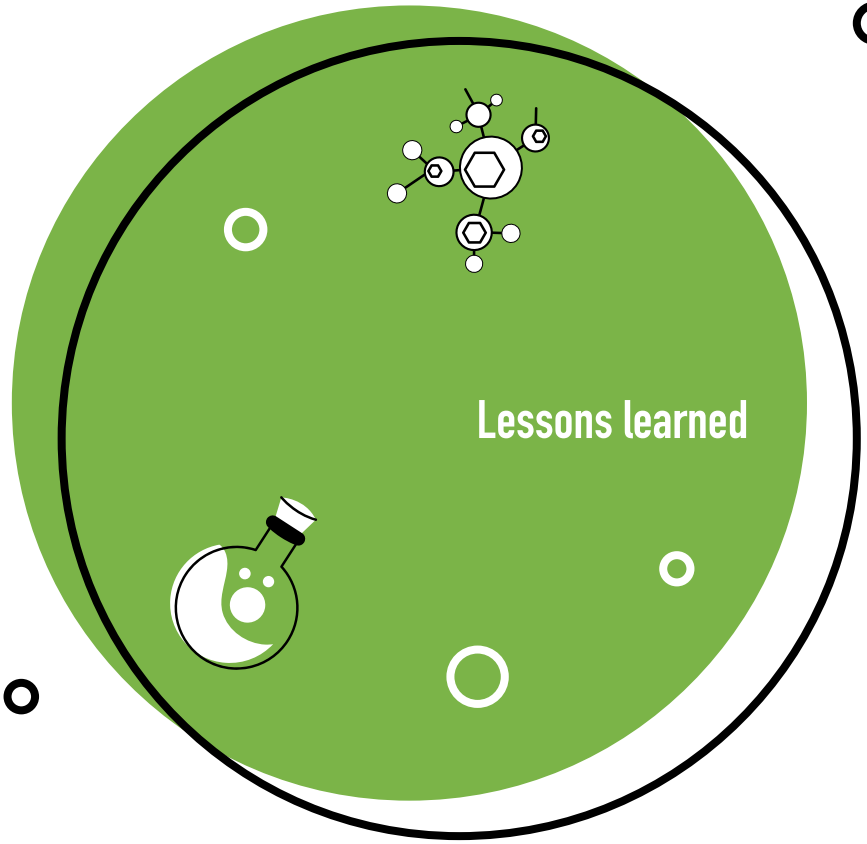
STANDARD INDICATORS FOR THE SOCIAL APPROPRIATION OF SCIENCE

PERSIST_EU

ERASMUS+ PROJECT



PERSIST

Standard indicators for the social appropriation of science. Lessons learned

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PERSIST_EU PROJECT

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About the project and the book

This book is the result of a two-and-a-half-year close collaboration between the seven partners of the Erasmus+ KA203 project "Knowledge, beliefs, perceptions about the science of European students (Persist_EU)".

One of the project's main objectives was to develop a tool to evaluate European students' initial knowledge when configuring their beliefs and perceptions about different science topics. Once the tool (platform) had been designed, the next step consisted of carrying out activities (Science camps), which would allow validating the platform and identifying changes in perception (through questionnaires with Likert scales), which students experienced during their participation in training activities, organised within the framework of the project. For this, five Science camps were organised in five European universities, two in central Europe (Germany, Slovakia), and three nations in southern Europe (Portugal, Spain and Italy). Therefore, we make sure to cover differences related to socio-geopolitical issues. The topics that were chosen for the debate were climate change, genetically-modified organisms (GMOs), complementary and alternative medicines (CAM) and vaccines, and it was expected that around 100 students would participate in each of the universities of the PERSIST_EU consortium (Valencia, Karlsruhe Institute of Technology, Trnava, Lisbon, and Vicenza).

The original idea of the project was to have the opinions of 500 students, 100 from each of the participating universities, but due to the pandemic situation and the particular circumstances of COVID-19, the final number of participants was reduced, and the Science camps had to be held online (Teams, Zoom, Blackboard Collaborate) and not in person, during the spring of 2020, as originally planned. In any case, being online, we had an advantage, and that is that students from other universities participated, and therefore the plurality of participants increased. The Science Camps with the students of the five European universities allowed us to know the modifications in the response scales, before and after the training, in the four blocks of questions on knowledge, belief, trust and perception. All the results of the five activities are collected in this book and guides to replicate the activities in other areas. From the project consortium, we hope that the results obtained will serve to support the platform's use to make evaluations of specific topics or other science dissemination activities and incorporate the research results into public health or environmental programs. In short, it helps improve science communication.

The project had two central objectives linked to two intellectual outputs. The first intellectual product that we developed was an evaluation method, based on an open, online platform so that in the future, any teaching activity and potentially at any educational level could evaluate whether students modify their worldview once they would acquire knowledge and training on a subject or, if despite knowledge, the lack of confidence in science, or in a particular subject, continues

to persist. Therefore, launching the open-access platform for everyone was the first challenge. Subsequently, hard work was done to incorporate a questionnaire into the platform to measure how the responses would be modified, through questionnaires with Likert's scales, to be answered before and after carrying out training activities. For example, how does the scale vary between the answer to questionnaire 1, sent a week before the training activity, and questionnaire 2, sent after attending the training activity, on topics such as vaccines? Probably, a student, before knowing the risks that not being vaccinated can produce on public health, could have a different level of perception than after attending a formative talk and a Socratic debate. That is the question that we were seeking to identify with the project.

The second intellectual output derived from PERSIST_EU is this book. This publication includes the processes and steps that we carried out for the project's execution and collects both the technical point of view and the research results (through the activities). Once the science camps have been held, we assess the weight that the activities have had in each participating country. The science camps helped us verify the platform's usability and validate it as an evaluation instrument. Likewise, the questionnaires' results, by checking how the scales have moved, once the training activities and debates were held, allowed us to analyse the differences between countries, gender and cultural differences among university students in terms of their social science. Besides, these scales can also measure when fundamentalist positions are due to ideological or religious issues. It can be identified when the responses did not move. For this reason, we believe that this type of platform can measure over time the profiles of students who have a more inclined tendency to increase or decrease the scale depending on how the debate presented and how the expert defended their topic.

The book, which is published in Open Access, consists of five chapters. In the first chapter, the state of the art is presented. In the second chapter, the design of the platform is explained. Besides, a detailed description of the platform is made and how the questionnaires and questions were entered and how they must be used correctly. In the third chapter, it is explained how the Science Camps were carried out in each university and the main results that were obtained. In the fourth chapter, the main questions students posed, the answers the experts provided, as well as a list of trustworthy online resources for the four topics are presented, so they can be used for support in different activities related to these topics. And, in the fifth and last chapter, the annexes, including a detailed guide to using the platform, and other included activities are detailed, as well as suggestions and proposals for other activities that could be carried out to improve the experience.

All the members of the PERSIST consortium have

participated in the book: Danmar Computers (Poland), FyG Consultores (Spain), Karlsruhe Institute of Technology (Germany), Instituto de Ciências Sociais (Portugal), Observa Science in Society (Italy), Trnava University (Slovakia), and University of Valencia (Spain). The overall work presented in this book was carried out as part of the project PERSIST_EU, funded by the European Commission (Erasmus+ program 2018-1-ES01-KA0203-050827). Besides, this book's publication was possible only due to the great support and cooperation of the consortium members and funding by the European Commission. Alongside the contributing authors, I would like to thank European students, experts, professors, and all people who were deeply involved in managing the development of the different Science Camps and the implication of this publication. Also, a very special thanks to each partner's leaders for providing editors with a trusting environment to prepare this publication.

Thank you all.

Starting from the theoretical paradigm on the

Image 1. Consortium members at the kick-off meeting

1. Cosmovision and worldviews of the university European students

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University of Valencia
Coordinator of Persist_EU

Cosmovision and worldviews of the university European students

worldview and the construction of the scales of values that people construct to relate socially, the British anthropologist Mary Douglas conceptualised through her work *Natural Symbols: Explorations in Cosmology*[1] the fundamental models of individual thought and behaviour in different contemporary societies. With the PERSIST_EU project (Knowledge, beliefs, Perceptions about Science of European Students), we wanted to identify if the level of confidence, perception, attitude and, ultimately, the cosmovision of European university students on science issues, would change after participating in training activities (Science camps) or, on the contrary, they would remain unchanged. Therefore, we wanted to know if training would be a key element that would allow changing the scale of values on the European university student body's science issues. The sociodemographic profiles of those who have proactive or passive attitudes towards science knowledge and, above all, people who are in favour or against certain science advances have been widely studied over the last decades.[2]

Likewise, the perception of science has also been studied from a belief system that shares motivational functions with religious and political ideologies, but also with motivation and morality, which help to advance how science is evaluated, in a period in which science is more accessible to all audiences than in previous generations.[3] Therefore, there is considerable scope for future research, as pointed out by Sbaffi & Rowley.[4] These authors detail the importance of sociodemographic variables focused on improving understanding, trust, and health information judgments. Recently, Sammut & Bauer[5] explained in a study that all the influences individuals have could be described through a systematic overview of the different modalities of social influence, including crowding, leadership, conformity, obedience, persuasion, the media and artefacts. Sammut & Bauer have called it the 'cyclone' model of social influence, which would regulate society's historical evolution through normalisation, maintenance, and the challenge of common sense.

