OPENING DOORS

Opportunities and education in networked innovation for new graduates with PhDs using open online resources

Science with and for Society in Horizon 2020

H2020-SwafS-2020-1

COURSE EVALUATION REPORT

Deliverable 3.2

This project has received funding from the European Union's Horizon 2020 Science with and for Society programme under grant agreement no. 101006514

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Document history

Version	Date	Author	Description
0.1	30/04/2022	Eleni Makri	Draft version
1.0	30/06/2022	Denise McGrath	Final Version

This project has received funding from the European Union's Horizon 2020 Science with and for Society programme under grant agreement no. 101006514

Document Information

Project Title	Opportunities and education in networked innovation for new graduates with PhDs using open online resources
Acronym	OPENING DOORS
Horizon 2020 Call	H2020-SwafS-2020-1
Grant Agreement no.	101006514
Work Package	WP 3
Deliverable	D3.2
Primary Author(s)	Eleni Makri, Denise McGrath
Work Package Lead	University College Dublin, Ireland
Delivery Type	Report
Dissemination Level	Public
Due Date	30th June 2022
Document Version	Final

This project has received funding from the European Union's Horizon 2020 Science with and for Society programme under grant agreement no. 101006514

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Executive Summary Outline

This document describes the “Opening Your Research to Collaborative Futures” course and how it has been evaluated through the perspective of the course participants. A qualitative evaluation of 30 participant interviews and 26 written reflections is described and integrated with a quantitative analysis on three questionnaires that were administered pre- and post-course. The questionnaires focused on open science perspectives and understanding, intercultural sensitivity and interpersonal and problem-solving skills. This mixed-methods analysis suggests that participants enjoyed a positive learning experience, while being challenged in new ways. The collaborative and supportive environment enabled them to take enduring actions and learnings that they have leveraged to work on innovative ideas in open science for PhD researchers.

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1. Introduction

A gap has been identified in current doctoral curricula: current offerings do not always foster big thinkers and creative problem-solvers - graduate attributes that our society needs (Bosch, 2018). It is recognised globally that the science and technology workforce is being inadequately prepared for careers in the coming century (National Research Council, 2017). These gaps relate to skills in data analysis and problem solving, and also teamwork, interdisciplinary communication and ability to collaborate with non-academic partners that span multiple cultures, geographic regions and time zones (Stokols, 2018). A report on career preparation highlighted that over half of university graduates felt that they were able to work effectively with those possessing different backgrounds, whereas only one fifth of managers thought this was the case (Hart Research Associates, 2015). This mismatch is suggestive of a lack of intercultural sensitivity, or even a clear understanding what that really means. It is becoming apparent that there is a growing need to re-imagine a PhD education that incentivises doctoral students to engage with other knowledge creators and consumers, not only within their discipline, but also across other disciplines and sectors, to have real societal and economic impact. At a professional and research level, international, interdisciplinary and intersectoral networks are on the increase with established researchers collaborating within and across disciplines to increase and improve innovation, creativity and knowledge (Chung, 2018; Jacob, 2015). However, it is questioned whether our PhD graduates today possess the necessary "interaction competence" to participate in collaboration networks of the future, where they need to move with agility between differing skill sets, sectors, epistemologies and cultures and helices.

The recent findings of the European University Association's in-depth study, "The role of universities in regional innovation systems" (2019) described in detail the features of nine open innovation networks in nine European countries based on over 130 interviews. They report seven profound changes, "perhaps even paradigm shifts" in the conception and organisation of innovation. These changes highlight very clearly that universities need to think differently about innovation as they look to the future. The linear traditional technology transfer model is now outdated, for example. But arguably more pressing than pathways to IP exploitation, universities need to think very differently about how they are educating their students to cope with the following "deeply transformational" changes in innovation that were evident across the nine European case studies:

1) from linear to nonlinear innovation;
2) from closed to open innovation;
3) from technological to systemic challenge-driven innovation;
4) from individual to collaborative and interdisciplinary innovation;
5) from spontaneous innovation to systemic innovation;
6) from exchange-based innovation to co-creation in innovation spaces;
7) from innovation projects to common innovation cultures.

"Innovation skills" is a broad term that covers the competencies needed to contribute effectively to common, open innovation cultures. The authors conclude that collaborative research, challenge-based learning projects and impact-oriented start-ups are the most important ingredients in the universities' role in regional innovation and the very fabric of innovation ecosystems.

Opening Doors created a 10-credit, online module for international PhD researchers that sought to enhance their skills in open science and open innovation. In line with the above study, the course--co-designed with stakeholders--included challenge-based learning where students worked in interdisciplinary groups to solve a "real-world" challenge contributed by external partners. This was

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done in a time-pressured way i.e. over a 3-week period to emulate typical timelines seen in industry settings. Participants led three meetings with their external partner and a facilitator was assigned to each group to help guide the process. Students also learned about and practiced communicating to non-academic audiences, learned about effective listening and nonviolent communication in conflict resolution; they engaged in skills self-assessments and career planning, and learned about open science and open innovation tools and practices. Course details can be seen on the course website: https://open-tdm.au.dk/blogs/openingdoors/. A qualitative and quantitative evaluation of their experiences and learning was undertaken and the findings are presented here.

2. Aims and Objectives

The aim of this deliverable is to present and discuss the mixed-methods evaluation of "Opening Your Research to Collaborative Futures" from the perspective of the course participants.

- A qualitative evaluation of students' experiences, perspectives and learning was undertaken through the analysis of entry and exit interviews, and the written reflections that were submitted by students at the end of the course
- A quantitative evaluation was undertaken using three questionnaires administered to course participants at the beginning and at the end of the course.

3. Qualitative Evaluation of "Opening Your Research to Collaborative Futures" Course

The qualitative evaluation involved thematic analysis of entry and exit interviews with course participants, along with an analysis of their written reflections that participants submitted at the end of the course.

3.1 Data Collection:

Between one month and one week before the beginning of the course, the group of 59 registered students were invited to take part in an entry interview. Interviews were undertaken over Zoom by the research scientist who was not involved in the delivery of the course. 17 participants gave informed consent to their interviews being recorded, transcribed and combined with other interviews for analysis. Participants were asked about their motivations for signing up to the course, what they expected from the course, what their current knowledge was with respect to open science and open innovation and finally, any thoughts/ideas they had for a 5-year career plan.

Similarly, course participants were invited to volunteer for post-course interviews, which took place between one and two months after the completion of the course. 13 participants gave informed consent for their data to be used in the research study. In these post-course interviews, participants were asked what they felt were the most impactful aspects of the programme, whether they had applied any learning from the course and what they would change about the module if it was run again in terms of content and delivery. They were also asked questions about their career plans and about how PhD supervisors can support students in their open science journey. The responses to these latter questions are reported elsewhere in deliverables 3.3 and 4.2 respectively.

Finally, all course participants, as part of their module assessment were asked to submit a written reflective piece with guidance as per Appendix 1. They were asked to reflect on their own experiences and learning on the course, and to include their career plans in the short and medium term. Though

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59 students registered to the course, only 29 students were interested in completing the assessment pieces to earn 10 credits. 26 students provided informed consent for their reflections to be used as part of the research study.

3.2 Data Analysis

The interview audio files were imported to otter.ai and transcribed automatically. The transcriptions were then manually corrected using the controls in the software. Finalised transcriptions and written reflections were analysed using thematic analysis according to Braun and Clarke (2006) i.e. first there was a familiarisation phase, then coding (by 2 researchers), then preliminary themes were drafted, discussed and finalised.

