeable pattern**. Indeed, although all the students were reporting that sex did not affect the quality of scientist or the capacity to involve in scientific careers before the workshops, **a lower proportion of students considered these aspects after the workshops.**

Before the workshops, all the students strongly disagreed that ***"Men are better scientists than women".*** Their answers were different from the Control Group in which 12% of them agreed with the statement. However, students **answers significantly changed after the workshops, as more than 18% of them provided neutral answers and 5% agreed with the statement**. **Such variation was different from the Control Group** students who tended to give more negative answers after the workshops.



"Men are better scientists than women"

In the same line, before the workshops, all the students disagreed that ***"Scientific careers are mostly for boys"***, but their answers significantly changed after the workshops, with higher proportion of neutral and positive answers.

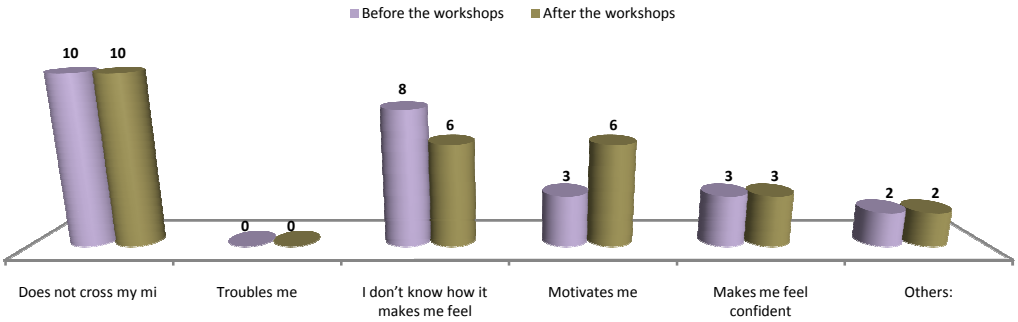


"Scientific careers are mostly for boys"

No link might be done between students' results and the project. However, a really reduced time was devoted to **explore gender issues related to science or scientific careers.** In that sense**, the workshops did not foster any critical approach towards gender in relation to science or science learning.** The reflection activity thought to assess gender stereotype was taken out of the workshops and then, facilitators never really entered with students in these aspects. However, driven by students' questions, one subgroup from Group 1 explored the differences in the characteristics of friendships between boys and girls (see Goal 2). Students could, thanks to the interviews conducted among their peers, have an overview of the differences and similarities according to the sex. However, no time could be devoted to include such results into a broader context or to link it to other aspects that are shaped /biased according to the gender.

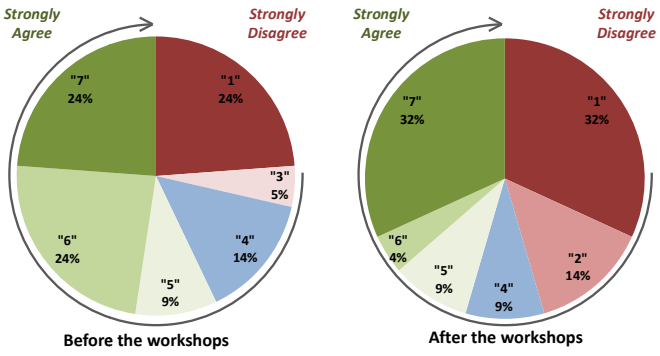
Finally, students' were asked about their **motivations for learning science and studying scientific careers**. Overall, although most **students did not have a clear idea** about studying a scientific career, **almost half of them considered science as important** and **useful for their future**.

Before the workshops, half students reported that "***The idea of studying a scientific career***" did not cross their mind, and 8 students reported they did not know how it made them feel. As we can see below, students tended to provide more positive answer in the Post survey (average variation=0.66). After the workshops, a lower proportion of students answers they did not know how it made them feel, in favor of a higher proportion of students motivated by that (from 3 to 6 students).



"The idea of studying a scientific career:"

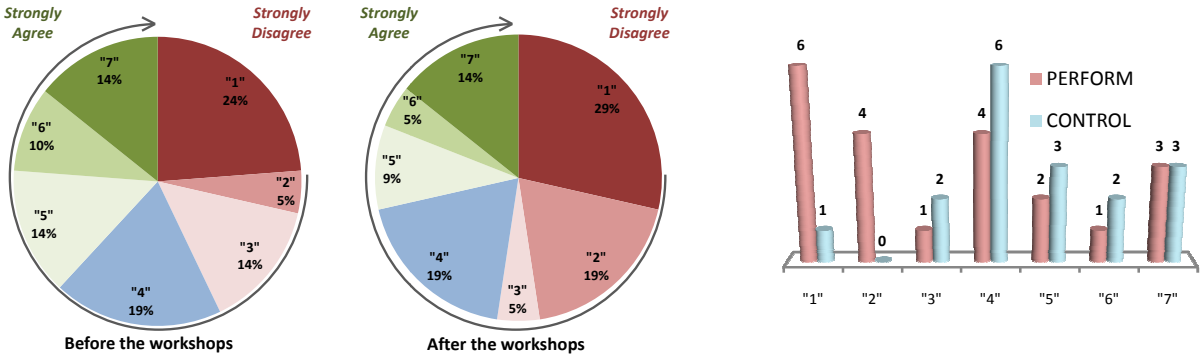
However, **more than half the students** reported that ***"(they) would like to study a career involving science (like biology, geology, physics, medicine or chemistry), technology, engineering or maths".*** Although the differences between both surveys were not significant, students tended to provide more negative answers after the workshops.



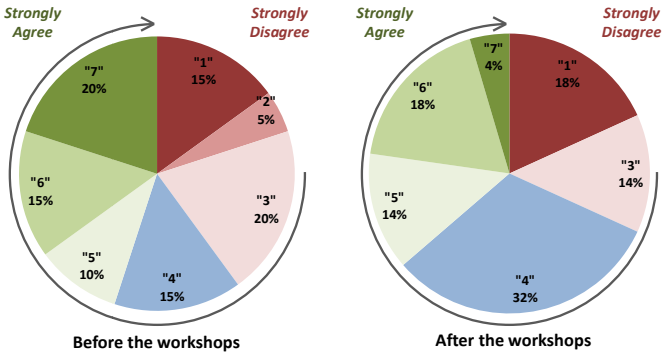
"I would like to study a career involving science (like biology, geology, physics, medicine or chemistry), technology, engineering or maths"

Coherently, more than half the students disagreed that ***"learning science is not important for [their] future success"*** (see Goal 3), proportion that increased to 62% of them after the workshops (significantly different from the variation of the Control group).