The PERSIST_EU project's philosophy is to determine the attitude and point of view that European students have on science topics, which could be socially controversial, such as vaccines, climate change, genetically modified organisms, or complementary and alternative medicines. Other topics such as gene editing, organ transplants, nuclear energy, fracking, radiation, etc., were also being considered for

1. Douglas, M. (2004). Natural symbols: Explorations in cosmology. Routledge.
2. a) Bauer, M., Durant, J., & Evans, G. (1994). European public perceptions of science. *International Journal of Public Opinion Research, 6*(2), 163-186; b) Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079; c) George, R. (2006). A cross-domain analysis of change in students' attitudes toward science and attitudes about the utility of science. *International Journal of Science Education, 28*(6), 571-589; d) Rubin, A., Pellegrini, G., & Šottník, L. (2020). Role of Science Communication in beliefs, perceptions and knowledge of science and technology issues among European citizens. In *EGU General Assembly 2020*. Online, 4-8 May 2020, EGU2020–2943.
3. Rutjens, B. T., Heine, S. J., Sutton, R. M., & van Harreveld, F. (2018). Attitudes towards science. In *Advances in Experimental Social Psychology, 57*, 125-165.
4. Sbaffi, L., & Rowley, J. (2017). Trust and credibility in web-based health information: a review and agenda for future research. *Journal of Medical Internet Research, 19*(6), e218.
5. Sammut, G., & Bauer, M. W. (2021). The Psychology of Social Influence: Modes and Modalities of Shifting Common Sense. Cambridge University Press.

future research, but the four topics which part of the consortium had previously worked on were chosen.[6] In any case, there are a series of topics on different science and technology applications, closely linked to personal decision-making or with attitudes towards science that could be significantly related to political or religious ideology or any other scale of values such as a philosophical natural word vision (healthy life, environmentalism, animalism, etc.).

Since, in the PERSIST_EU project framework, no experiments were designed, with a control group, nor was qualitative work carried out with the attendees, we could only find out whether the training on the four topics under discussion had produced student changes in perception. Therefore, we can conclude that the student worldviews were modified after training, and we also know with which topics the Likert's scales used were most affected and in which countries. However, the most interesting finding was to know if the change in attitude occurred in the block of questions related to trust, opinion, or knowledge. In the light of the above, the platform made it possible to diagnose a certain level of fundamentalism in certain topics and identify when training or knowledge on a science theme would not be related to people's decision-making point of view. Bauer[7] explained in an essay how resistance to techno-scientific developments occurred, regardless of the knowledge that existed about them. In fact, this is how this author argued the birth of public controversies on science issues and their consequences, which are largely motivated by the resistance of public opinion to the changes that occur in the development of science.

Concerning religion, recent work by O'Malley *et al*.[8] argued that most of the world would claim to have a religious affiliation as an element of identity and worldview. Therefore, faith would skew many personal opinions about science, technology and society in general. In this sense, the authors proposed that religious communities and religious leaders could contribute to improving public perception and the confidence of scientists, promoting evidence-based policies and improving diversity, equity and inclusion in the fields of science. About the biases that religion could introduce in some positions, such as, for example, in the case of organ transplants, Evans and Kelley[9] stated that, if public knowledge of science continued its increase or acceptance of the theory of evolution, support for transplantation was most likely to increase, as had been the trend in recent years. According to Funk,[10] many scientists believe that if the American public

6. a) Pellegrini, G. (2009). Biotechnologies and communication: participation for democratic processes. *Comparative Sociology, 8*(4), 517-540; b) Schmidt, L., & Delicado, A. (2018). Analysis of the questions concerning energy and climate of the European Social Survey 2016. D002: Research on public attitudes 2017. Report to EUROfusion.; c) Cano-Orón, L., Mendoza-Poudereux, I., & Moreno-Castro, C. (2019). Sociodemographic profile of the homeopathy user in Spain. *Atencion primaria, 51*(8), 499-505; d) Moreno-Castro, C., Corell-Doménech, M., & Camano-Puig, R. (2019). Which has more influence on perception of pseudo-therapies: The media's information, friends or acquaintances opinion, or educational background? *Communication & Society, 32*, 35-49; e) Moreno Castro, C., & Vengut-Climent, E. (2019). Información y mensajes sobre salud en los medios de comunicación. *FML, 24*(3), p. 4; f) Rubin, A., Pellegrini, G., & Šottník, L. (2020). Role of Science Communication in beliefs, perceptions and knowledge of science and technology issues among European citizens. In *EGU General Assembly 2020*. Online, 4-8 May 2020, EGU2020–2943; etc.

7. Bauer, M. W. (2015). Atoms, bytes and genes: Public resistance and techno-scientific responses. Routledge.

8. O'Malley, R. C., Slattery, J. P., Baxter, C. L., & Hinman, K. (2021). Science engagement with faith communities: respecting identity, culture and worldview. *Journal of Science Communication, 20*(1), C11.

9. Evans, M. D. R., & Kelley, J. (2014). Influence of scientific worldviews on attitudes toward organ transplants: national survey data from the United States. *Progress in Transplantation, 24*(2), 178-188.

10. Funk, C. (2017). How much does science knowledge influence people's views on climate change and energy issues. Pew Research Center.

were more informed about the science behind climate change and energy problems, citizens would hold views more aligned with scientific experts. Nevertheless, that is an illusion; actually, what people know about science only modestly and inconsistently correlates with their attitudes about climate and energy issues. However, partisanship is the biggest factor in people's beliefs, according to a 2016 Pew Research Center survey.

Vaccines are now a burning topic. A lot of international studies identified why some people refuse to be vaccinated or doubt the decision. In reality, they do so for various reasons, but the lack of trust in science and scientific institutions is usually a determining factor when deciding about vaccines, as Dubé & Gagnon[11] explained in their work on trust in information sources. These authors explain that, in the recommendations of the World Health Organization (WHO) Working Group on Vaccine, it stated that confidence was one of the three main determinants of vaccine hesitation along with complacency and convenience. In fact, they found that in countries where access to health services was not a significant barrier to vaccination, the groups' attitudes and beliefs targeted by vaccination programs were the main factors influencing the vaccine coverage. As Dubé & Gagnon point out in a survey that included 65,819 people in 67 countries, it showed that general attitudes towards vaccination were positive, although there was considerable variability between participating countries and regions. Unlike other health behaviours, participants from countries with higher education levels and adequate access to health services experienced less favourable attitudes towards vaccination.

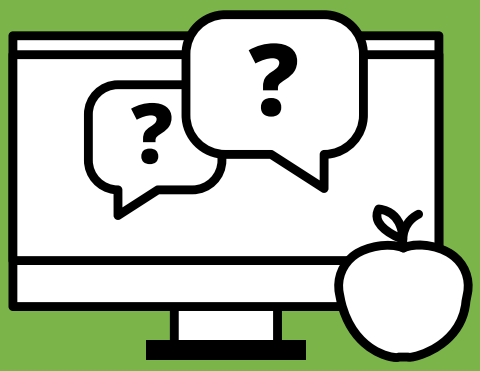
According to De Witt, Osseweijer & Robin,[12] concerning social responses to new biotechnologies, they provoke perceptions shaped by individuals' cultural worldviews. Basically, they bet on a concept of the worldview that distinguishes among the traditional, the modern and the postmodern. Therefore, for information / training on new biotechnologies, an integrative approach must be taken on socio-technical changes, generating knowledge about paradigmatic gaps in the social sciences and formulating inclusive policies.
Concerning climate change, Lewandowsky *et al.*[13] stated that the audience's social consensus is a fundamental element for supporting or rejecting some topics. Through a study on the analysis of comments from blogs, which played an important role in the dissemination of against positions on the role of the anthropocentric vision of climate change, Lewandowsky and colleagues[13b] discovered that beliefs are partially shaped by the perception of readers about the extent to which other readers seem to share an opinion expressed in a blog post. Nor could they explain the effect of this content on people's attitudes. In particular, it is unknown how the interaction between blog post content and blog comments affects readers' attitudes. However, through the experiment that Lewandowsky and his colleagues conducted, using blog posts and comments that supported or not the scientific consensus on climate change, they found that the perceived social consensus among readers, in turn, is determined in case of blog

11. Dubé, È., & Gagnon, D. (2018). Trust, Information Sources and the Impact on Decision-Making: The Example of Vaccination, Paganelli, Céline (Ed.) *Confidence and Legitimacy in Health Information and Communication*, 43-65. Montpellier: Willey.
12.De Witt, A., Osseweijer, P., & Pierce, R. (2017). Understanding public perceptions of biotechnology through the "Integrative Worldview Framework". *Public Understanding of Science, 26*(1), 70-88.
13. a) Lewandowsky, S., Gignac, G. E., & Vaughan, S. (2013). The pivotal role of perceived scientific consensus in acceptance of science. *Nature Climate Change, 3*(4), 399-404; b) Lewandowsky, S., Cook, J., Fay, N., & Gignac, G. E. (2019). Science by social media: Attitudes towards climate change are mediated by perceived social consensus. *Memory & Cognition, 47*(8), 1445-1456.

comments that endorse or reject the content of a post. When the comments reject the content, the reader's consensus is lower than when the comments endorse the content. Therefore, the results underscored the importance of perceived social consensus in the formation of opinions.