3.3 Findings

Interviewees spanned 1st to final year PhD stages and came from various disciplines and PhD research topics: food waste, eco villages, soil biology and agricultural sciences, psychology, publishing, plant genetics, children prescriptions, molecular medicine, sustainable agriculture, AI, online education, computational chemistry, Machine Learning, universal jurisdiction, transitional justice, peace building and reconciliation, business innovation and marketing, collective entrepreneurship. Their age ranged between 22-60 years old. 88% of interviewees were enrolled in Irish academic institutions and the rest registered at Danish universities, while the majority (70%) were of non-Irish origin, thus comprising a multicultural sample.

Three primary themes were identified in the data, and will be discussed below:

1) The multifaceted nature of the course managed to address the diverse motivations and learning needs of the course participants, though some topics received only-surface level attention; this broad learning experience required a considerable time commitment and intensive effort by the students that was deemed challenging but worth it
2) Experience and skills in collaboration are sought by PhD researchers as they are not always available through their research programme; they can thrive when given such opportunities that push them out of their “comfort zone”
3) Skills in open science and open innovation can be “transferred” in practical ways at an individual and collective level, given the right conditions

Figure 1: Themes describing the experiences and learning of course participants

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Theme 1:

The multifaceted nature of the course managed to address diverse motivations and learning needs of the course participants, though some topics received only-surface level attention; this broad learning experience required a considerable time commitment and intensive effort by the students that was deemed very challenging but ultimately, worth it

Work Packages 1 and 2 were based on stakeholder engagement that informed the design of the "Opening Doors" course. These stakeholders were drawn from open science/open innovation networks and included PhD graduates, PhD employers, current PhD students and doctoral education developers. The result was a course with broad learning objectives, listed below, that went beyond open science and open innovation tools and approaches, but that also encompassed advanced, intersectoral, interdisciplinary communication and collaborative skills. The challenge then was to synthesis these objectives into a theory-informed instructional design, with relevant content delivered in a way that would attract, engage and benefit students, keeping in mind the competing demands (with respect to time) of their research project and intuitional obligations.

The course learning objectives:

1. Build awareness of, and practice using open innovation frameworks and tools to facilitate co-creation and innovative thinking with stakeholders to increase the societal value of research.
2. Build awareness of, and practice using a selection of open science tools and approaches including ethical considerations such as research integrity and data management.
3. Design and implement collaborative projects with other researchers (from different sectors, disciplines and geographies), with other industry or community groups, understanding the importance of process as well as outcomes.
4. Communicate and open your research up to a variety of international stakeholders including researchers from other disciplines, community organisations, governments, businesses, and civil society.
5. Articulate and explain your knowledge, worldview, methodologies and research goals and be able to respectfully engage on these topics across sectoral and disciplinary boundaries.
6. Create a plan for professional development and the development of a professional network to support traditional and/or non-traditional career paths that align to your values, talents and interests.

Given this context, it is maybe not surprising that the course attracted a cohort of PhD researchers with varying motivations for enrolling in the course. These reasons may be broadly summarised as: 1) a desire to network and collaborate with people and organisations outside of their research discipline; 2) a desire to explore career opportunities outside of academia; 3) a desire to learn about and use open science and open innovation approaches e.g. sharing data and code. The majority of participants were unfamiliar with this area, with the exception of two interviewees who were already quite active in the "open" field prior to the course. Detailed responses to these questions can be found in Appendix 2.

The data suggests that overall, the course had a very positive impact on participants, with many sentiments such as *"it is one of the best decisions I have taken [to do the course]*", *"it was a wonderful experience", "it was very helpful", "rewarding", "informative", "an incredible privilege to be offered to work with a real company for a real problem".* When asked about what they found most impactful, students reported different experiences and learning moments, though it was clear that the challenge-based learning with external organisations had left a mark for many. This makes sense

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as course participants had spent so much time and energy on this activity in the first 3 weeks of the course. Other aspects mentioned included the "immersive experience", the "different learning approach with swift practical application", "plenty of content in the presentations", enjoyable group/peer discussion, Thesis-in-3 workshop. The following are some example of different learner experiences during the course (pronouns they/them are used to protect identity):

One course participant reflected on the challenge-based learning as being a very impactful activity. They felt at first that their group challenge was, *"in a sense, very, very strange. It has nothing (not a single thing) to do with [her] PhD project whatsoever"*. Early on, they felt that this group challenge *"may not go well"* and they had *"no affection for the challenge at all"*. But after a brief meeting with their group, they felt *"strangely motivated, concentrated, and even reassured".* Within their group, *"the communication was smooth, and the atmosphere was supportive and understanding"*. Explaining their ideas to others feels very strange indeed. And learning from others' perspectives "*was even stranger... but the simple act of sharing ideas within the group was gorgeous"*. In the pursuit of success for their group challenge, they felt that they had to *"temporarily let go of [their] academic expertise altogether".* They came to value the experience in the spirit of *"venturing into terra incognita…kind of feeling on the Moon sometimes. May be not the Moon, but Jupiter, or Saturn"*. They managed to open their mind so much that they felt they were *"sketching a vision, a future, a possible empire"* for the organisation, forgetting about *"applicability"* and *"pragmatism"*, until reminded by their teammates.

One participant indicated that the Thesis-in-3 activity had previously been advertised in their own academic institution, but they did not engage due to their tendency to avoid public engagement/speaking. However, they really enjoyed this exercise in the course, and perceived it as helpful for them to focus on the basic information about their own PhD research, engage with a random audience and prepare corresponding slides - all in approximately 20 minutes. They thought that this course activity was not only helpful to streamline and communicate the important aspects of their PhD research project, but to also to practice communicating the emotional side of thei research so that it becomes more engaging for a non-specialist audience.

Another participant felt that the *"open science task was the most confusing and perplexing for me, probably because I am at the early stages of my research. However, at the end, I gained a general understanding of the importance of this concept and possibilities for my research. Prior to this course, I had a very limited knowledge about open science, but now I am learning to understand it better and how to engage in some steps, such as engaging public through my research, data management and study preregistration in the later stages of my research*".

Another participant explained in their reflection that they focused more on the team dynamic of executing the challenge and that this aligned with the areas for growth that were highlighted in the self-assessments at the beginning of the course. So even though they did not take the opportunity to learn more about open science, they feel that it is something that they can revisit in the future when they are at a more appropriate place in their research journey.

These examples highlight how course participants were challenged and benefited in different ways through the diverse course activities. Such a multifaceted learning experience required an intense effort from the course participants and facilitators, alike. Although many students said that they would not change anything about the course as they found it to be such a positive experience, multiple comments of a similar nature were offered by participants, with respect to not enough time spent on different activities, and the fact that there were long periods online in front of a computer:

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"Perhaps if some of the talks could be pre-recorded for participants to view in their own time and then have a live virtual 'discussion' at a set time exploring the topic, rather than having both the talks and the discussions in the live sessions, it could be more accommodating to those with hectic schedules"

"Extend the intense schedule to a [full] week to be more flexible and allow more time on smaller exercises and challenges"

"More space for discussion between the diverse audience, as this was enjoyable"

"Allow more time (5'-10') on participant demonstrations"

"Add social events in the online collaboration"

"Divide less career development and PhD-related reflection and more focus on open science and open innovation aspects (e.g. open science movement, parts of open science to open, parts of open science not to open, sharable notebooks, platforms for developing and sharing reproducible methods, open access, etc.)"

Additionally, it was suggested that more diversity in people taking the course and delivering the course would be an asset, particularly from less privileged areas i.e. beyond Europe.

Theme 2:

Experience and skills in collaboration are sought by PhD researchers as they are not always available through their research programme; they can thrive when given such opportunities that push them out of their "comfort zone"

The most prevalent theme in the qualitative data was collaboration, particularly interdisciplinary collaboration. PhD researchers saw collaboration as an important aspect of their PhD journey, and it was a key motivator to signing up to the course:

"I want to develop my skills in teamwork as I am a single player".