In the same line, 45% of the students disagreed that ***"(they) do not expect to use science much when I get out of school"*** before the workshops. However, this **proportion lightly increased** after the workshops. In the post survey, **PERFORM students provided higher proportion of negative answers than the control group**.



Before the workshops, 45% of the students reported that **"(they) *can see (*themselves) *doing science in the future*"**. Although the variation between pre and post surveys was almost null, this proportion **lightly decreased after the workshops** in favour of a higher proportion of neutral answers.



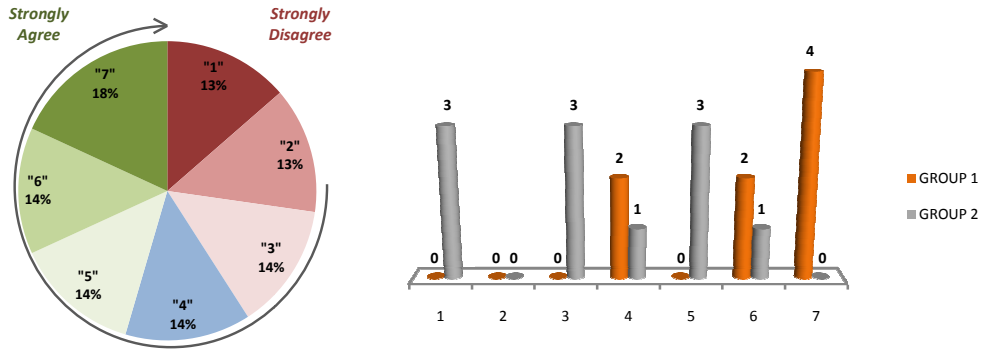
"I can see* (myself) *doing science in the future"

INCLUSIVENESS

As already developed in Goal 3, we could see that more than ¾ of students reported that they ***"actively participated in all the group tasks during the workshops***"; and ¾ of the students agreed to say that they ***"shared different tasks within their group during the realization of the workshops"***.

Similar to the context of Vauréal, all along the workshops, from researchers' observations, we could report that there **was not precise task assumed by some specific students,** but rather a grouped and individual participation asked during the different exercises. Differently from Vauréal, students in Marie Curie were **participating to the different activities without a notable difference according to the kind of activities.** However, it was also clear that **students were much more active** and **enthusiast** when **performing and debating than when working on reflection activities.** Among the different workshops**,** we could observe that students were sharing tasks and roles in **a balanced way**. As most work done in subgroups was also supervised by facilitators, all the students generally participated. In contrast with Vauréal, **when working in subgroup all students got generally involved in it, and did not seem less interested by the reflection activities than by other activities** (such as the theatrical exercises or the creation of their PERSEIA). Overall, and similar to Vauréal, all the students **participated to the activities in a similar way, without any clear difference between boys and girls.** For the PERFORM project, the groups formed for the project in Marie Curie joined 22 students, divided in two equal groups, formed by 5 boys and 6 girls in Group 1 and 9 girls and 2 boys in Group 2. There was neither **any clear pattern of division of tasks nor roles according to the gender**. Both girls and boys were involved in the different activities in a similar way, and it could not be seen either any difference in their cognitive or emotional engagement during the workshops. Moreover, in Group 1, one boy was no fluent in French who was helped at the beginning by the teacher for completing the pre survey questionnaire. Further assistance was provided to him at some specific moments, such as when the activities implied reading and/or writing.

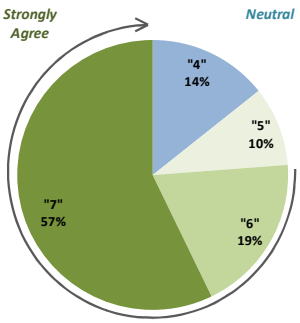
This balanced participation of students during the workshops was allowed by different aspects of the **facilitation that fostered dialogue among students.** However, although students felt mostly confident during the workshops (as reported in Goal 3), it **seemed that this context did not allow all the students to ask whatever they wanted, in contrast with Vauréal context**. Indeed, only half of the students agreed to say to "***during the workshops*** **[they]** ***asked the facilitators whatever*** **[they]** ***wanted to"***. It significantly differed between groups, as only students from Group 2 reported (6 of them or 1 was neutral) that they could not ask whatever they wanted to the facilitators. However, no further explanation on this perception could be brought during the focus group, as all the students answered they could ask whatever they wanted to.



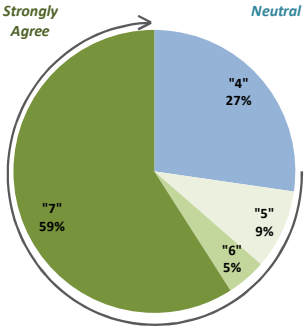
"***During the workshops I asked the facilitators whatever*** **[they]** ***wanted to"***

Although not all the students perceived they could ask easily whatever they wanted, students reported that they **felt their work was recognized by the facilitators, teachers and ECR**.

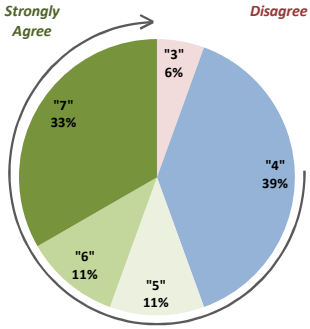
Indeed, they **felt their work was recognized by:** i)the **science communicators**, **for more than 86% of them** (3 students reported neutral answers) ; ii) by the **teachers for 73% of them**, (6 students who were neutral); and iii) by the **ECR for 55% of them** (6 students who were neutral). Related to this latter, significant differences exist between sexes and groups. **Girls** tended to provide **higher proportion of neutral** answers, but also**agreedmore strongly** than boys. Students from **Group 1 tended to provide more neutral and negative answers than Group 2 where all students reported positive answers.**