Finally, one of the topics that are in vogue in science communication research today, especially since the beginning of the COVID-19 pandemic, is the trust of citizens in the sources of information and whether their decision-making on topics related with science and technology are influenced by the information they receive from the media, by their relationship or by their professional experience.[6d] In some way, social scientists' interest has grown to know our degree of confidence in the face of the excessive volume of information we receive. It is not easy to assess on which pillars the trust is based. In some issues, people's trust is linked to personal relationships (in some way, the experience of someone close or relative). On other issues, professionals prefer to be advised by professionals in a certain field, as in medical-patient relationships. Some also have a fundamentalist position, either for ideological or religious reasons and therefore, the training or expert opinions do not cause any change in their perspective on a topic. With the proposal of this project, we hope that some inquiries can be made in this regard.

2. PERSIST_EU ICT tool



2. PERSIST_EU ICT tool

In the last decades, the Science, Technology and Society (STS) approach has broken with the traditional science education, mainly focused on transmitting facts and concepts, and has introduced in schools the interrelations among Science, Technology and Society.

This approach presents Science in its context and takes into account that for our daily decision making, we do not only rely on our knowledge in a topic but in our values, in which trust, perceptions and beliefs are directly involved.

With this in mind, in PERSIST_EU we developed an instrument to assess the quality of science-based training, focusing specifically on how the student views on certain topics could change after undergoing said training. The topics were selected due to the societal controversy they presented at the moment of developing the project. Namely, the platform was developed to measure changes in students' views in climate change, vaccines, genetically modified organisms (GMOs) and complementary and alternative medicines (CAM).

The platform was developed in a co-creative way from an international perspective and thinking about its transferability to other countries.

2.1 What is the PERSIST tool

The online platform consists of a questionnaire for the assessment of science literacy before (Q1) and after (Q2) training. Students would receive a personalised link for responding to the questionnaire in the platform and their before/after answers would be compared to evaluate change in their perceptions and opinion.

The questionnaire was designed at the LTTA Learning Teaching and Training Activity in Valencia in June 2019. It covered all four topics and included both questions inspired by already existing surveys and new questions, built to purpose. For each topic, the questions covered four categories: knowledge and information; beliefs; perception; and trust (Table 1). The questionnaire also included questions about the habits of searching for science information, as well as questions about the socio-demographic profile of the students.

Table1. Questions included in the online platform related to each topic and category.

	Climate Change	GMOs	Vaccines	CAM
Knowledge	How well informed are you about climate change?	How would you assess your information about GMOs?	What is your level of understanding on how vaccines work?	How much do you know about alternative medicine?
Perception	Is climate change already affecting our daily life?	Do GMOs have more advantages or disadvantages?	Do vaccines have more advantages or disadvantages?	Do alternative medicines have more advantages or disadvantages?
Beliefs	Climate change is caused by human activity.	GMOs will save future generations from hunger.	Not vaccinating children puts other people in danger.	Alternative therapies are not a threat to public health.
Trust	Scientists stated in 2018 that we only have 12 years to prevent devastating climate change.	The benefits of scientific and technological research on GMO are greater than the risks.	According to scientific research, side effects of vaccines are rare or non-existent.	Medical treatments not based on scientific evidence should be discouraged.

The questionnaire can be customised to each user needs, with the possibility of including in it questions related to:

- Sociodemographic
- Climate change
- GMOs
- CAM
- Vaccines
- Sources of information

Sociodemographic questions are general questions that can be applied regardless of the country of use:

- Year of birth
- Gender
- Nationality
- Field of study
- Year of study
- Stage
- Parent 1 educational background
- Parent 2 educational background

All questions are optional, so it is possible to tell students just to fill some specific questions.
Finally, data related to sources of information reveal the common sources to reach science information and the social media used to look for it.
Information related to how to use the platform, can be found in Annex 1.

Questions on climate change

In the case of **climate change**, the question on knowledge is similar to the one used in Eurobarometers about climate change.[14] These surveys show that the subjective level of information (the extent to which respondents feel informed about climate change) affects their perception of the phenomenon, namely that those who say that they feel more informed are more inclined to think it is a serious problem. The question on perceptions focuses on the impact of climate change in daily life. For a long time, climate change was seen as a long-term problem, that would only be visible after it became irreversible.[15] However, though scientists hesitate to connect specific events to climate change, it is already noticeable the rise in temperatures, the loss of ice in the poles and the increase in frequency and severity of extreme weather events. This question was used by the 2019-2020 EIB (European Investment Bank) climate survey.[16]

The question on belief addresses one of the key dimensions of climate scepticism[17]: whether climate change is a natural phenomenon (caused, for instance, by solar activity or natural long-term variations) or an anthropogenic phenomenon, caused by

greenhouse gas emissions that have increased exponentially since the nineteenth century, due to industrialisation, the use of fossil fuels and intensive farming and animal rearing.

The question on trust is based on the warning by the UN's IPCC (Intergovernmental Panel on Climate Change) in 2018[18] that we only have 12 years to avert catastrophic climate change, that is, that emissions would have to be significantly curbed by 2030 in order for global warming to be kept to a maximum of 1.5°C.

14. See, for instance, the 2008 Special Eurobarometer 300 Europeans' attitudes towards climate change , the 2009 Special Eurobarometer 313 on the same topic, or the 2011 Special Eurobarometer 364 Public Awareness and Acceptance of CO_2 capture and storage.
15. This is sometimes called the 'Giddens paradox', coined by the author himself in the 2009 book 'The politics of climate change' (Polity Press), but Castree, in his 2010 review of the book for *The Sociological Review* clarifies that this is already a well-known idea.
16. Citizens' perception of climate change and its impact. 2019-2020 EIB climate survey. https://www.eib.org/en/surveys/2nd-climate-survey/climate-change-impact.htm# European Investment Bank.
17. See Van Rensburg, W. (2015). Climate change scepticism: A conceptual re-evaluation. SAGE Open, 5(2), 2158244015579723.
18. IPCC (2018), Special Report Global Warming of 1.5 ºC

Questions on GMOs

Despite the production of GMOs and their commercialisation in Europe became authorised, as of 17 October 2002, by Directive 2001/18/EC of the European Parliament and the Council, citizens knowledge still remains low.[19]

The self-reported knowledge question is similar to that used in other questionnaires. It is usually assumed that the level of knowledge in biology is related to the attitudes towards GMOs. However, several studies have shown that GMOs is a topic where there exist polarised opinions regardless of the level of knowledge. In this sense, the question about perception allows us to measure if students present more or less positive views towards GMOs and check if the direct relationship with the knowledge is actually not present.

In 2018, the World Resources Institute published a report showing that GMOs can be a solution to prevent the global population (that is expected to reach 10 billion people in 2050) from starving.[20] The beliefs question was formulated to assess the level of scepticism of students towards this scientific claim.

GMOs risk perception on human health and the environment is one of the key factors that defines the attitudes towards GMOs.[21] Meanwhile the precautionary principle is still used by people with more negative attitudes, scientists claim research on GMOs has been extensively during decades and that they have more pros and cons. The level of agreement with the statement "the benefits of scientific and technological research on GMO are greater than the risks" can be an indicator of the trust in scientific claims.

Questions on vaccines

Considering **vaccines,** the knowledge question had the main objective to study the level of understanding of news concerning a very complex topic. Vaccines, in fact, are a multi-faceted topic and normally this type of issue must be addressed by primarily verifying cognitive attitudes. This question was asked following the order in which the recent Eurobarometer survey of 2019 was also carried out.[22]

The issue of vaccines is quite controversial, and groups opposed to their use have often been activated. For this reason, a question was chosen that tends to detect a possible polarisation towards vaccines, in order to verify the level of contrast that could exist among students.