"The biggest expectation coming into this course was to meet others and to most likely be one of the few, if not the only [their discipline] student involved. My hope going into this course was not simply to meet others, but to learn more about what research others are doing, learn how I can work with them and speak to others in a productive manner. Oftentimes [their discipline] students can be quite narrow minded and don't engage in interdisciplinary work or courses such as this, which is a shame. It is one of the main reasons [their discipline] is often left out of important conversations such as climate change".

Through the challenge-based learning, the students got first-hand experience of what it is like to work with people who held different perspectives from their own, and all students wrote in their reflections how they navigated this – some more easily than others. They were encouraged to contest viewpoints/ideas in a respectful, constructive way – through listening, questioning, negotiating and accepting:

"Several weeks after participating in the course, I am glad I did… it was valuable [because] it was built on collaboration and knowledge sharing. The sessions were divided into mini-sessions for participants from multiple fields within the pure sciences to social sciences throughout the weeks. We had to share critical ideas, deliberate and, in some instances, challenge what was shared by facilitators. I found this incredibly practical as it allowed for perspectives from both worlds to be heard".

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Practical knowledge sharing was also highlighted by others as being a key benefit of the course:

> *"During the course, many useful and free resources were recommended by either organisers, speakers, or other participants. Within the group I worked with on the group challenge, we also exchanged many tips on various resources. It was definitely one of my favourite perks of this course".*

> *"My team used effective tools for collecting data and creating the report. Some of the tools were new for me and it was a good learning experience for me. I learned to become better at them so that I could work with my current team and future teams better".*

One students account typifies the experience for many: initial fearfulness that gave way to enthusiasm and a sense of "we can do this", underpinned by an understanding of interpersonal relationships:

> *"As regards the Collaborative Group Challenge, initially going into the group made me stressed. I suddenly realized how much work was ahead of me and how little time I really had. There was also the fear of not having written a report that wasn't explicitly academic in nature. It can be very difficult to move from the rigid academic structure that is drummed into you at university. I knew that I would be able to adjust my thinking but you never know how others will deal with similar challenges. Especially people you have just met".*

> They quickly realised that they were in the right group. Their group was made up of *"like-minded individuals who were willing to give this a go one way or another. We were not sure what was expected, but we were going to show up with something. From the get go, we showed each other respect. No point was ever considered irrelevant or wrong. Since we weren't sure what was expected, we couldn't say that something was wrong. So we kept everything in and said that we would find a way to link everything together at the end".*

> *"I found that we really treated each other with respect which can oftentimes be lacking in group work. We got to know each other before we started working… getting to know each other first made it a much more comfortable working experience. It meant that when anyone needed to step away or if something came up and we were not able to do a specific task by the time had set, we were comfortable telling each other. This worked well for us as a group as we had many other work and family commitments".*

Participants also described the impact of this collaborative environment on their future research plans:

> *"…it was helpful to have a course targeting early career researchers, especially one that was cross-cutting and brought students together from different universities and research focus. The collaborative group project provided much more research outcomes than anticipated. It exposed me to conducting research in other fields where I would not venture before the programme. It gave me an opportunity to consider new future research outlooks for the coming years. I am situated confidently to view these research plans in the future".*

Theme 3

Skills in open science and open innovation can be "transferred" in practical ways at an individual and collective level, given the right conditions

Much has been written about "transferrable skills" but it is not always clear what exactly is transferred, and to what end. In our data, there were many examples of how the learning in open science and open innovation was enabled through the instructional design, and how this was then

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transferred to other situations. Many students were able to envisage how to apply the learning to their own research activities:

> *"On looking at the pre-course [self-assessment] questionnaire, I think it is evident that I hadn't thought about the "as open as possible, as closed as necessary" motto that accompanies the responsible use of open science. I saw this concept as much more black and white, as in everything would have to be either open or closed. However, after doing the course, I realise that you can be a little bit more selective with what you are open with. I think that this is particularly relevant in healthcare research as you are dealing with highly private, sensitive and identifiable information, and GDPR is of the utmost importance. This is something very relevant to my research as I want to make a concerted effort to make my research more open, but also understand the importance of participant anonymity in my field".*

> *"I loved working with people and will be much more open to collaborative opportunities in the future, this is a strength I need to embrace. This challenge helped me to realise this strength and I look forward to reapplying these skills again. (module coordinator's) feedback on our work as we progressed was excellent, clear, and constructive. [Her] approach is something that I will bring with me in terms of questioning and reviewing my work going forward- such as [creating narratives] in presentations and structuring reports".*

Many students demonstrated an ability to integrate their learning at a deep level:

> *"The…collaborative project consisted of brainstorming and formulating a plan that [the organization] may use. Originally when I heard about this task, I was confused as to how it related to open science. After some consideration and learning more about open science, I realised that without the free and open data that the group accessed online, the project would have been much more difficult and lacked authenticity. Additionally, it allowed us to exercise open innovation frameworks. The project also allowed us to assimilate new knowledge about day-to-day life in different European countries".*

Within two months of completing the course, participants had applied their learning in various ways e.g.:

- Prepared Thesis-in-3 slides for future communication
- Undertook engaged research involving external stakeholders
- Worked with diverse groups in a more open way
- Sought feedback on PhD research project from non-experts
- Applied the win-win negotiation in conflict resolution
- Revised PhD research methodology to be more open
- Motivated co-workers to deposit data on certain platforms
- Held a brown bag lunch with peers about creating data management plans

These examples highlight how course participants were empowered to reach out to others to share and leverage further learning in open science and open innovation.

Additionally, as part of an assessment task – a task that was originally supposed to be undertaken as individual – a small group of course participants self-organised into a group to design an online course in open science for PhD researchers; a course that PhD researchers could do in their own time, focused on the more practical approaches and tools used in open science. As it turns out, this project has grown and the students have undertaken an enormous amount of work to bring it to fruition. The project is called "Agape". They have engaged many more PhD students in this effort and

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now want to grow the community to get more contributors. The impetus for this work came from the fact that the original collaborative challenge they undertook at the beginning of the course went so well for some students, that they wanted to continue their collaboration and create more outputs together. The assessments were designed specifically to be flexible and to be negotiated with each student, so that they could undertake an authentic piece of work that was meaningful/useful to them. Thus, the students were empowered to approach the module coordinator and propose their group idea (Agape) as the assessment. They were subsequently provided with a forum to disseminate their work on this project (the Opening Doors/Chameleons conference "Innovations in Doctoral Education"), where they were introduced to people from Ireland's National Science Funder who are interested in Open Science policy. They were provided with audio-visual tools to disseminate their work. They have been mentored in applying for funding to support this work and they are currently being mentored to write and publish an open access article on the course design process, as another means of dissemination.

A key objective of Opening Doors was to create an "open", collaborative, egalitarian and supportive environment for participants on this course which was so important in creating the space for ideas like Agape to emerge and come to life. Such psychological safety is critical to innovation. Genuine sharing of experiences and copious examples by the teaching team gave the participants a sense of possibility and created authenticity in communication. The facilitators' transparency around what they knew and did not know created a sense of "we are all in this together"--that anyone's idea is as valuable as the next person's. Responsive communication and shared, rapid problem solving was a key factor in progressing ideas/projects and creating a collective, innovative mindset where participants could quickly capitalise on and adapt to potentials. Some comments from participants in this regard are as follows:

> *"Our facilitators always helped, telling us what is missing, what we should focus on, it was brilliant. They were very supportive, helped us with everything we wanted to, and gave us very useful perspective on things and shared their experience. So for us, we can read about a lot of concepts, but to hear it from someone who experienced it, it always counts".*
>
> *"[Facilitator] was our mentor in the challenge, with [module coordinator] guiding most of the overall experience. All were very helpful, a pleasure to work with and to learn from. What made us really effective, was their interdisciplinary approach with transdisciplinary skills and background; the range of skills meant that they could not only recognise what we were working on, but also to contribute and to see it from our perspective".*
>
> *"[Members of the teaching team] all were amazing on the feedback, [module coordinator] managed the course and back up team [Danish team] was telling each and every one [about technical things]. My mentor, in spite of being in such a hectic schedule managed to get the time for ourselves. That was really commendable.*
>
> *"[Module coordinator] was available 5-10 minutes after writing to her. The team and mentoring were great".*
>
> *"[Module Coordinator] shared a paper with us at the right time; absolutely on point, all about coaching, highly relevant for team development, it was so valuable to work with it"*
>
> *"I enjoyed the discussion with [module coordinator] and guest speakers, it was very useful. [Module coordinator] offered very good suggestions on how to develop in academia and industry in time ahead. I feel we are taken care of".*

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"The most impactful aspect of the course was the (module coordinator's and facilitator's) insights of their experiences and how they asked questions".