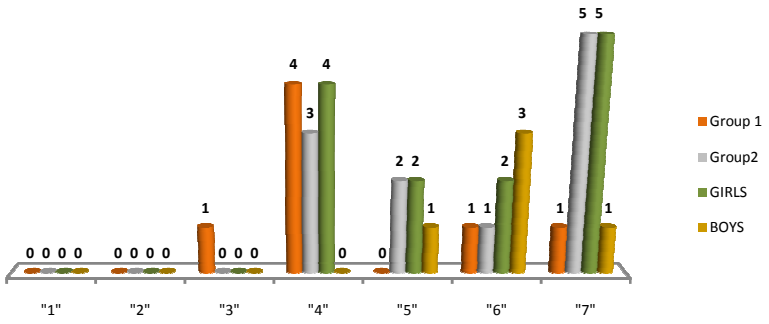
By the science communicators



By the teachers



By the ECR



These overall positive feelings might have been largely due to the **relation established by facilitators**. In general, the relation between facilitators and the students was **fluent, smooth and enthusiast**. The communication occurred in an easy way, students participating spontaneously, sharing ideas between them and with the adults (facilitators and the ECR) without difficulties. In that sense, **the whole group tended to be receptive, active and with a good interaction with the facilitator.** Indeed, since the first workshops, both facilitators were really **inclusive and attentive to the needs of the students.** Facilitators were **present and showed a lot of tact.** For instance, with the new student in Group 1, the facilitator took him apart and explained to him that if he did not want to participate, he could, but it would be a shame for him (and not for the teacher he wanted to bother). The performer established a climate of trust and pushed the students to trust themselves. The facilitator accompanied the students with joy, trust and attention. Overall, facilitators created **quickly a climate of trust, horizontal relation with students and funny atmosphere**. Facilitators were using humour, jokes to create a cohesive dynamic. In that sense, a fluent relation quickly established among the group.

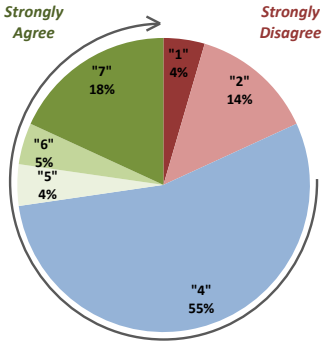
The context of inclusiveness was also fostered by giving space to students to use **their own previous experiences and knowledge**. It occurred when students were working on the different activities, during the debates, for the research of their question and during the theatrical exercises. **Students' research questions were largely embedded in students' experience** as **one third of the students chose to explore issues related to their daily life.** For instance, several boys chose to **bring issues related to the current social conflict occurring between two districts in Paris, and also to the impacts of the social media on adolescents**. Use of previous experiences occurred both when students were debating about these issue in plenary and also in subgroup. For instance during PW6 in order to create the scene, in group 1, in the

subgroup with the ECR, students were asked to think about their own experiences related to the use of social media and also about the relation of friendship between girls and between boys. In the subgroup exploring the conflicts between districts with the facilitators, students were asked to testify about their experience in relation to the topic on conflicts between districts.

As also observed in Vauréal, a main part of **fostering dialogue between participants** and **students' mobilization of their previous experiences** occurred through **the exercises of performing art. Indeed, except during the first workshops,** facilitators promoted the use of art-related methods in all the activities. Facilitators were asking students to use their body, to be creative, to invent and create scenes, situations and improvisations all along the workshops about different topics, including the topics of their own research questions. Because it was not related to schooling knowledge and competences, most students could mobilize their own embodied and lived experience**. Students were really reactive to these exercises and most students who did not participate much during the debate and the reflection activities were more involved when they had to move, to improvise or to perform**.

To a lesser extent than in Vauréal, the format of the workshops did not seem to allow **a context for fostering a deep dialogue with other actors**, especially with the young researchers (see Analysis of the Goal 1). In this line, **52% of the students** reported they ***"wish (they) could have had more interaction with the researchers"*** (see Goal 1). However, compared with Vauréal, the implication of the ECR in students' own process of research was largely higher.

Finally in terms of dialogue, although the use of the Facebook page that was initially thought to better foster dialogue between the different participants did not seem to really foster better inclusion of students in the project. Indeed, more than half of the students did not know how to answer about "**the use of the platform helped (them) to participate more in the project**".



"The use of online platforms helped me participate more in the project"

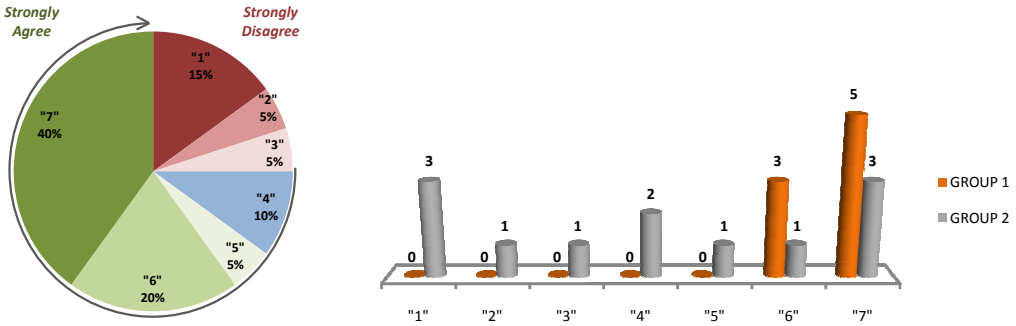
Exploring **how the workshops dealt with inclusiveness intimately relates to the way students could have made choice all along the process**. Three different contexts have been specifically explored in order to see how student could make choices: i) their participation into the activities; ii) their research question and the topic developed for the PERSEIA; and iii) the content of the PERSEIA and their role in it.

Regarding their overall participation during the activities, the way the different workshops have been conducted by the facilitators generally allowed students to make their own choices and students could clearly choose to participate or not. Facilitators provided them the possibility to involve how they wanted and gave the possibility to the students who did not want to participate to the performance to be involved in other aspects of the show (by leading logistical aspects for instance).

In general**, regarding the choice of the research question, the topic and the content of the PERSEIA,** around **60% of them reported they could make choices,** with a **higher proportion of students** who **disagreed**

belonging to the Group 2 (especially related to the research question and the content developed for the PERSEIA). Students tended to agree more on their possibility to make choice when asked about the acting in the PERSEIA; however, there was still a difference between groups.

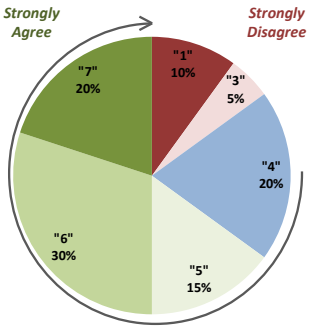
First, 65% of the students reported they could decide on their research question. Significant differences existed between groups, as while all the students almost or totally strongly agreed they could choice their research question, students provided more diverse answered, with the same amount of students who disagreed and agreed with the statement (4 of each). However, two of them who reported negative answers were boys who did not want to participate since the beginning. In that sense, we supposed their feeling was more related to their own (dis)interest for the project rather than a real feeling of non consideration.