The question of beliefs aims to probe in depth some values that guide personal choices. For this reason, a situation was chosen in which to verify an attitude towards the common good such as that of immunity guaranteed to the population through the responsibility to get vaccinated. This type of question therefore makes it possible to precisely verify the position with respect to a universal value such as public health.

The question of trust allows us to study to what extent students rely on science trust. While considering the inevitable uncertainty of science, it is important to note whether scientific institutions and scientists are believed to be credible and reliable, particularly for assessing possible adverse effects. The issue of side effects, in fact, has often been at the centre of public debate and represents a crucial element to gauge the level of public confidence.

19. Questions and Answers on the Regulation of GMOs in the EU – Memo/02/160 – rev., March 2003
20. World Resources Institute (2018), Creating a Sustainable Food Future
21. Bawa, A. S., Anilakumar, K. R. Genetically modified foods: safety, risks and public concerns—a review, *J. Food Sci. Technol., 50*(6): 1035–1046.
22. See Eurobaromete on vaccines 2019

Questions on CAM

As for the other topics, the knowledge question was also formulated to assess the self-reported level of information regarding this topic. CAM covers a wide range of non-related practices, thus, being difficult to self-assess one's own expertise in such a broad area. This may allow us to identify mainly people who think they have a good level of information because they are interested in these practices and those who think they know a lot about CAM because they have strong pro-science beliefs. The key to identify them is the analysis of the answer to this question along with the answer to another one in this questionnaire.

CAM usage in Europe has increased during the last decades and it is a common practice, mostly in a complementary way. It is not usually employed as an alternative medicine[23] and most people do not differentiate between the concepts of alternative and complementary. Moreover, their acceptance, usage and regulation also vary among European countries, making it more difficult for a person to have a defined idea on the topic.

The questions related to the level of perception, beliefs and trust may allow to differentiate ideas students may have and are better analysed as a whole. For example, one may think CAM has more advantages but that medical treatments not based on scientific evidence should be discouraged if they see CAM from a complementary perspective in which it provides an emotional bonus to help patients follow a Western conventional treatment.

The questions allow to have a broader picture of the multidimensionality of the topic.

23. See Kemppainen et al. (2018). Use of complementary and alternative medicine in Europe: Health-related and sociodemographic determinants. *Scand J Public Health*, *46*(4):448-455.

Scale

The selection of the scale can have a wide influence in the results obtained from a questionnaire.

Given that the standardisation of responses in the questionnaire largely eliminates the possibility of recording specific and original answers of individuals from the surveyed population, it is desirable, on the other hand, that respondents be offered adequate options that are as close to them as possible. And even though these options may be general, they still correspond to their situation, opinions, attitudes or evaluations.

In our case, the 5-point Likert scale was therefore very suitable for recording the knowledge, perception, beliefs and trust of respondents analogously used in all 4 topics in our research: climate change, vaccination, GMOs, complementary and alternative medicine.

The main reasons for applying this scale were:

- To offer a continuum of answers from minimum to maximum. 2 negative degrees + middle variant + 2 positive degrees (for example: very low, low, moderate, high, very high / strongly disbelieve, disbelieve, neither believe nor disbelieve, believe, strongly believe).

- The answers are not expressed numerically (1, 2, 3, 4, 5) but verbally so that all respondents can understand them as unambiguously and equally as possible and then so that they can choose the one that is closest to them and with which they can best identify.
- Verbal variants of the answers (and not numerical ones) can also be clearly interpreted in the research results.
- They are easier for respondents to move through the questionnaire, and they are not confused with several scales with different number of degrees.
- Visually, the questionnaire is clearer and more friendly to fill out.
- Use of the same pattern of scale answers also has other advantages in more advanced statistical processing –e.g., when creating variation of change of responses, creation of indexes, or in cluster analysis.

The PERSIST_EU project went beyond the development of the ICT tool to assess knowledge, beliefs and perceptions and designed an activity to validate this platform and to determine the changes resulting after participating in this activity, called Science Camp (SC).

3. Science Camps as an activity to use the tool

3.1 Insights into the ScienceCamps

This chapter explains the basics on the SC and the results obtained by implementing the use of the PERSIST_EU platform to this activity.
Insights into the Science Camps

The SC was designed to be a dynamic and participatory activity, immersing students into different science topics for one morning or afternoon. However, due to the SARS-CoV-2 pandemics, SC had to be converted into Virtual ScienceCamps (VSC), a shorter online version in which each topic was dealt with in a different activity.

Both SC and VSC were divided into a first part of receiving information about the different topics, through short videos and talks held by experts in each one and a second participatory part consisting of a Q&A section, a discussion for finding arguments in favour or against a sentence presented for each topic and a final debate among the students (Table 2).

The questions raised by the students and the corresponding expert answers were compiled and can be found in the next chapter.

Table 2. Schedule of VSC

Time	Activity
5-10 minutes	Welcome, introductions and rules (team member).
20-25 minutes	Q&A with an expert.
5 minutes	Presentation of the next stage (team member).
20-25 minutes	Students discussion and debate. Groups of 4-8 students each. One group will discuss arguments in favour of the proposed sentence and the other group, against it. There should be a team member moderating in each group session.
10-15 minutes	The two groups merge, and the two spokespersons present their arguments.
15 minutes	Final general discussion (moderated by a team member).
10 minutes	Final wrap-up (team member) and questionnaire answer.

Several VSC covering the four topics of the project, climate change, vaccines, genetically modified organisms (GMOs) and complementary and alternative medicines (CAM) were held in 5 European countries: Portugal, Spain, Italy, Slovakia and Germany. The activities took place at different times in the period from May to December 2020. Table 3 provides an overview of the dates in the respective countries.

Table 3. Dates of VSCs per country

	CC	GMO	CAM	VAX
Portugal	19 May	26 May	24 September	20 May
Spain	29 October	5 November	6 November	7 November
Italy	17 October	5 June	26 June	9 June
Slovakia	20 October	21 October	21 October	20 October
Germany	22 July 9 December	16 December	9 December	11 July 16 December

The targeted students were from diversified knowledge areas and attended voluntarily. By sharing their views, they contributed to generate knowledge about beliefs and perceptions on these topics.

All VSC shared the same general structure. One week before attending the VSC, the participant students received their personal code to answer the questionnaire on the ICT platform. A few days before the VSC they received a link to a short video related to the topic and were asked to send their questions via e-mail or platforms like Slido. In online activities sometimes people interact less, having questions beforehand can help to start this interaction during the Q&A section and the debate.

The day of the activity the expert gave a short talk followed by a Q&A section. Then, students were divided in groups of 4-8 participants and given a statement to work with. One group would have to prepare arguments in favour of the sentence and the other one, against it. Afterwards, the groups would go back into the plenary and present their arguments. A final discussion would ensue. Finally, participants would receive the link to the second questionnaire.

The videos and the sentences were selected in order to generate discussion on particular science issues (table 4).

Table 4. Topics, science issues, videos and statements used for the VSC.

Topics	Issues	Video	Statement
Climate change	Theory and hypothesis	Climate models. Global weirding, PBS Digital Studios. Video	Existing climate models should guide structural political decisions about climate change mitigation.
GMOs	Theory and hypothesis	Europe's new approach to GMOs, European Parliament. Video	Since we still do not know enough about GMO's consequences, we should delay their approval.
CAM	Precautionary principle / risk management	The side effects of vaccines: how high is the risk? Kurzgesagt - In a Nutshell Video	The placebo effect justifies the state paying for alternative medicines like homeopathy.
Vaccines	Placebo effect	Homeopathy explained: gentle cure or reckless fraud? Kurzgesagt - In a Nutshell Video	Statistics show that side-effects from vaccines are very rare and worth the risks.

Beyond this common agreement, each country adapted these guidelines to their particular situation.

Portugal and Germany based the presentations of the experts in the initial questions raised by the students, meanwhile in Spain, Italy and Slovakia the experts prepared their presentation based on the relationships between the topic and the science issue linked to it.

In Italian ScienceCamps students were not assigned a stance to defend but students in each group discuss arguments in favour and against the presented statement.

In the following section, we will briefly introduce the results obtained through the use of the platform before and after VSC.

Image 2. Poster informing about Virtual ScienceCamp in Italy

Image 3. Poster informing about Virtual ScienceCamp in Portugal

3.2 Results from the Science Camps

The results and specificities of the ScienceCamps can be found in the reports of each country, which are also available in our webpage and free to download.

Herein, we present, first, an analysis of the overall results obtained by category, considering all countries. This allows us to see if PERSIST_EU ICT tool is able to measure changes in self-reported knowledge, perception, trust and beliefs.

Second, we present briefly a comparison of the results per topic and country. This analysis shows the applicability of the tool in different cultural environments and to different backgrounds.

Even though we tried to have a great variety of participants in the sample, the students participating in each country, and even in each ScienceCamp, have different academic backgrounds, which has probably influenced the results obtained in each case. To see the exact profile of these students you can access the reports of the SC in each country in our website.