"The mentorship was great: really good, swift responses. Clear expectations. The welcoming nature of discussions"

"Facilitators were very comfortable in their areas and really well informed"

"The external partner from the challenge activity was loose with their learning objectives which offered us the freedom to have agency in the preferred direction"

Thus, in teaching transferrable skills for PhD researchers, course developers must think about how to create an environment that enables creativity and flexibility in how skills are learned, what baseline knowledge and personal attributes are needed/cultivated and then how and where the learning might be transferred, so that this can be designed from the outset. Managing a multicultural, complex system made up of: diverse learning needs and disciplinary backgrounds, external stakeholders with their expected outcomes, diverse topics and learning activities, a compound teaching team (7 contributors), invited guest speakers, individually negotiated assessment tasks, administration of 10 credits and technological challenges that are associated with an online, international classroom, plus an aligned research programme--was a challenge. But this system successfully facilitated open, collective cognition and thus, innovation. In accordance with complexity science, creating a strongly bounded, virtual learning space (i.e. a curriculum, a clear schedule with clear goals, sound logistics and technology, clear communication, concrete spaces to work) with favorable initial conditions (e.g. psychological safety, agency/choice, excellent PhD researchers), enabled the emergence new activities e.g. podcasting, the participants' current project "Agape", the Open Science course for PhD students. This "bifurcation" has taken our efforts in an unexpected but important direction that was not foreseen at the beginning of the project. It is also clear that the type of PhD researchers who signs up to courses like this are already of an open and innovative mindset, and simply need a forum for them to flourish.

4. Quantitative evaluation of "Opening Your Research to Collaborative Futures" Course

4.1 Data Collection & Analysis

The Open Science Self-assessment questionnaire from the "Orion" H2020 project on Open Science was used at the beginning and at the end of the course, both as a reflective tool for the students and as an assessment of changes in perceptions/understanding about Open Science following the course. Given that intercultural sensitivity and problem-solving are two important skills/attributes that have been highlighted in the literature (e.g. Stokols, 2018) and given that these were also incorporated into the course learning outcomes that were derived through stakeholder engagement, standardised questionnaires were used pre- and post-course to investigate any changes in these dimensions: Intercultural Sensitivity by Chen and Starosta (2000), and Interpersonal and Problem-solving Skills from Civic Attitudes and Skills Questionnaire (CASQ) by Moely et al. (2002). Course participants were also invited to reflect on these questions/answers in their final reflection. The questionnaires were administered during class time via a Qualtrics link distributed on the class forum. It was explained very clearly to students that contributing their data to the research project was completely voluntary and that it did not affect academic standing in any way. 18 course participants provided their consent to

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use their data as part of the research. However not all 18 did both the pre- and post- questionnaires, thus a dependent t-test was not possible to perform on the data. Descriptive statistics are presented without using inferential statistics to test hypotheses.

4.2 Findings

4.2.1 Open Science Self-Assessment Questionnaire

A detailed presentation of results for each question is available in Appendix 3. Overall, there were some notable changes observed in the pre- and post- data. Only changes greater than 15% in either direction are reported in Table 1 (i.e. representing a change in ~3+ respondents).

Table 1: Summary of medium to large changes in the pre-post Open Science Self-assessment Questionnaire

Orion Question	*Pre-Course (% of respondents who agreed)*	*Post-Course (% of respondents who agreed)*
In your opinion why should science be open? Rigour: open access, open data and/or open replicability make science easier to review.	60	75
In your opinion why should science NOT be open?		
Risk to fundamental research: Open Science would only benefit applied science and be detrimental to fundamental research.	6.7	37.5
Danger and potential misuse: Open Science may interfere with research integrity (ex: release of medical personal data). It could also facilitate misuse of research results (e.g. biological weapons).	46.7	75
Unfairness: If a research group generates knowledge with own resources, it could be unfair if others use this knowledge to get economic benefits for themselves	13.3	37.5
Imagine in your everyday work at your institution you decide to embrace (or you already have embraced) an Open Science perspective. What do you think (or know) are the most important barriers you will be facing?		
Lack of clear steps to follow: How do I begin? How do I proceed?	60	25
Budget and funding constraints: How do I find the funding to ensure open data and open publications?	60	25
Time constraint: I don´t have time to practice Open Science, it is too time-consuming.	40	0

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Fears and uncertainties for career development: Will my Open Science practice be valued at institutional level or during my career? Does it mean I will receive more funding or merit?	53	25
Do you already participate in any Open Science activity/action?		
Ethical aspects of science and research integrity: participation in ethics committees, bioethical research, training, awareness activities, etc.	60	25
Collaborating and networking: How to improve collaboration through Open Science	26.7	87.5
Communicating science to the general public: Different audiences, practical guides to getting started, online and offline options	13.3	62.5
Involving the general public in research: Citizen science data gathering, data analysis, use of results	6.7	50
Assessment of the impact of initiatives in public	13.3	37.5
Do you receive support or incentives from your institution related to Open Science?		
Technical infrastructure Templates, software, storage, databases, publication and/or data repositories, etc.	40	70
Financial support and rewards	20	50
Careers perspectives and recognition	26.7	62.5

These data suggest that course participants perceived fewer barriers to practicing open science and felt more supported by institutions to practice open science following the "Opening Your Research to Collaborative Futures" course. There is a greater appreciation of the fact that open science can enhance research rigour. Under the question: "*In your opinion why should science NOT be open?",* it appears that participants became more risk aware with respect to sharing data universally. This may be due to a) receiving a guest lecture on intellectual property and what is needed to protect it, and b) learning about the safeguards that need to be implemented before sharing data freely (e.g. with respect to GDPR considerations). Discernment in these areas is a positive thing, and knowing how to operationalise the phrase, "as open as possible and as closed as necessary" would be an excellent level of skill to attain in this space. While we cannot say for certain that students achieved this level of skill, the responses to these questions suggest a level of discernment that was not present before. Interestingly, there was a reduction in the percentage of respondents reporting involvement in the

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"ethical aspects of science and research integrity i.e. participation in ethics committees, bioethical research, training, awareness activities, etc". There is no obvious course-related reason for this apparent change/anomaly, other than perhaps respondents subjectively reframed ethical aspects of science and research in a different way, though this is not corroborated in the qualitative data in any way.

4.2.2 Intercultural Sensitivity

Intercultural sensitivity was measured with 24 items with a Likert scale (1= strongly disagree, 5= strongly agree). The answers where then attributed values on a scale where a value of '1' was attributed to an attitude for low intercultural sensitivity, while a value of '5' was attributed an attitude for high intercultural sensitivity. An overall mean score was calculated with all 24 items where values '1' and '5' have similar meaning. Results are presented in the Table 9 below.