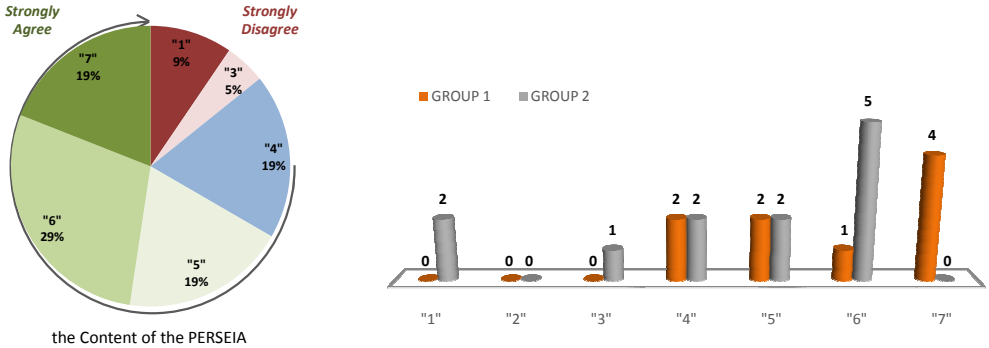
the Research Question

"During the creation of the PERSEIA, I could make choice on the research question"

Similarly, **around 60% of the students agreed they could make choices about the topic and the content** developed during the PERSEIA. As shown for other questions, students from Group 2 were the only ones to report negative answers.



the topic of the PERSEIA

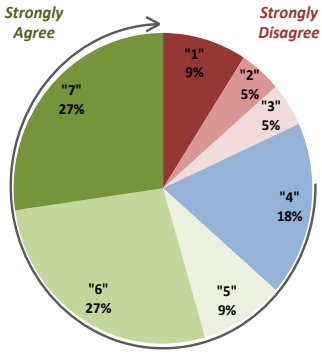


the Content of the PERSEIA

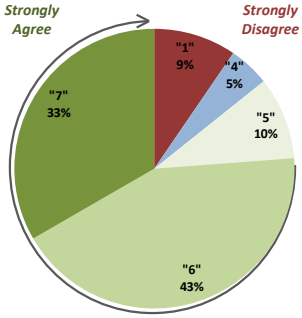
"During the creation of the PERSEIA, I could make choice on …"

In contrast, regarding **their role in the PERSEIA,** more than half the students agreed to say that "**[they]** ***could choose how I wanted to participate in the Perseia",*** and almost all the students reported **they could decide their role played** during the PERSEIA. Similar to the item related to the research question, significant

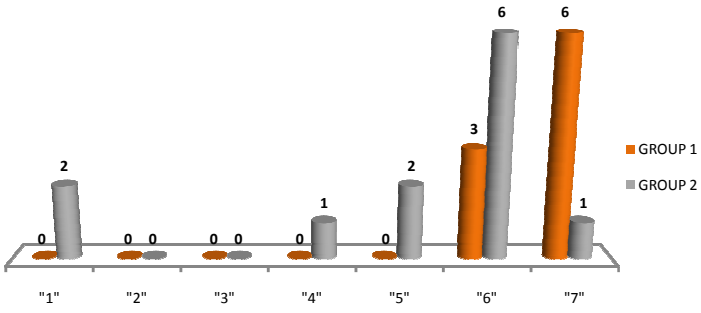
differences existed between groups, and students from Group 2 were the only ones to provide neutral or negative answers. It was due, as said before, to the presence of two students who did not want to participate at all. However, one of them however nuanced his answer by adding in the survey that "*I did not want to participate to the theatre, thus with facilitators we suited that I would not perform, but I did participate to the workshops*".



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

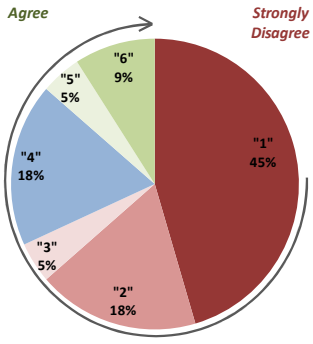


the Acting during the PERSEIA



"During the creation of the PERSEIA, I could make choice on my acting"

In the same line, 68% of the students reported that they disagreed that "***Our Perseia did not include (*****their) *ideas***" but 4 students gave neutral answers and 3considered it did not include his ideas.



"***Our Perseia did not include my ideas***"

Overall, although the way facilitators led the choice of the research question and the creation of the PERSEIA was similar to both schools, we see here that in contrast with Vauréal, **students from Marie Curie were much more critical towards their possibility to make choice during the whole process**. Although such results have to be considered with the biases of two-three students who did not want to participate at all, these results however underlined that somehow**, students could get a reflective thinking on the overall**

project and their involvement during the PERFORM. In that sense, students **could reflect on how their ideas and propositions were taken into account or not**, in a higher extent than students from Vauréal.

Part of some reflections students brought regarding the process of the creation of the PERSEIA, they highlighted for instance that **only some research questions were highlighted**, as suggested in the following:

"Boy 2 (group 2): *us, we could not really answer to our questions. There were some questions that were asked but finally not all were considered and then, we made research about others' questions.*

Boy 3 (Group 2): in fact, at the beginning, everyone brought a question and then, at the end, only one stayed, and there was not us who decided which one would be kept, I guess it is them who decided."

In this line, students **expressed somehow their frustration towards the process that apparently allowed students to make choices on their topic and the content of the PERSEIA** but that finally did not consider all the students' ideas. Such inputs also appeared within students surveys, as when asked the thing they liked the least, one reported specifically "*the fact that the scenes were not really chosen by us* ". Some students from Group 2 explained:

"Girl 1: *in fact, we have not really chosen the script*
Boy2: *exactly! We did not chose the script*
Girl 1: *we did not chose to do that*
Girl 2: *in fact, the thing was, they took ideas from a group, for instance, the interview. We did it in the subgroup, and then, they said 'well, this is in the show', even if us, we did not really chose this*
Girl1: *it would have been better if we could have chosen*
Boy1: *in fact, we worked for a group, and then, all the people are doing it. In fact, we were working all for us, the scientists, and in fact all the people were looking for things about it, but it would have been done faster if we would have done it for our own."*

Some students further explained that they would **have been more motivated if they could have had more space to decide on the PERSEIA,** as suggested in the following, when asked students how they felt about the absence of their research question in the PERSEIA:

*"Girl 1 (group2)***:** *to me, yes it bothered me, because if we would have proposed our own script, related to the topic, then we would have enjoyed much more to perform it, but here...*
Girl 4: it is more we were imposed to
Girl 1: yes you were requested to
Boy 1/ Boy 4: Yes
Girl 2: for us, it was good, well there were things that we did not propose and that were included, but most of the time, it was us who proposed. Eyh boy 2, remember? You proposed great things for the choreography and they were maintained!
Boy 2: yes, it is true; but some others not
Girl 2: well, it was maintained partly."