Image 4. Informative leaflet about VSC in Spain

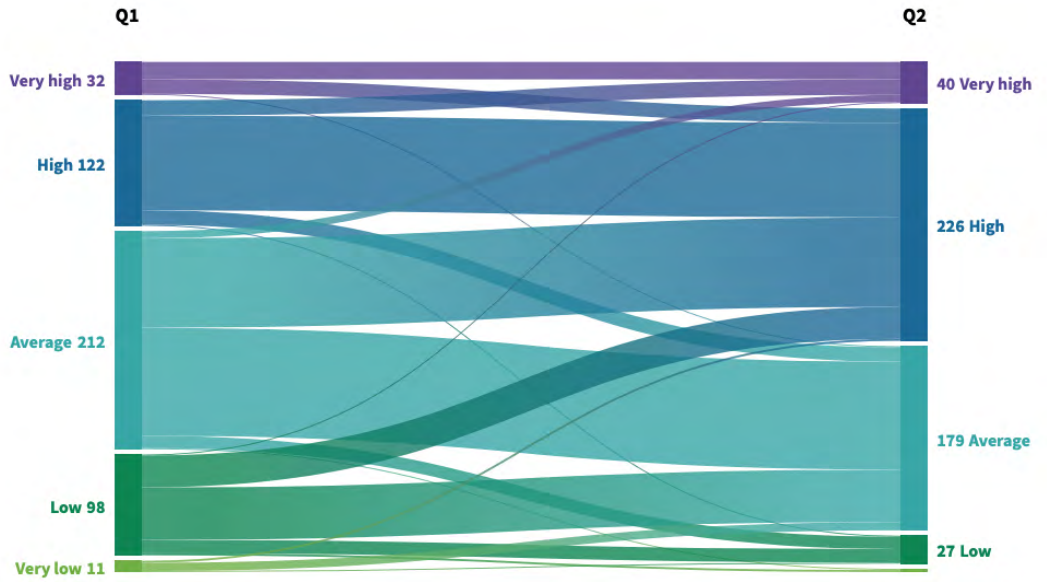


Figure 1. Self-assessment of the knowledge level[24]

For a long time, knowledge was considered the central indicator by which the effect of science communication and education could be measured. For example, numerous studies investigated whether factual knowledge is consolidated after reception. However, as part of a deliberate move away from the deficit model, a dialogue with recipients and therefore other indicators came into focus, such as trust and others.[25] Nevertheless, knowledge continues to be a key indicator of the quality of science communication activities. In particular, when a decrease in knowledge becomes apparent, this is evidence either of the complexity of a topic or of a lack of an efficient teaching and learning process.

Apart from the objective knowledge, self-reported knowledge can also be used as an indicator of the quality of a training or an activity since even though it cannot be correlated to the conceptual knowledge[26] it can have influences in decision making.

Therefore, within the Science Camps, students' self-assessment of knowledge on the respective topics was examined before and after the activities. The results showed that the level of self-reported knowledge increased for the most part across all topics. Before the Science Camps, the level on the topics of VAX, CAM and GMOs was in the midrange. Whereas, on the topic of CC, it was comparatively high even before the activity. The variation between the questionnaires then is consistently positive. However, the variation for CC is significantly lower. This was not surprising, since the topic is well known worldwide, especially among younger groups, at least since the emergence of the Fridays for Future movement. Therefore, a higher level of self-assessed knowledge even before the activities can be assumed here.

In summary, the positive variation shows the beneficial effect that a science camp can have on the participants' self-reported level of knowledge. However, this was to be expected, since the transfer of knowledge goes hand in hand with a scientific examination of the topics and also usually is a key objective. However, this success always depends on the implementation of the individual activity.

It is also interesting to highlight the effect the VSC had on some students, who reported a lower level of knowledge after the activity. Most probably because they became aware of the limitations of their actual knowledge.

24. The questions and possible answers vary among the different topics. For further detail on questions see table 1
25. E.g. Bucchi, M. (2008). Of deficits, deviations and dialogues: Theories of public communication of science. In Handbook of public communication of science and technology, Routledge.
26. Bell, B. S. & Federman, J. E. (2010). Self-assessments of knowledge: Where do we go from here? [Electronic version]. Retrieved on March 10, 2021, from Cornell University

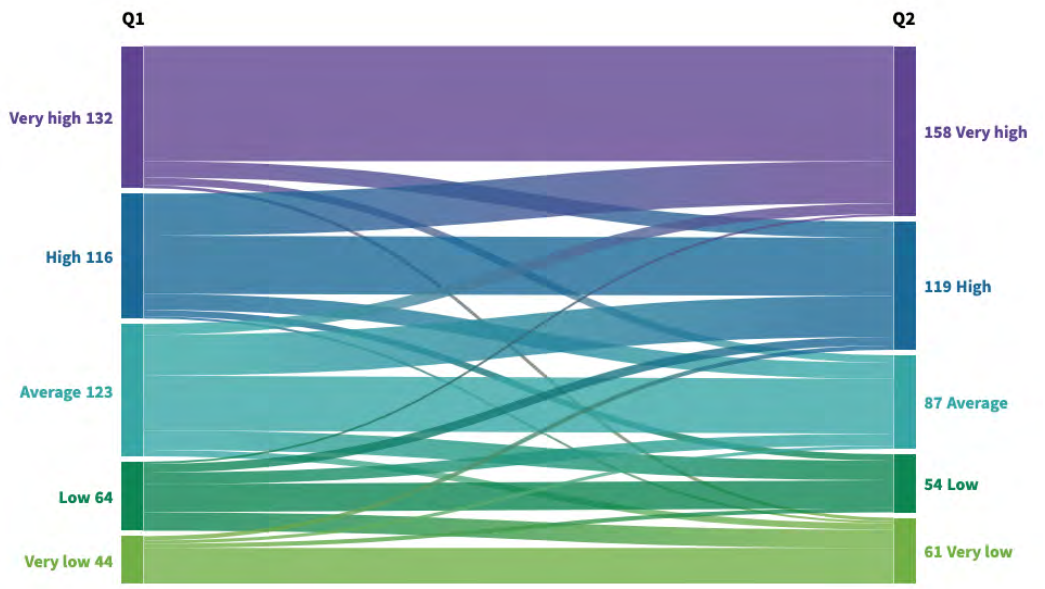


Figure 2. Self-assessment of perception level.[24]

In general, data collected before and after the science camps highlight noticeable differences in the levels of perception of students.

In the case of climate change there are considerable variations in the higher level of perception regarding the influence of the phenomenon in daily life. The activities of the science camps have therefore increased the level of sensitivity on the subject.

Also, in the case of vaccines it is noted that the students have declared a greater conviction about the possible advantages and very few have demonstrated doubts about their effectiveness.

In the case of GMOs, the number of those who recognise their usefulness has tripled between the pre and post phase of science camps. It is also interesting to note that the people with a neutral position towards GMOs at the end of the science camp are half of those who had chosen this position before the science camps.

Perceptions of alternative and complementary medicines have changed after science camps towards more critical positions that recognise greater disadvantages in their use. However, the fact that in some of the GMOs and CAM activities carried out, the perception levels decreased, which balances the overall change in perception seen in figure 2.

The results achieved during the science camps highlight that the development of students' interest through a more meaningful, authentic, relevant and contextualised science education makes it possible to decisively influence their perception.

Trust

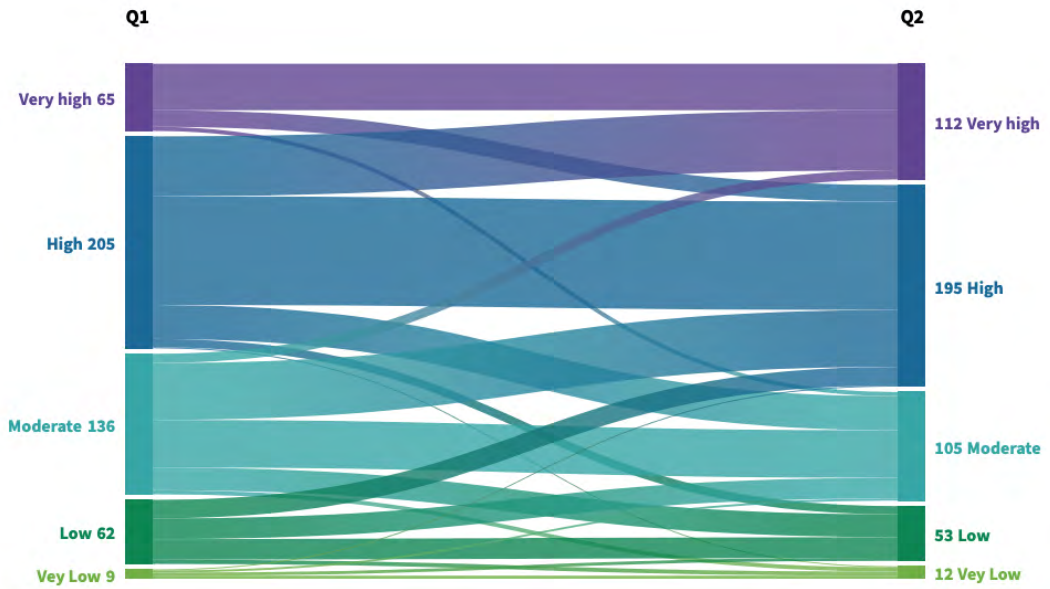


Figure 3. Self-assessment of trust levels[24]

Trust is affected by various factors such as gender, culture, political ideology and even how science information reaches us, along with one's own level of knowledge regarding a topic. Usually, the highest levels of trust are based on facts that cannot be refuted.[27]

Initially it can be noted that participants are very trustful of what the scientific community predicts regarding both climate change and vaccines, while levels of uncertainty and disagreement are highest regarding alternative medicines and GMOs. After the science camp activities, it is assessed that the levels of trust regarding vaccines slightly exceed those regarding climate change. Thus, the levels of climate change, although they were strengthened, did not do so significantly, because they were quite high already. It is also important to point out that students' trust levels have increased in all topics except for complementary and alternative medicines.