Table 2. Intercultural Sensitivity

	Mean scores	
Intercultural sensitivity items (1= low sensitivty, 5=high sensitivity)	Pre	Post
1. I enjoy interacting with people from different cultures.	4,56	4,17
2. I think that people from other cultures are narrow-minded.	3,89	4,17
3. I am pretty sure of myself in interacting with people from different cultures.	4,11	4,33
4. I find it very hard to talk in front of people with different cultures.	3,39	4,00
5. I always know what to say when interacting with people with different cultures.	2,94	3,00
6. I can be as sociable as I want to be when interacting with people from different cultures.	3,83	4,17
7. I don't like to be with people from different cultures.	4,39	4,67
8. I respect the values of people with different cultures.	4,56	4,50
9. I get upset easily when interacting with different cultures.	4,39	4,67
10. I feel confident when interacting with people from different cultures.	3,89	4,33
11. I tend to wait before forming an impression of culturally-distinct counterparts.	3,56	3,50
12. I often get discouraged when I am with people from different cultures.	4,22	3,67
13. I am open-minded to people from different cultures.	4,78	4,67
14. I am very observant when interacting with people from different cultures.	3,67	4,50
15. I often feel useless when interacting with people from different cultures.	4,22	4,17
16. I respect the ways people from different cultures behave.	4,17	4,17
17. I try to obtain as much information as I can when interacting with people from different cultures.	4,44	4,17
18. I would not accept the opinions of different people from different cultures.	4,61	4,67
19. I am sensitive to my culturally-distinct counterpart's subtle meanings during our interaction.	3,17	3,33
20. I think that my culture is better than other cultures.	4,22	4,33
21. I often give positive responses to my culturally different counterpart during our interaction.	3,61	4,17
22. I avoid those situations where I will have to deal with culturally distinct-persons.	4,50	4,33
23. I often show my culturally-distinct counterpart my understanding through verbal through verbal or non verbal cues.	3,89	3,33
24. I have a feeling of enjoyment towards differences between my culturally-distinct counterpart and me.	4,17	4,33
Intercultural sensitivity - overall scale	4,05	4,14

Overall, it seems that the effect of the course on inter-cultural sensitivity was minimal as measured by this instrument. There may be a slightly greater orientation towards intercultural sensitivity attributes in some questions, post-course, but nothing definitive.

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4.2.3 Interpersonal and problem-solving skills

Interpersonal and problem-solving skills was measured with 12 items of a Likert scale (1= strongly disagree, 5= strongly agree), with the mean scores calculated for each answer. A value close to '1' implies an attitude for low skills, while a value close to '5' implies an attitude for high skills. An overall mean score was calculated with all 12 items where values '1' and '5' have similar meaning. Results are presented in the Table 10 below.

Table 3. Interpersonal and Problem-solving Skills

	Mean scores	
Interpersonal and problem solving skills items (1= low skills , 5= high skills level)	Pre	Post
I can listen to other people's opinions.	4.67	4.57
I can work cooperatively with a group of people.	4.33	4.71
I can think logically in solving problems.	4.47	4.71
I can communicate well with others.	3.93	4.29
I can successfully resolve conflicts with others.	3.33	3.71
I can easily get along with people.	4.13	4.57
I try to find effective ways of solving problems.	4.40	4.29
When trying to understand the position of others, I try to place myself in their position.	4.27	3.86
I find it easy to make friends.	3.47	3.29
I can think analytically in solving problems.	4.27	4.14
I try to place myself in the place of others in trying to assess their current situation.	4.20	4.00
I tend to solve problems by talking them out.	3.87	4.14
Interpersonal and problem solving skills overall scale	4.11	4.19

Like the previous questionnaire, there is not a large effect of the course on interpersonal and problem-solving skills as measured by this instrument. Tentatively, there may be some improvements with respect to communication and working cooperatively. What is interesting is the relatively low value for the question: "I find it easy to make friends" both pre and post course. This suggests that more could be done to provide PhD researchers with social opportunities to build relationships within their departments.

5. Conclusion

Integrating both the qualitative and quantitative data, we submit that the "Opening Your Research to Collaborative Futures" course engendered a strong learning effect for course participants that spanned a broad spectrum of knowledge, skills and attributes that had been targeted in the course design. Participants brought diverse learning needs and interests and these were met in different ways, both through the diversity of topics included in the course, along with the instructional design. The challenge-based learning activity--which involved solving a "real-world" problem contributed by an external organization over a period of three weeks--was the task that exercised the majority participants the most. This is not surprising given the complexity of this task, but it gave rise to deep learning and confidence through the collective effort. Open science and open innovation knowledge and attitudes seemed to evolve throughout the programme, with many students taking concrete actions and already having impact in their own communities with respect to data management and sharing and engaging with nonacademic audiences. Time was a constraint felt acutely by participants at times, where they were pressurized to deliver agreed outputs, while also wishing for more time to be spent on a variety of topics, that could be enabled through a somewhat extended course.

The PhD researchers who signed up to this course were already of an open, innovative mindset, ready to experiment with their skills and with each other to create solutions in a very dynamic way. Many PhD researchers possess these attributes and we need to create environments where they can flourish in these ways. The course participants who have embarked on the "Agape" project will

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continue to be supported in birthing their project along with a new community of practice in Open Science.

A student pointed out in their reflection that they received a copy of their answers to the questionnaires (via Qualtrics), but it was hard to know what exactly they were meant to do with these results apart from "reflect" on them. They scored quite positively in all the different elements but unfortunately it was unclear to them what this actually meant. When they did the assessment the second time, the scores were pretty similar, so if they were to base their experience off these assessments, they would think that they had learnt nothing over the few weeks – which they knew to be untrue. This insightful reflection highlights the limitations of using one-dimensional standardised instruments to detect learning in complex situations. We suggest that future work should examine this issue in greater depth so that the learning of transferrable skills in PhD education in open science and open innovation can be investigated in a systematic, fit-for-purpose, practical way.

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Appendix 1: Brief for the Reflective Writing Assignment

You are asked to keep a reflective learning journal throughout this course, which will involve writing at least 2 entries per week about your experiences with the course. Reflective practice and reflective writing invite you to think deeply about a particular activity that you are doing or have done. It ensures that the insights you gather through reflection can be integrated into your current knowledge so that the learning can influence your future ideas, actions and interactions. It is a very important skill for deep learning, for high performance and for leadership.

In order to pass this course, you are asked to submit your personal reflection by week 5, leaving you two weeks after the course delivery is completed to finish writing your reflective piece. There is no prescribed length for this task. You can use relatively informal language, but you must be sure that it is *your authentic, honest voice*. You are advised to have either a digital or physical notebook always with you during the next 3 weeks as you engage with this course, so that you can jot down notes/impressions/ideas quickly that can later form the basis of your reflection. You are also invited to share some of your reflections on the course's blog post, as a way to share your learning with the international early career researcher community.

You are asked to begin your reflective writing task on day 1 of the course, and to continue throughout. Questions that may guide your reflections are as follows (you may not address all of these questions and you may address others that you come up with yourself – this is just guidance):

Beginning the course:

- Why did I choose to do this course?
- What do I expect to gain from it?
- Having undertaken the self-assessments on day 1, what are my main areas for growth? Why is it important to me to grow my knowledge/skills/attitudes in these areas?
- What challenges do I foresee? How might I deal with these challenges?

The Collaborative Group Challenge:

- What are my feelings in relation to this group challenge?
- What do I think might happen with this challenge?
- What are my thoughts/feelings during and after working with my group? Are things working out as I expected?
- What was it like explaining my research to others (Thesis in 3)? What did I learn from others' perspectives of the challenge? What was it like to share my ideas with others?
- How am I dealing with the challenges of working with an interdisciplinary group, on a challenge that is outside of my expertise? Is there anything I should do, say or think

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to make the experience successful? How can I be best prepared for the tasks at hand? What research skills/soft skills/ project management skills am I using?
- What do/did I particularly value about this experience, and why?
- What am I doing particularly well?
- What insights come to me immediately after, and/ or later when I have more emotional distance from the situation?
- Is there anything I would do differently before or during a similar situation?
- What am I learning / what have I learnt about collaboration?
- What am I learning / what have I learnt about non-academic projects/challenges?
- What did I learn from other groups on the course?