Although such frustration might be due to students own perception of the process and might be put into perspective, **teachers also reported a similar doubt about the real possibility** for students to make their choice and how students' work was integrate into the PERSEIA.As reported by Girl 2 in the previous quotation, students were invited to propose ideas during the theatrical exercises. Similar to Vauréal, facilitators were proposing students to make improvisations on the different topics of the research questions. By seeing students' performance during these improvisations, facilitators could identify some specific ideas students provided in order to keep them for the final PERSEIA. Therefore, **the final product of the PERSEIA was partly selected by students**, as also reported by one student: "*When we were in subgroup, subgroup about the topic, then we did perform improvisations and with this, ideas were kept for the show or*

not." However, **not all the students' inputs could be taken into consideration, mostly due to the lack of time to further develop the sketches, as recognized by both students and teachers.**

Finally, it is worth reporting that the **context of fostering inclusiveness has however been challenged by the composition of the PERFORM group,** since, as mentioned elsewhere, the class group was formed by a majority of students interested in the project but also a few students not interested. Because of that, in both groups (although mostly in Group 2), facilitators had to develop several resources to make the group cohesive and to include all the students. Despite of that, the two **students who did not want to participate** were not included in the final PERSEIA, except one who could help the facilitator with logistical issues (see Goal 2).

In sum, from the different inputs reported by students and teachers, it seems that the **inclusive process that occurred in Marie Curie**, more developed in Marie Curie than in Vauréal, **allowed students to be aware of their possibilities to make choices and woke their desire up to get even more involved in the creation of the final performance.**

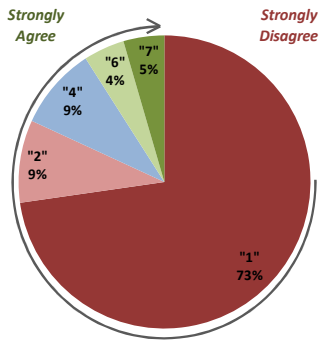
ENGAGEMENT AND CRITICAL THINKING

Emotional engagement

As also reported in Vauréal, we could observe students' **affective responses to the methods** (e.g. affective **behavioural reactions that could be noted during the activities) all along the workshops**. Overall, students were **really enthusiast and shared easily their happiness** to develop the different activities. However, their **participation and engagement was higher during the theatrical exercises than during the other activities (specifically reflection activities)**. Almost all the students were really enthusiast while they had to perform.

Overall, most students' inputs towards the process were really positive, and a large majority of students reported they felt "***confident during the workshops***" (see Goal 3).

When asking students on what they did **like the most and the least during the project**, more than half of them reported what they liked the most was to **perform the scenes**, to do **theatre**, and to do the different exercises (especially the Samurai). In that sense, it is not surprising that students reported they found an interest into creating the PERSEIA. Indeed, except two boys who agreed and two who were neutral, all the other students disagreed that **"they *found it of little interest to get involved in the creation of their PERSEIA".***



"I found it of little interest to get involved in the creation of our PERSEIA"

As in Vauréal, students' emotional engagement was fostered by facilitators who invited students to explore and express their emotions (further details in Goal 3), but also to reflect through/upon their emotional responses. Facilitators also frequently **open a space to discuss about students' feeling after the realization of some exercises.** Overall, as seen in Vauréal, facilitators were **encouraging students** during the different activities of the workshops, and recognized the difficulties students might encounter. They devoted time for students to express their feelings about how they played those roles.

Regarding students' affective responsesin Group 1, students (mostly boys) did share their doubts and fears towards performing in front of their peers, and specifically about being 'snapshated' during the PERSEIA. As their worries could not be totally understood the first time they expressed them, the situation of doubts got stronger in the next workshop (PW7). However, it opened a space of discussion about emotional reactions to performing the play. Thanks to this, other students could also express their doubts and arrived to the final rehearsal with more trust and motivation to perform in front of others. In that sense, this issue could be solved with students by taking time to open the dialogue about their real fears and to find a way to avoid any problem during the PERSEIA.

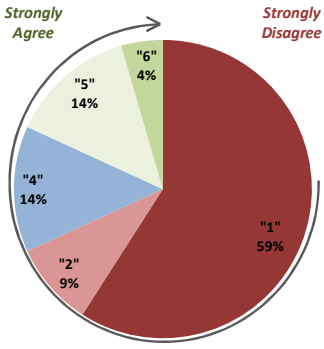
Overall, we could **not observe any kind of excitement or amusement related to the learning science or to the topic**. Students were laughing more in relation to other's jokes, but they were however really excited and amused by the different exercises proposed by the facilitators. **Students did seem to experience**

surprise once during the workshops, when facilitators were presenting the results of the survey conducted among their peers about the impact of social media on adolescents and the differences between boys' friendships and girls'.

Students' cognitive engagement and critical thinking

In general, students **were responsive to the topics addressed during the activities**. According to the teachers, they acknowledged that overall; **students were active and showed interest in the activities proposed by the facilitators,** even the ones who were at the beginning sceptical towards the project, progressively got involved in this process. For instance, in contrast with Vauréal, many different questions emerged from the presentation done by the ECR on their research topic and discipline. Both ECR agreed to say that students looked interested and engaged with their presentation. Teachers also confirmed that they perceived students were **generally really interested by the different topics assessed during the workshops** (both the topics brought by the facilitators and their own research questions).

In this sense, students generally disagreed that "they ***found it of little interest to get involved in the reflection activities and group discussions (cards activity, articles activity, interview role play and art and science activity", although with lower disagreement*** (68%, while 4 did agree with the statement and 3 were neutral).It is however coherent with the proportion of students who reported to enjoy acquiring knowledge on STEM.



"I found it of little interest to get involved in the reflection activities and group discussions (cards activity, articles activity, interview role play and art and science activity."

Overall, in contrast with Vauréal, **students' interest did not seem to vary** that much **between the reflection activities and the activities related to both think about their research question and the PERSEIA and the theatrical exercises.** Although most of the students were engaged into the reflection activities and all along the workshops, we observed however some differences in several boys' engagement and dynamics within the group. In general, **boys tended to be more disperse than girls** and during some workshops, they were laughing among them rather than doing the activity and somehow disrupting the group dynamics(mostly due to the presence of one specific boy who did not really want to be involved in the project).