Students showed low levels of uncertainty in all topics except when it comes to GMOs, where almost half of the participants place themselves as being unsure about the statements. These doubts decrease after the contact with specialists in general, apart from CAM.

Climate change is also the topic in which one can observe very low levels of mistrust and these are maintained after the science camps. The same is not observed with vaccines and CAM that present slightly alarming values, but which decrease after the activity. In genetically modified organisms there is a negative reinforcement, i.e., participants started to distrust science more.

It is believed that these levels of trust reflect the levels of knowledge and information that the students show before and after the science camps, since climate change levels are high and tend to intensify, while at the beginning the other topics show average levels of knowledge and the unawareness decreases dramatically. The increased level of knowledge and information causes students to become more critical about science information. This relationship may explain the rise of distrust in science regarding GMOs and CAM statements because there is not as much research and information as there is for climate change and vaccines in the countries where the science camps took place. The students' poor or insufficient knowledge about CAM and GMOs is mirrored in their levels of trust in scientists.

27. Scarfuto, J. (2020, Feb, 16), Do you trust science? These five factors play a big role. Retrieved from Do you trust science? These five factors play a big role | Science | AAAS)

Beliefs

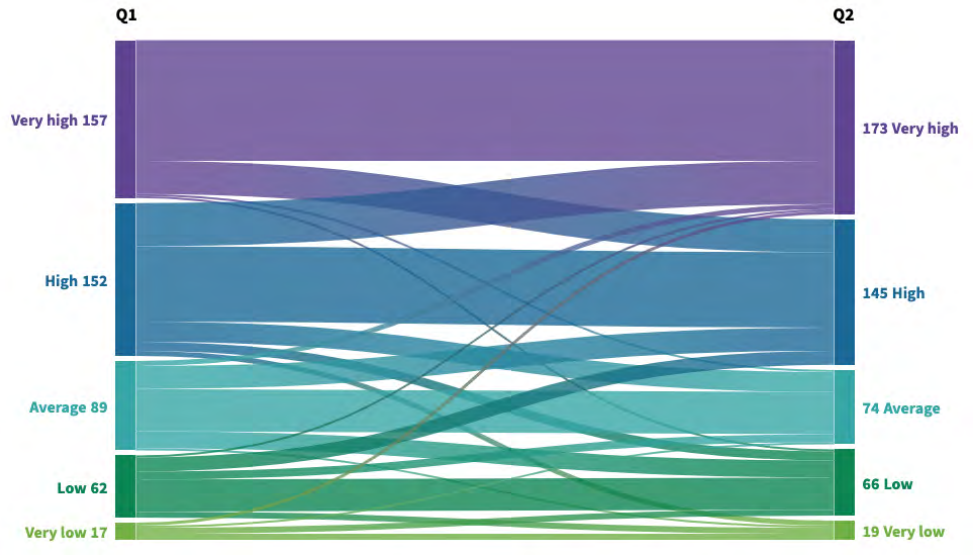


Figure 4. Self-assessment of belief levels[24]

Beliefs play a key role in human cognition and can modify our psychological state and even our behaviour. Interestingly, recent studies suggest that believing in science can play the same compensatory role as the one usually associated with religious belief.[28]

As for trust measurement, participants had a strong belief in science relations with social issues for climate change and vaccines, while levels of disbelief were greater for GMOs and CAM. Again, after the science camp activities, the levels of beliefs regarding vaccines slightly exceed those regarding climate change. In both cases, though, the levels of belief were strengthened, even though they were very high before the activity. It is important to highlight that the highest level of belief increased in all topics except for GMOs, in which the disbelief seems to be slightly reinforced.

Students show low levels of uncertainty and disbelief for climate change and vaccines. However, for GMOs and CAM more than half of the participants placed themselves as not sure or disbelieving the statements. These doubts slightly decreased after the training activity in general, apart from GMOs. Levels of belief are related to the degree participants endorse the legitimacy of the science statements presented, and therefore, the legitimacy of the scientific approach before and after the SCs. These levels can be related to different factors, from the perceived scientific consensus to their daily experiences, also related to their perceptions. In the case of climate change, students may perceive there is a scientific consensus on the cause of climate change and that is reflected in the high beliefs in climate change before and after the SC. In the case of vaccines, although in some countries the anti-vaccines movements may be arousing, there is still a strong belief in the benefits of vaccinating children. The opposite happens with GMOs and CAM. For the former, the differences between the European laws applied to GMOs and all the benefits scientists claim they have, make participants perceive scientists may be biased and exaggerate their benefits, this can be reflected in the reinforcing of disbelief for this topic. Finally, in the case of CAM, their beliefs may be influenced by their daily experiences and the distrust of pharmaceutical industries, and the belief there is not as much research and information as there is for western conventional drugs.

28. a) Farias, M., Newheiser, A. K., Kahane, G., & de Toledo, Z. (2013). Scientific faith: Belief in science increases in the face of stress and existential anxiety. *Journal of experimental social psychology*, *49*(6), 1210-1213; b) Uzarevic, F., & Coleman III, T. J. (2020). The psychology of nonbelievers. *Current Opinion in Psychology*, *40*, 131-138

Topics

Climate change

The topic of climate change has confirmed that young students have a rather stable position. In terms of knowledge, perception and beliefs, stability is noted in all countries, especially in Spain where no decrease in mobility could be seen. Portugal, Germany, Slovakia and Italy confirmed the stability as well with small changes in different positions. A higher mobility in the position of students is noted in Portugal regarding beliefs and trust and in Slovakia regarding the perception.

The level of knowledge on the topic of climate change was quite high even before the SC activity and the variation between the questionnaires are significantly lower as the topic is well known especially among younger groups. We can see slight growth in the knowledge for each country, but most student's knowledge remains unchanged.

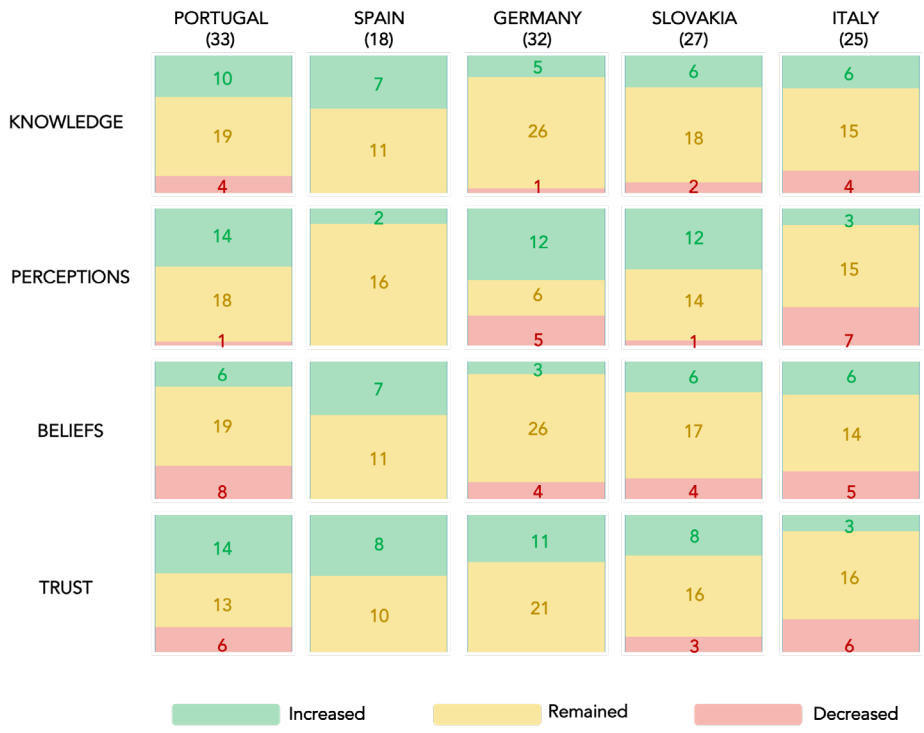


Figure 5. Visual representation of the variation in the levels of knowledge, perception, beliefs and trust for climate change.