Career Planning:

- What was this experience like for me?
- What was difficult/enjoyable/valuable about it? What did I not enjoy?
- What emotions did I feel - when/why?
- How will I take this process forward? What are my next steps? Is it of value to me to take this process forward?
- What did I learn about myself and my career options through this process?

Ending the course:

- How did it go, working on my areas for growth as identified at the beginning of the course? Did I choose the right areas of growth to work on, did new one emerge as the course progressed?
- Is there anything in particular that came up during this course that I want to continue to work on beyond this course, in terms of specific knowledge, skills or attitudes? Do you feel capable to pursue this learning independently?
- How were my knowledge/skills/attitudes in open science/open innovation changed as a result of participating in this course?
- What was the most impactful aspect of the course?
- What did I value about this experience, and why?
- What was least useful for me?
- Did I learn anything new about myself?
- Was this course what I expected? Did I get what I wanted to get out of it?

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Appendix 2: Summary of Entry Interviews Motivations, Expectations and Current Knowledge

Table 1. Outline of 17 entry course interviewee's motivations, learning expectations, awareness about Open Science and (or) Open Innovation and reflection about their 5-year professional (or career development) profile

Motives for Signing Up to the course	Learning Expectations	Awareness about Open Innovation in Science	Career Development or Professional Profile in the 5-year time	Additional Comments
Involvement in collaborative projects within PhD training	Think outside the box on how to collaborate	Not familiar	Be in a research institute	Like the way the course is structured, it is fantastic, a win win learning curve
Get insight and learn from people of different disciplines and country origin	Tackle serious and complex issues	Would say different people from different fields come to work together to solve problems	Develop myself to find innovative ways to solve problems	Interact with peers in a "physical" space when in course
Prior knowledge of entrepreneurship, innovation, ideation, commercialization, creativity	Whether internship, data management plan or participatory research would be better learning	Love the word open, open source	Get my PhD, close to retirement but hope to be able to sustain a working livelihood	Interesting to see how people practice open science and if and how they become motivated towards shared objectives
Develop a career development path in a non traditional area	Interested in learning about open innovation, open science tools, as further career development	Use open source tools for other people become engaged with your research	Quite open to find other opportunities	
Ability to articulate my worldview	How to plan open research	Open science is about making your data available to various stakeholders	Still seeing myself in doing research in some form	

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Learning new skills	What to expect while interacting with people from business or community groups	Open innovation is a concept new to me	Whether academic or not, I am not sure	
Learn more about open research	Explore non traditional postdocs or clinical works	Open source software like Linux	Be part of research in a industry or company, less interested in academic field	
Learn about open source software	Networking following COVID 19 employment changes	Not an expert in these issues, but can mean to open up companies and merge them with open innovation communities, industry experts and all these working with university professors	Develop behavioural-based solutions	
Networking with other students, national and international	Connection between research and practical application	Limit the distance between research and development to industry, research at the university difficult to communicate	Seek professional job in publishing industry, but also to go back to teaching as well	
Learn more about stakeholder engagement	Open source tools	Creative space open to anyone, industry partners and academics	I get easily distracted, so I enjoy new projects	
Natural to look for a course in open science and innovation since already working in industry	Deal with other research professionals from different places and improve my communication	Sharing of information between different institutions and disciplines with regards to innovation	When I lost my job due to COVID 19 labour force effects, I went back to academia where I am excited and want to stay. If there's an offer from industry for a one year or two projects I will go and then return to academia and teaching because I love teaching. If there's a	

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			possibility to combine academia and industry, however, I will think about it	
Looked interesting to develop my skills	Think more about my career development	It's about proper science	Finish my PhD and get into lectureship position	
Using tools to publish data from different resources	Learn more about open innovation	Like the ideas of open science	Definitely stay in a research capacity	
Get feedback from industry	Stay connected to industry	Open innovation is a nice framework for research and development, where the separation of industry and academia makes it easier to collaborate	Bridge research in my university I currently do in my PhD and that of an associated research centre	
Quite new to the research community	Enjoy teamwork	I use so much open source software and open science has so much potential	Stay in academia, be on my second postdoc, have a nice project to be passionate about	
Communicate better my results across people from different countries	Develop my skills in research	Science communication	Get on with my PhD research topic, focus on implementing PhD research in practice, combination of research in academia or research in industry	
Interest in interdisciplinary research	I like acquiring knowledge from different backgrounds and maybe I can get suggestions from others to research questions I have in my PhD	Open innovation: what solutions are there, what methodologies are there to fix or provide insight into a potential problem	Not very clear now, 5 years is a very long time. To have a PhD title, then go to academic field, learn as much as possible about my topic, still be a researcher, trying to solve questions in my research, be	

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			at a tech company, follow my research interest	
Thinking about my career development after PhD	Like to see what problems industry is interested in solving	Open innovation: access researchers through small companies and start-ups	Ideally get into industry	
Huge fan of open source software	Learn more about open science	Open science is part of open innovation, legislation is part of open innovation in a way	Travel to Europe to pursue my research interests	
Great to work with transferable aspects of disciplines outside my research	Experiences and challenges met in different fields, from academia to industry and other participants	Free software	Be in academia, go after community health research and developing corresponding courses	
Develop my skills in teamwork, IRR, teamwork as I am a single player	Practical knowledge and bigger network	Open innovation: taking open science and putting it into an industrial setting (e.g. Fedora)		
Interested in cooperation in research	Focus on my area of research	Open source accessible to the immediate public		
Needed the 10 ECTS points offered	Better understanding of open science and innovation concepts, successes and opportunities	Would like to learn more about open innovation, as I don't know much about it		
Interested in open science and publishing in open access repositories		Just becoming more aware of it in the past year or two		
Like the idea of innovation in general and wish to transfer from academia to industry after my PhD		Get the experience from inside		
The course reaches a global international reach, industry, academia and different experts in different fields				

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My PhD supervisor motivated us to participate				

Appendix 3: Responses to the "Orion" Open Science Self-Assessment

Table 1. To whom should science be opened

to whom should science be opened? (1=not be opened / 5=very opened)	Pre	Post
scientists from the same area/discipline	5.00	5.00
scientists from other disciplines	5.00	5.00
all citizens	4.80	4.38
civil and social organisations	4.80	4.50
specially concerned groups (e.g. patients)	4.87	4.63
funders and policy makers	4.80	4.63
industry and companies	4.60	4.50
how open do you think the different aspects of the scientific process should be (1=not be opened / 5=very opened)	Pre	Post
to the scientific community	4.81	4.68
to the society	4.77	4.45
to funders and policy makers	4.59	4.63

As answers were measured with a Likert scale (1= not to be opened, 5= very opened), then mean scores were calculated for each answer. A value close to '1' implies an attitude for science not to be opened, while a value close to '5' implies an attitude for science to be very opened.

The results show that participants strongly believe that science should be opened to sciences either from the same or from other disciplines (M=5.00). This belief remained quite similar even after the course (M=5.00). Participants also strongly believe that science should be opened to all citizens (M=4.80). This belief remained quite similar after the course, although mean score was slightly lower (M=4.38). Participants also strongly believe that science should be opened to civil and social organizations (M=4.80). This belief remained quite similar after the module, although mean score was slightly lower (M=4.50). Participants also strongly believe that science should be opened to especially concerned people (M=4.87). This belief remained quite similar after the course, although mean score was slightly lower (M=4.63). Participants also strongly believe that science should be opened to funds and policy makers (M=4.80). This belief remained quite similar after the course, although mean score was slightly lower (M=4.63). Finally, participants also strongly believe that science should be opened to industries and companies (M=4.60). This belief remained quite similar after the programme, although mean score was slightly lower (M=4.50).