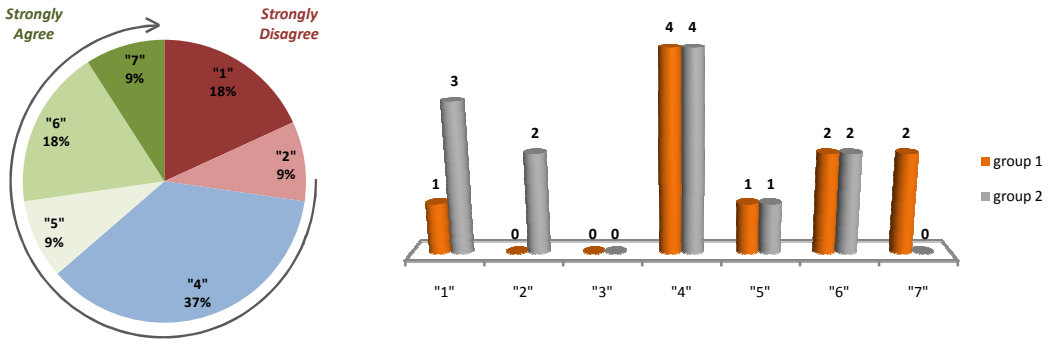
Students were **dynamic and provided several inputs**, both during the **work in the whole group when approaching scientific topics** and **during the work in subgroup**. In a lesser extent than in Vauréal, students however tended to get **more involved when they had to express their ideas orally than by using written support.**

However, although **critical thinking was developed during reflection activities** of PW3and also during the different discussions about student's PERSEIA related to their own questions, the workshops **did not seem to**

allow students to acquire this concept. For instance, when asked students on the **meaning of critical thinking** during the focus group, **none of them could really answer**. This said, when reminding them the approach of critical thinking, some **students reported they used it when they were looking at some answers** on their questions. Specifically, two students mentioned that they were not sure of the relevance of their findings as the sources were not reliable.

In general, **cognitive involvement of students for their own research question was higher than in Vauréal**. In relation to their process of the PERSEIA creation, students reported they would have needed more time to prepare their own work, and also reported that reflection activities were good but were useless as they were not connected with the PERSEIA. In this line, **students' cognitive engagement got higher when they realized that all their research and the results of their improvisations would be part of the final PERSEIA.** Although facilitators presented the idea of the project and that all the activities would lead to the creation of a final PERSEIA, students apparently did not realize its implications before late in the project. It mostly occurred after the PW4. In this sense, students did not seem to understand totally the aim of the different activities before that. As teachers reported also, **they doubted students understood the process of learning regarding both kinds of activities (reflection activities and theatre).**

However, students' engagement into the own process of learning was quite reduced while out of the workshops, but was overall higher than in Vauréal. Indeed, **in relation to their perception regarding the process of learning for the realization of the PERSEIA**, more than 1/3 of the students (8) considered that "***The Perseia could have been done without homework***"; but a large proportion provided a neutral answer (37% of them). Students answers differed according to their group: **a higher proportion of students from Group 2 disagreed with the statement** than in Group 1.



When asked about the motivation of their research questions and their homework, students pointed out that **only few research questions were selected for the PERSEIA** and that at the end; only few of the research questions had been kept for the PERSEIA. In the same line, most **students reported that their research did not serve for anything.** They also reported that they could not explore and really share the results of their research done at home.

"Me*: could you share your homework during the workshops?*
Girl 1 (G 2)*: yes*
Girl 1 (G 1)*: no*
Girl 1: *yes we did, we made a large circle and we talked about it*
Girl 3 (Group 2): *Yes, but only once, and then, we never talk about it again*"

Furthermore, motivation to explore the research questions seemed to be more affected by some students' difficulties. For instance, one girl reported that when looking at information about aliens, she could not know what sources were reliable and strong enough. Similarly, although students **reported they did homework**,

teachers noted that they were not sure whether students got really involved in looking for information for their own research questions. They recognized they could not follow the process (via facebook). They reported that some did research but that it was really short, like "*two-three lines and that was all*".

In the same line, teachers **wondered how students' exploration of their research topic and the activities related to scientific issues had been integrated and connected to the process of the creation of the PERSEIA**. Moreover, they regretted that the **scientific dimension was approached only superficially and that it had been somehow taken out of the show**. They recognized it would have needed **more time to explore and to do research on students' question for better integrate them into the show.** In this sense, one teacher was suggesting to begin the workshops/ the project since the beginning of the schooling year, in order to have the opportunity to develop further research all along the schooling months.

> Teacher 1 *« (…) I guess it would have been worth to begin earlier in the schooling year, in order to have more time for the research of the topics that will be showed and to be able, in a second time, to focus mostly on the creation of the show, during which it is a time to write and for the students to integrate the topics. But I feel the time devoted to the research on scientific topic has not been long and deep enough, because rather they could have found things.(…) We were expecting them to realize a doctoral thesis, but at least that it was more concrete and not only a research on Wikipedia. »*