There are considerable variations in the higher level of perception regarding the influence of climate change in everyday life. The activities of the SC have increased the level of sensitivity on this subject, especially in Portugal, Germany, and Slovakia.

The levels of belief were strengthened per each country, even though they were very high before the SC activities in the topic of climate change. Students show low levels of uncertainty and disbelief for climate change per each country.

The students are trustful of what the scientific community predicts and points to for climate change and we can see that after the SC activity the trust increased per each country. The level of trust was not strengthened significantly, because it was quite high already before the SC activity. Climate change is also the topic in which we observed low levels of mistrust and these are maintained after the SC.

Genetically modified organisms (GMOs)

The level of knowledge about GMOs increased in almost every country (good or very good) showing that students considered to have learned meaningful science information during the SC activities. In Italy, students considered their knowledge either increased or remained the same as before the VSC. Notwithstanding, in general, the impact of the VSC was not strong enough to present strong variations in their perceptions as students considered GMOs to still have slightly more advantages. However, in Slovakia they clearly changed their perceptions as the majority changed from equal advantages and disadvantages to more disadvantages. This was probably due to the fact of very low knowledge about GMO's in Slovakia in general. After the science camp new knowledge increased in this topic among students who became more critical and raised their distrust in science regarding GMOs.

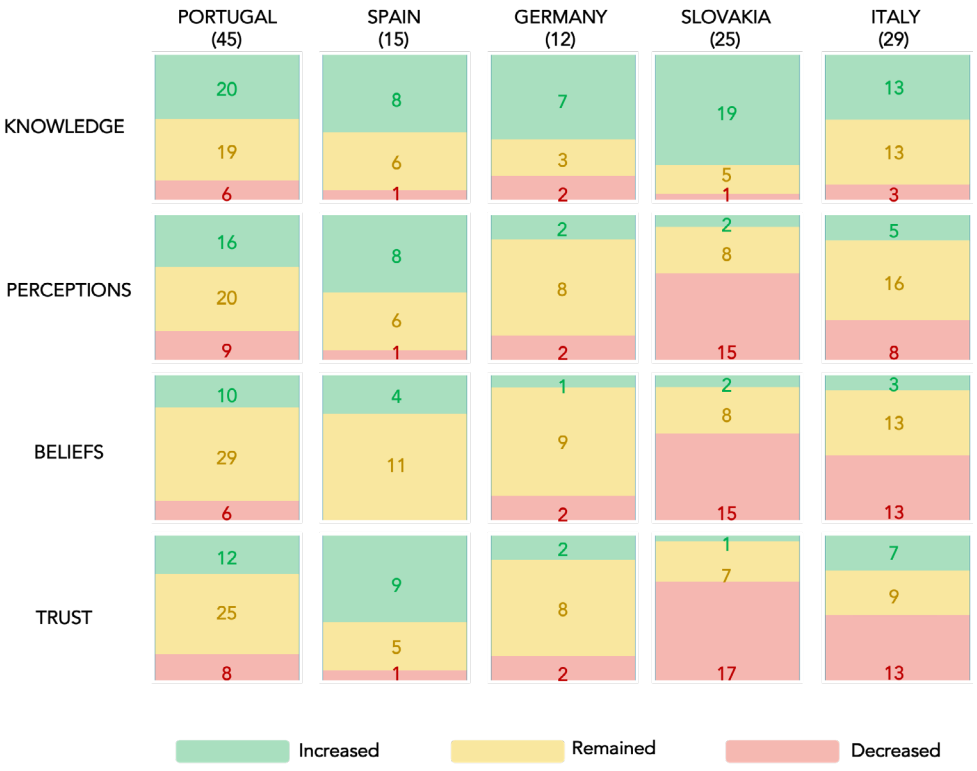


Figure 6. Visual representation of the variation in the levels of knowledge, perception, beliefs and trust for GMOs

Similarly, in terms of beliefs, the most expressive variation was in Slovakia as students showed a more negative belief on the possibility that GMOs will save future generations from hunger though countries such as Portugal and Italy also faced a little negative change. Finally, the assessment students made regarding the risks and benefits of scientific and technological research on GMOs also presented a stronger variation in Slovakia reinforcing the existing risks. That was also the case in Italy where students reassessed their trust levels more negatively. Conversely, in Spain more students changed towards the benefits surpassing the risks. In Portugal and Germany, the majority of the students did not change their views about trust.

Complementary and Alternative Medicine (CAM)

As for GMOs, students perceived their level of knowledge had increased after the ScienceCamps. Interestingly, students from Portugal, Germany and Spain decreased their positive perception in CAM and increased their level of trust whereas in Slovakia there was an increase in positive perception of CAM and a decrease in the level of trust. However, even though German students also decreased their level of belief, Spanish and Slovak students maintained it, while Portuguese students increased their level of belief in CAM. This can be explained by the level of scepticism and uncertainty Portuguese students showed towards the topics that are less discussed in the social sphere, since even though their perception and trust was slightly changed, it still remained in the level of uncertainty.

The Spanish case was also particular since after the SC, participants maintained their belief that CAM are a risk for public health, reinforced their trust in conventional medicine and considered medical treatments not based on scientific evidence should be discouraged but still perceived that CAM have more advantages than disadvantages, probably because of the wide discussion about the placebo effect during the SC.

Finally, we should highlight that in Slovakia, the SC seemed to have reinforced the positive views towards CAM.

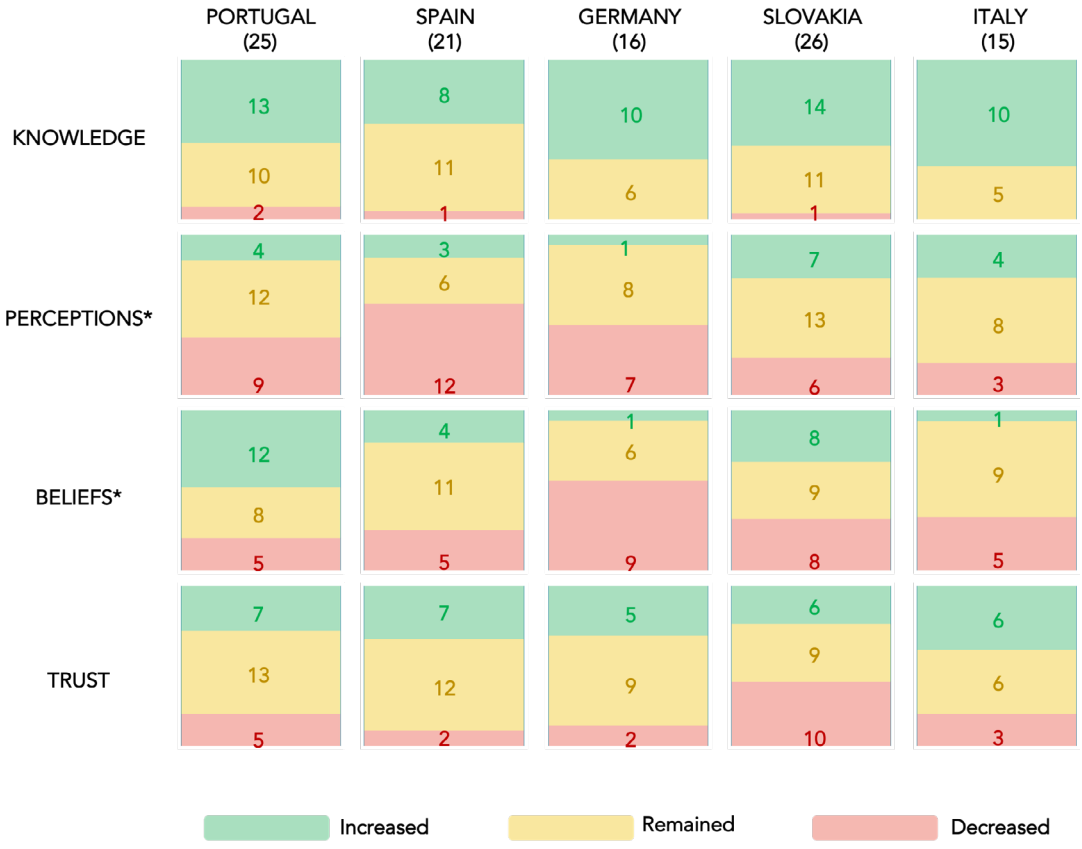


Figure 7. Visual representation of the variation in the levels of knowledge, perception, beliefs and trust for CAM.