As for all aspects of scientific process the openness was measured with a Likert scale (1= not be opened, 5= very opened), then a mean score of participants' answers measures the overall attitude for openness to scientific community, society and funders and policy makers. A value close to '1' implies an attitude for science not to be opened, while a value close to '5' implies an attitude for science to be very opened.

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Participants strongly believe that different aspects of the scientific process should be opened to the scientific community (M=4.81). This belief remained quite similar after the course, although mean score was slightly lower (M=4.68). Participants also strongly believe that different aspects of the scientific process should be opened to the society (M=4.77). This belief remained quite similar even after the programme, although mean score was slightly lower (M=4.45). Finally, participants strongly believe that different aspects of the scientific process should be opened to the funders and policy makers (M=4.59). This belief remained quite similar even after the module, although mean score was slightly lower (M=4.63).

Then, it is examined why science should be opened or not. Each answer represented a particularly reason. Participants should answer how important this particular reason was to them. In the next Tables 2 and 3, results for all reasons are presented. These results represent the percentage of participants who answer that each particular reason is important or most important to them.

Concerning diversity, 66.7% of participants believe that is an important/very important reason why science should be open. This percentage remained quite similar after the course, although it was slightly lower (62.5%). Concerning new and innovative economic possibilities, 80.0% of participants believe that is an important/very important reason why science should be open. This percentage remained quite similar after the programme, although it was slightly higher (87.5%).

Table 2. Why should science be open

	Important / most important reason	
In your opinion why should science be open?	**% Pre**	**% Post**
Diversity: incorporation of underrepresented groups in science (gender, races, cultures, etc.)	66.7	62.5
New and innovative economic possibilities: crowdfunding, new types of founders, etc.	80.0	87.5
Efficiency: sharing of data, procedures and/or to optimise science	73.3	87.5
Equity: access for all to scientific results, methods, software, etc., regardless of economic capacity or institutional affiliation	80.0	87.5
Ethics: Open Science is aligned with principles of research integrity	73.3	75.0
Fairness: Science is often funded by society, so all results from the research should be available to society	80.0	75.0
Impact: To outperform traditional metrics for scientific impact: larger audience, higher engagement, etc.	53.3	62.5
Rigour: Open access, open data and/or open replicability make science easier to review	60.0	75.0

Regarding efficiency, 73.3% of participants believe that is an important/very important reason why science should be open. This percentage remained quite similar after the course, although it was somewhat higher (87.5%). Concerning equity access for all to scientific results, 80.0% of participants believe that is an important/very important reason why science should be open. This percentage remained quite similar after the programme, although it was slightly higher (87.5%). Concerning ethics, 73.3% of participants believe that is an important/very important reason why science should be open. This percentage remained quite similar after the course, although it was slightly higher (75.0%). Concerning fairness, 80.0% of participants believe that is an important/very important reason

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why science should be open. This percentage remained quite similar after the programme, although it was slightly lower (75.0%). Concerning impact, 53.3% of participants believe that is an important/very important reason why science should be open. This percentage remained quite similar after the course, although it was somewhat higher (62.5%). Finally, concerning rigour, 60.0% of participants believe that is an important/very important reason why science should be open. This percentage remained quite similar after the course, although it was considerably higher (75.0%).

Table 3. Why should science NOT be open

	Important / most important reason	
In your opinion why should science NOT be open?	**% Pre**	**% Post**
Not a priority now. Currently, there are higher priorities in the scientific community	6.7	12.5
Public's luck of understanding. Society cannot make decisions or have a useful input without an understanding of science/the scientific process	13.3	25.0
Public is not ready now. Society is not ready for participation in science (lack of skills, tools, etc.)	20.0	12.5
Risk to fundamental research. Open Science would only benefit applied science and be detrimental to fundamental research	6.7	37.5
Low quality. By releasing publications prior to classical peer-review, the veracity of papers will be difficult to assess by individual researchers. Quality is not guaranteed by preprint servers	40.0	37.5
Danger and potential misuse. Open Science may interfere with research integrity (ex: release of medical personal data). It could also facilitate misuse of research results (e.g. biological weapons)	46.7	75.0
Lack of incentives. Open data.publication runs counter "meritocracy" and individual effort, and they are not captured and rewarded through traditional metrics	13.3	12.5
Unfairness. If a research group generates knowledge with own resources, it could be unfair if others use this knowledge to get economic benefits for themselves	13.3	37.5

As regards not a priority now, 6.7% of participants believe that is an important/very important reason why science should NOT be open. This percentage was increased very much after the course (12.5%). Concerning public's lack of understanding, 13.3% of participants believe that is an important/very important reason why science should NOT be open. This percentage was increased after the programme (25.0%). Concerning public is not ready now, 20.0% of participants believe that is an important/very important reason why science should NOT be open. This percentage was decreased after the course (12.5%). Concerning risk to fundamental research, 6.7% of participants believe that is an important/very important reason why science should NOT be open. This percentage was increased very much after the course (37.5%). Concerning low quality, 40.0% of participants believe that is an important/very important reason why science should NOT be open. This percentage remained quite similar after the programme, although it was slightly lower (37.5%). Concerning danger and potential misuse, 46.7% of participants believe that is an important/very important reason why science should NOT be open. This percentage was increased very much after the course (75.0%). Concerning lack of incentives, 13.3% of participants believe that is an important/very important reason why science should NOT be open. This percentage remained quite similar after the course, although it was slightly lower (12.5%). Finally, concerning unfairness, 13.3% of participants believe that is an important/very important reason why science should NOT be open. This percentage was increased very much after the course (37.5%).

Then, the barriers to open science are explored. Each answer represented a potential barrier. Participants should answer how much important this potential barrier was to them. In the next Table 4, results for all barriers are presented. More particularly, these results represent the percentage of participants who answer that each potential barrier is important or very important to them.

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Table 4. Barriers to Open Science

Imagine in your everyday work at your institution you decide to embrace an Open Science perspective **What do you think are the most important barriers you will be facing?**	**Important / very important barrier** **% Pre**	**% Post**
Lack of proper infrastructure. How/where do I store open data?	53.3	50.0
Lack of clear steps to follow. How do I begin? How do I proceed?	60.0	25.0
Authentic public engagement. How do I achieve representative samples of citizens (motivate people other than already concerned groups)	46.7	50.0
Budget and funding constraints. How do I find the funding to ensure open data and open publications	60.0	25.0
Time constraints. I don't have time to practice Open Science, it is too time-consuming	40.0	0.0
Fear and uncertainties for career development. Will my Open Science practice be valued at institutional level or during my career? Does it mean I will receive more funding or merit?	53.3	25.0

Concerning lack of proper infrastructure, 53.3% of participants believe that is an important/ very important barrier to open science. This percentage remained quite similar after the course, although it was slightly lower (50.0%). Concerning lack of clear steps to follow, 60.0% of participants believe that is an important/very important barrier to open science. This percentage was decreased very much after the programme (25.0%). Concerning authentic public engagement, 46.7% of participants believe that is an important/very important barrier to open science. This percentage remained quite similar after the course, although it was slightly higher (50.0%). Concerning budget and funding constraints, 60.0% of participants believe that is an important/very important barrier to open science. This percentage was decreased very much after the seminar (25.0%). Concerning time constraints, 40.0% of participants believe that is an important/very important barrier to open science. This percentage was decreased very much after the programme (0.0%). Finally, concerning fear and uncertainties for career development, 53.3% of participants believe that is an important/very important barrier to open science. This percentage was decreased very much after the course (25.0%).

Then, it is examined whether participants already participate in any open science activity/action. Each answer represented a potential activity/action. Participants should answer how much frequently they participate. In the next Table 5, results for all activities/actions are presented. More particularly, these results represent the percentage of participants who answer that regularly or sporadically participate in each activity/action.