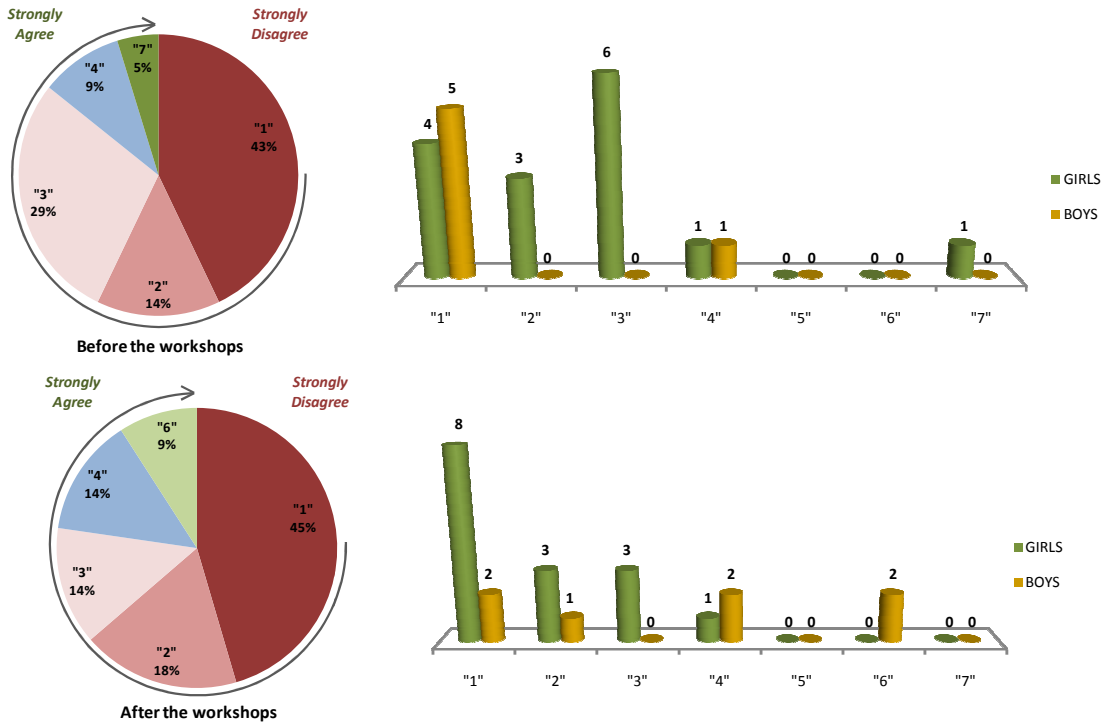
Finally, **teachers and students proposed some ideas to better involve students in their process of research and creation of the PERSEIA.** First, both teachers and students reported that it would be relevant **to better fit the topics of the research questions with schooling curriculum**, meaning the content of STEM classes. From both sides, they highlighted that it would highly enhance the motivation of students (but also teachers) to see the interest of their research, not only for the creation of a scene, but also in their own curriculum and learning process. A student specifically reported: "*to do PERFORM to use aspects we are learning in school. If we could go through the schooling curriculum through a funnier way, because in classes we are sit and we are doing this, doing that, we are reading the lessons; in contrast here (PERFORM), it was fun, but it was not... well it was science but it was not science like the schooling content.*"

Moreover, **when asked whether students would be motivated if we propose them research questions,** rather than offering them to invent one, one specifically mentioned the importance **of choosing a topic that is connected to adolescents' life and concerns**, she said:"*yes, it might be good, but it depends because if it is too complex, or if it does not concern students, I mean, adolescents, well... because to have a question really psychological or whatever, it might be less interesting than for instance the conflicts between districts. This, it was interesting because we felt concerned by this.*"

Finally, we approached the understanding of the nature of science, both through the perceptions of students, and through the capacity of the project and the activities designed to include ethical aspects of research and share science also as a process.

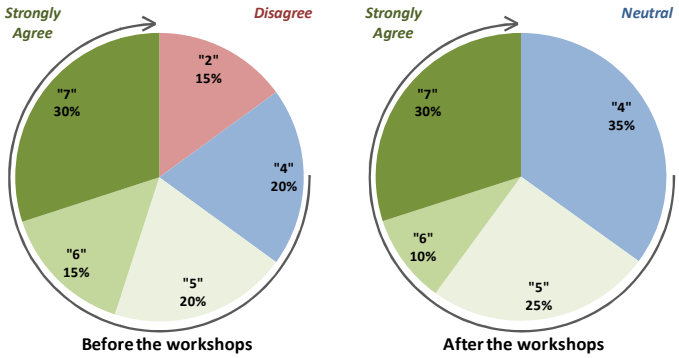
First of all, similar to Vauréal's students, in Marie Curie, they seemed **to already hold a perception on science production that does consider science as a process embedded in human qualities,** as more than 3/4 of them considered that good scientists can fail when doing science and 65% of them considered scientific knowledge as involving imagination and creativity.

Indeed, before the workshops, except 1 student who agreed and 2 who were neutral, all the students disagreed that ***"Good scientists do not fail while doing science",*** with a higher proportion of boys that strongly disagreed. However, although the variation between both surveys was not significant, after the workshops, a lower proportion of students disagreed with the statement, and a higher proportion of girls disagreed than boys.



"Good scientists do not fail while doing science"

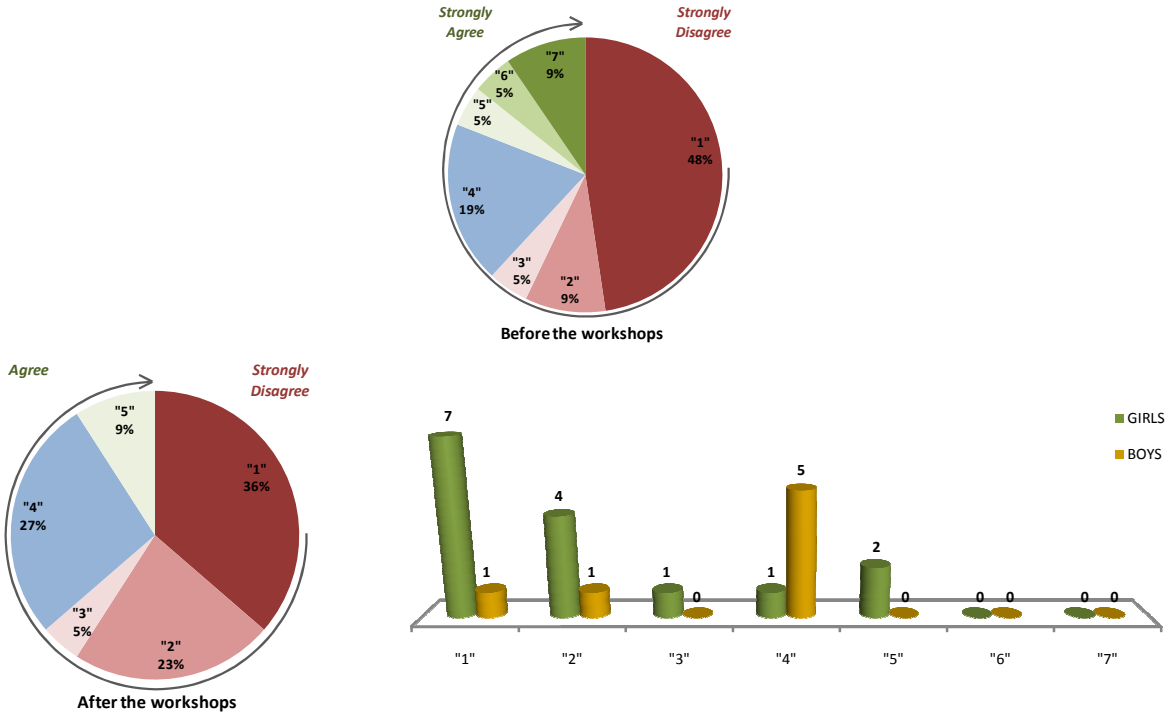
Moreover, before the workshops, 65% of the students agreed that **human imagination and creativity are needed for producing scientific knowledge, proportion that remained the same after the workshops,** except that there was not any student who disagreed with the statement, but rather more neutral answers.



The production of scientific knowledge involves human imagination and creativity

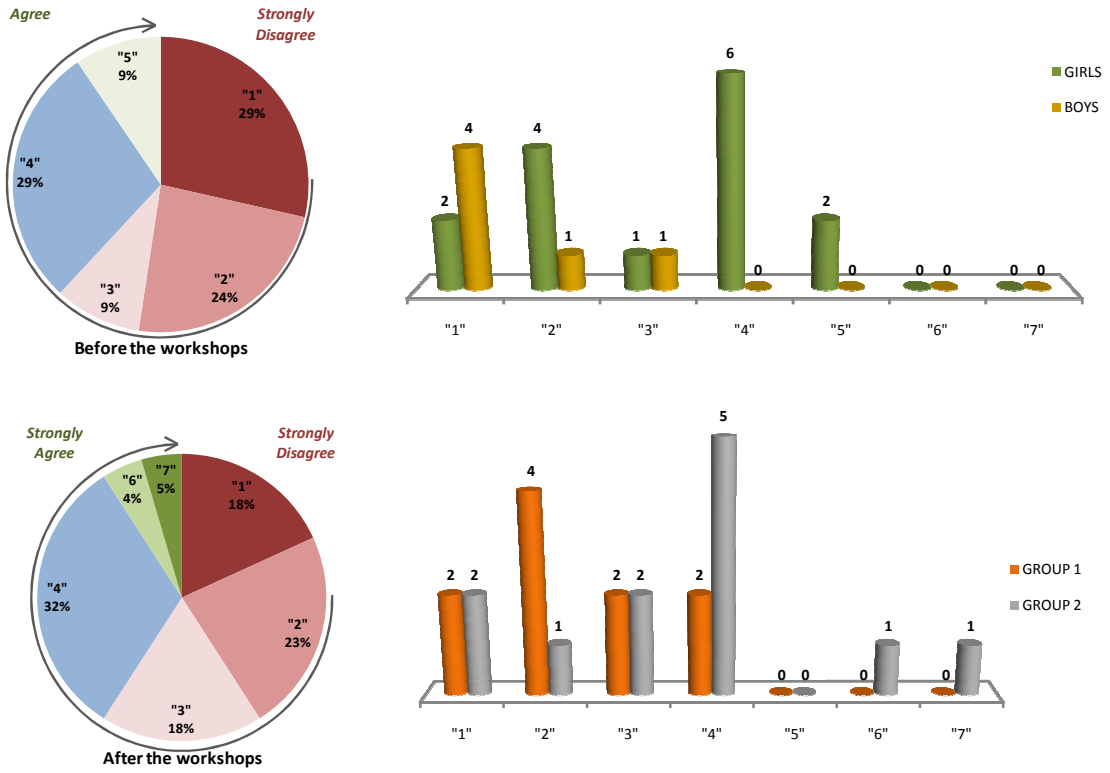
Although students did not significantly change their opinions towards the 'human component' of doing research, the different workshops **approached slightly the social and human dimension of science**. It occurred through the presence and participation of the ECR who were much more present than in Vauréal. It was especially the case in Group 1, as almost 2/3 of the students chose a question related to social issues, embedded in the ECR's discipline. Although more interaction occurred between students and the ECR, it was reduced and it could not really allow the ECR to develop more on their **personal experience during the workshops. However, one of the ECR reported that she** *"guess they could have a first view that we can be a young and dynamic woman and do research, and also that social sciences do exist"*(ECR Group 1).

When asked about the nature of scientific knowledge, 62% of the students **did not think that "*scientific knowledge is always certain*"**. Such **understanding remained the same after the workshops**, but girls tended to provide more strongly disagreement with the statement than boys.



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

Regarding the impacts of science in the society, in the pre-survey, 62% of the students reported they disagreed that "***science only has good impacts on people***", whereas 29% of the students gave a neutral answer. There was a significant difference between boys and girls, as only girls reported neutral or positive answers. Although students' answers did not change after the workshops, there was a significant difference between groups, as only **students from Group 2 provided positive answers.**



"Science only has good impacts on people"

Overall, **global approaches to embed contrasting perspectives when approaching science or a given scientific issue could not? be developed** during different workshops, probably **due to the lack of depth in the approach to scientific topics**. Indeed, **contrasting perspectives about science were provided mostly only during one specific workshop** (PW3). The whole activity was about developing critical thinking and thus highlighting contrasting perspectives. By allowing students to question what they were reading, they could share and think about the different issues related to science and business, the conflict of interest between research and market as well as the processes of knowledge creation within science. However, although facilitators tended students to always put into perspectives what they were sharing, no more time was devoted to developing a contrasting approach to science.

Similar to Vauréal, **no precise time was devoted with students to reflect about ethical behaviour in research practice.** However, some related discussions occurred when students were talking about their own research questions. For instance, related to the construction of the sketch about the conflicts between districts, some comments were done by students about the possibility or not to mention names of place, of people etc when performing the activities. However, no time was really devoted during the workshops to approach such aspect. Only few mentions referred to the importance of anonymity for the realization of the surveys students wanted to conduct among their peers.

Finally, the **contextualization of STEM topics within daily life and societal context has been developed through the reflection activities and the work on students' research questions.** For instance, facilitators presented to the students the aim of the activities of PW1 by asking students to list all the current societal challenges they might have in mind. Moreover, some occasions occurred for students to share about their research questions and work was made in both the whole group and subgroup in order to go deeper into students' process of research. For instance, during PW4, in Group 2, time in subgroups allowed students to think more globally on the context of their research question, thanks to the facilitators who were helping students to get a broader overview of different aspects and concepts related to their questions. Indeed, **an effort has been done in order to foster the social relevance of the topics approached, especially because most of the research questions raised by students (in Group 1) did not relate to STEM topics.** In this group, only one third of the students chose a topic related to STEM. In that sense, it somehow challenged the framework of the project, aiming to approach STEM topics. However, the approach adopted by facilitators allowed to develop a scientific framework, and could involve the ECR in the process of the research with students and thus on the creation of the PERSEIA. It was even more developed in Marie Curie than in Vauréal as students who were involved in research questions related to sociological issues could develop their own research. However, **facilitators kept these questions and tried to explore them with students and they could be presented during the PERSEIA.** Furthermore, facilitators looked for a way to include a research approach for these specific topics not directly related to STEM. At the end, such *demarche* was **highly recognized by students and teachers as a powerful tool that could allow students to "really" adopt a scientific approach**.