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Table 5. Open Science activity/action participation

Do you already participate in any Open Science activity/action?	Reguraly / Sporadically % Pre	% Post
Collaborations across institutions and disciplines (interdisciplinary groups, projects or meetings, collaborative initiatives, etc.)	80.0	87.5
Dissemination to the public and outreach (social networks, articles or talks to the lay public, relationship with the media, etc.)	60.0	50.0
Dissemination to scientists (conferences and seminars, courses, articles, etc.)	60.0	50.0
Ethical aspects of science and research integrity (participation in ethics committees, bioethical research, training, awareness activities, etc.)	60.0	25.0
Gender equality (gender or sex is taken into account in your research, promotion of women visibility in science, training, mentoring, etc.)	46.7	50.0
Open Access publication (open access journals, economic support to publish in open access, open peer review, etc.)	42.9	37.5
Open Data (use of public data infrastructure to deposit and/or access data, participation in open data management, training, etc.)	66.7	62.5
Participation of the public and/or different stakeholders to your research (dialogues with the public, science cafes, citizen science initiatives, collaborations with NGOs, patient associations, etc.)	46.7	50.0
Collaboration with industry (joint events, joint projects, partnerships, etc.)	46.7	37.5
Collaboration with funders (participation in open science calls, efforts to incorporate the vision of open calls in research, etc.)	50.0	37.5
Science education (school-research partnerships, role model activities, non-formal education activities, etc.)	53.3	50.0

Concerning collaborations across institutions and disciplines, 80.0% of participants participate regularly or sporadically. This percentage remained quite similar after the course, although it was slightly higher (87.5%). Concerning dissemination to the public and outreach, 60.0% of participants participate regularly or sporadically. This percentage remained quite similar after the programme, although it was somewhat lower (50.0%). Concerning dissemination to scientists, 60.0% of participants participate regularly or sporadically. This percentage remained quite similar after the course, although it was somewhat lower (50.0%). Concerning ethical aspects of science and research integrity, 60.0% of participants participate regularly or sporadically. This percentage was decreased very much after the programme (25.0%). Concerning gender equality, 46.7% of participants participate regularly or sporadically. This percentage remained quite similar after the seminar, although it was slightly higher (50.0%). Concerning open access publication, 42.9% of participants participate regularly or sporadically. This percentage remained quite similar after the course, although it was slightly lower (37.5%). Concerning open data 66.7% of participants participate regularly or sporadically. This percentage remained quite similar after the course, although it was slightly lower (62.5%). Concerning participation of the public and/or different stakeholders to their research, 46.7% of participants participate regularly or sporadically. This percentage remained quite similar after the course, although it was slightly higher (50.0%). Concerning collaborations with industry, 46.7% of participants participate regularly or sporadically. This percentage was decreased after the programme (37.5%). Concerning collaborations with funders, 50.0% of participants participate regularly or sporadically. This percentage was decreased after the course (37.5%). Finally, concerning science education, 53.3% of participants participate regularly or sporadically. This percentage remained quite similar after the module, although it was slightly lower (50.0%).

Then, it is examined whether participants receive any training in open science activity/action. Each answer represented a potential training activity/action. Participants should answer whether they receive adequate training. In the next Table 6, results for all activities/actions are presented. More

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particularly, these results represent the percentage of participants who answer that receive adequate training in each activity/action.

Concerning research and data management 20.0% of participants receive adequate training. This percentage was decreased after the course (12.5%). Concerning research integrity 66.7% of participants receive adequate training. This percentage remained quite similar after the programme, although it was slightly lower (62.5%). Concerning research publishing and dissemination 40.0% of participants receive adequate training. This percentage remained quite similar after the course, although it was slightly lower (37.5%). Concerning collaborating and networking 26.7% of participants receive adequate training. This percentage was increased very much after the module (87.5%).

Table 6. Training to Open Science

Do you receive training from your institution related to Open Science?	Adequate trainning % Pre	% Post
Research and data management (Data storage, sharing, FAIR-"Findable, Accessible, Interopable, and Reusable"-approaches)	20.0	12.5
Research integrity (Animal research, data analysis and interpretation, research with human samples, good practice in the lab, etc.)	66.7	62.5
Research publishing and dissemination (Open Access, pre-prints, peer review)	40.0	37.5
Collaborating and networking (How to improve collaboration through Open Science)	26.7	87.5
Communicating science to the general public (Different audiences, practical guides to getting started, online and offline options)	13.3	62.5
Involving the general public in research (Citizen science: data gathering, data analysis, use of results)	6.7	50.0
Evaluation of research projects and researchers	26.7	37.5
Assessment of the impact of initiatives in public	13.3	37.5

As regards communicating science to the general public, 13.3% of participants receive adequate training. This percentage was increased very much after the course (62.5%). Concerning involving the general public in research, 6.7% of participants receive adequate training. This percentage was increased very much after the programme (50.0%). Concerning evaluation of research projects and researchers, 26.7% of participants receive adequate training. This percentage was somewhat increased after the course (37.5%). Finally, concerning assessment of the impact of initiatives in public, 13.3% of participants receive adequate training. This percentage was somewhat increased after the module (37.5%).

Then, it is examined whether participants receive any support or incentives in open science activity / action. Each answer represented a potential support or incentive. Participants should answer whether they receive adequate support or incentive. In the next Table 7, results for all potential supports/incentives are presented. More particularly, these results represent the percentage of participants who answer that receive adequate support or incentive in each action/activity.

Concerning written guidelines, 33.3% of participants receive adequate support. This percentage was decreased after the course (25.0%). Concerning technical infrastructure, 40.0% of participants receive adequate support. This percentage was increased very much after the programme (75.0%).

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Table 7. Support or incentives to Open Science

Do you receive support or incentives from your institution related to Open Science?	Adequate support % Pre	% Post
Written guidelines (webpage/ leaflet/videos), policies, recommendations	33.3	25.0
Technical infrastructure (templates, software, storage, databases, publication and/or data repositories, etc.)	40.0	75.0
Specialist support (experts on different aspects of Open Science, research data committees, courses, workshops, etc.)	6.7	12.5
Financial support and rewards	20.0	50.0
Careers perspectives and recognition	26.7	62.5

In relation to specialist support, 6.7% of participants receive adequate support. This percentage was increased very much after the course (12.5%). Concerning financial support and rewards, 20.0% of participants receive adequate support. This percentage was increased very much after the programme (50.0%). Finally, concerning careers perspectives and recognition, 26.7% of participants receive adequate support. This percentage was increased very much after the course (62.5%).

Finally, the general view of participants to open science is examined. Results are presented in the Table 8 below.

Table 8. View to Open Science

Overall, if you had to summarize your view on Open Science, what would you say?	% Pre	% Post
Open Science is an exciting opportunity for Science, mostly with benefits	46.7	42.9
Open Science is an opportunity for Science, with the benefits overcoming the drawbacks	33.3	28.6
Open Science is mostly positive for Science, it has benefits but also important drawbacks	13.3	28.6
Open Science is an unimportant bureaucratic burden for Science	6.7	0.0

The findings show that 46.7% of participants believe that open science is an exciting opportunity for science, mostly with benefits. This percentage remained quite similar after the course, although it was slightly lower (42.9%). 33.3% of participants believe that open science is an opportunity for science, with the benefits overcoming the drawbacks. This percentage remained quite similar after the programme, although it was slightly lower (28.6%). Thirteen percent (13.3%) of participants believe that open science is mostly positive for science. It has benefits but also important drawbacks. This percentage was increased very much after the course (28.5%). Finally, 6.7% of participants believe that open science is an unimportant bureaucratic burden for science. This percentage was decreased very much after the module (0.0%).

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