* In these cases, the increase means an increase in a positive perception and belief in CAM, therefore, a decrease in positive perception and belief in science.

The differences in variations can be due to multiple reasons, mainly cultural and social differences, composition of the sample, the talk of the expert and the issues discussed afterwards.

Vaccines

Although the topic of vaccines has developed different positions at the general population level, it is noted that young students have a rather stable position. Both in terms of knowledge and in terms of perception and beliefs, stability is noted in Portugal, Germany, Slovakia and Italy. Greater mobility in the position of students is noted in Spain with regard to beliefs and trust.

It can therefore be said that the students who participated in the Science Camps have an optimistic view of vaccines and therefore do not seem influenced by campaigns of refusal or criticism of vaccination coverage.

Indeed, as for the knowledge measurement, in general, students recognise a medium-high level of knowledge of the topic and after the VSC the participants generally maintained or increased their level of knowledge in all countries.

Scepticism towards vaccinations does not seem to be present among university students: indeed, most of the VSC participants' already had a strong pro-vaccination attitude and the students have widely debated about how to deal with opponents of vaccination and how to combat fake news.

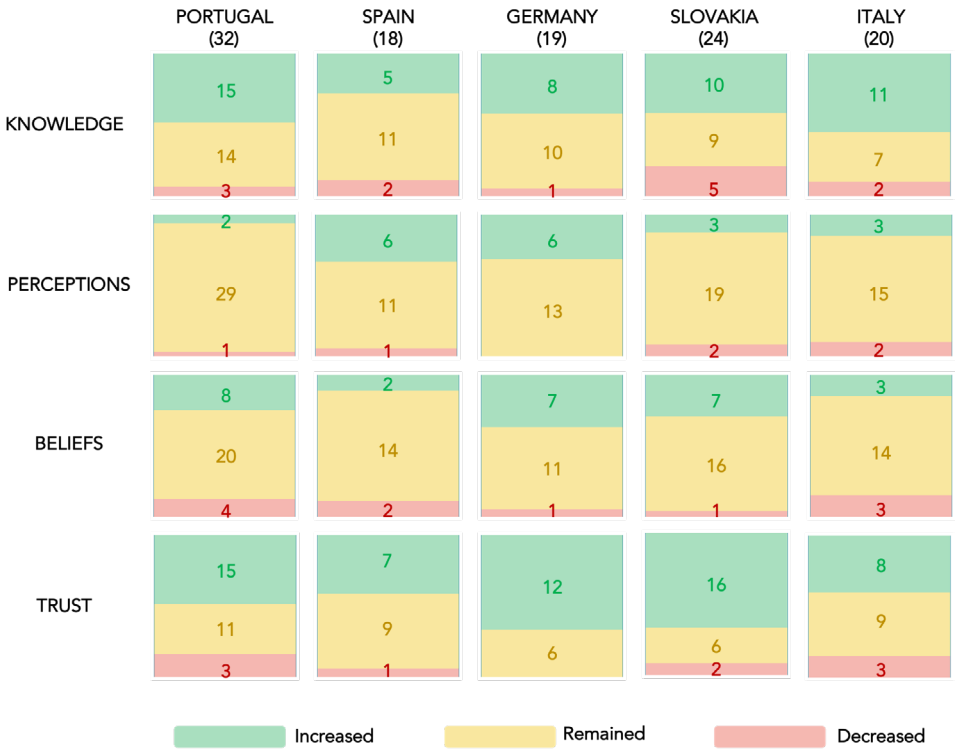


Figure 8. Visual representation of the variation in the levels of knowledge, perception, beliefs and trust for vaccines.

Virtual Science Camps took place during the summer – at the end of the first wave of Coronavirus pandemic – and after the "second wave" when the discussions about possible vaccines against SarS-CoV-2 were beginning. This fact has largely influenced the discussion and it is possible that it has influenced the participants perception.

However, the participants were strong supporters of scientific theories and the benefits of vaccinations and, again, after the VSC activities, the perceptions regarding vaccines remained substantially stable with a slight shift in positive.

The high level of trust in science, and the agreement on official scientific positions also has repercussions on the level of beliefs and the participants show high levels of certainty and accord to science statements. The level of belief, after the SC activities, were strengthened in all countries, except in Italy and Spain where it remained stable.

Summary

In summary, an influence of the Science Camps on the students' knowledge and attitudes is noticeable. For the most part, the participants develop into a positive direction in all four categories. However, it should be noted that in most cases a positive attitude towards science already existed before the Science Camps. Thus, most responses across all categories are already in the "Moderate" to "Very High" range even before participating in a Science Camp (see Figure 1-4). However, the fact that students have a positive attitude towards science given their current situation within life was to be expected, and it is encouraging that there has been a further increase beyond this.

However, the visualisations of the variation per topic also show that the effects are strongly dependent on the individual implementation of the science camps (see Figure 5-8) as well as the given topic. A stronger impact of the respective realisation of the Science Camps seems to be particularly visible for the topics GMOs and CAM. Here, there is comparatively more decrease after participation. In contrast, the changes in the topics of climate change and vaccination, which are particularly present worldwide, seem to be less noticeable. Nevertheless, the success of the events and the impact on the questionnaire strongly depends on many different factors, which can result from both a cultural and social context. For advice on how to successfully implement Science Camps or other formats with which the tool is applicable, see Annex 3.

4. Common questions posed by participants on each topic

The experience of the Science Camps in five countries, in particular the contribution of the experts who made presentations and engaged in a dialogue with participants allowed us to collect relevant information about the four science topics addressed[29]. This chapter contains the main questions students asked after watching the videos, as well as the answers the experts provided. We believe this can be useful for clarifying participants' doubts during science dissemination events. Additionally, we collected a list of trustworthy online resources for the four topics.

4.1 Climate change

Climate change models

What are climate models? How are they built?

The climate models are models that solve Newton's equations (Fr = m.a is the basis of all models in the physics of climate models). The equation comes from 1716 and in 1862 in France it was adapted for fluid circulation. The inferential equations that solve all the motion of a fluid, in this case the air of the atmosphere, also solve the interaction with the surface and is also associated with the law of conservation of mass (equations of motion) and the law of conservation of energy. These 4 equations are the basis of all climate or weather prediction models.

It is not possible to solve the equations for the entire globe, so the globe is divided into parallelepipeds, with various resolutions, which have evolved over time, increasing their resolution, as international reports show. The latest resolutions have introduced various components of the earth system. The earth system includes the interaction between the surface, the atmosphere, the circulation of rivers, changes in vegetation, volcanoes, clouds, solar radiation, all of which are simulated in the models. All of this is simulated in the models, which are quite complex.

Over the decades, the models have taken into account different elements such as the effect of clouds, the amount of ice, the ocean, sulphate emissions and volcanic activity.

There are several models and they coincide at the climatic level, but differ in the representation of processes on a smaller scale, so some of them show more detail. Climate models solve mathematical equations that describe the physics of the atmosphere, oceans, and land surface, make predictions and display different future scenarios for a given region. Currently there are several scenarios, some more positive that predict economic and social development, the increase in GDP, the intensification of resources to renewable energy, changes in the behaviour of society, as well as the decrease in illiteracy; there are more negative others that show the increase in carbon emissions – due to the use of non-renewable energy, reduction of urbanisation, due to temperature and the reduction of pastures.

Climate models do not take into account observed data and are not adjustable in terms of the observed data. The components of the models are developed with adjustments to the observed data made by campaigns conducted by scientists or meteorologists. As for the certification of the models, there is an international community that serves as a referee in relation to what is proposed as adjustments. The World Meteorological Organisation (WMO) is responsible for the collection and maintenance of the observations. In Europe, each of the meteorological institutes does this and therefore the WMO has some coordinating

29. We are most grateful for the collaboration of experts in climate change (Hans Schipper, DE; Andreu Escrivà, ES; Sara Moraca, IT; Rita Cardoso, PT; Katarina Strapcova, SK), GMO (Harald König, DE; Esther Molina and Àngela Vidal, ES; Giancarlo Sturloni, IT; Leonor Morais Cecilio, PT; Kačmariková Margaréta, SK), CAM (Hinnerk Feldwisch-Drentrup, DE; Salvador Máñez Aliño, ES; Francesca Busetti, IT; Joana Almeida, PT; Silvia Putekova, SK) and vaccines (Nicola Kuhrt, DE; Óscar Zurriaga, ES; Francesca Busetti, IT; Adriana Gaspar Rocha, PT; Jana Martinková, SK).

role. In other parts of the world, WMO keeps the archives or finances their maintenance and the quality of the data.

Are climate models reliable? I remember a somewhat sceptical professor who claimed that predictive models were not entirely reliable.

Obviously predictive models have uncertainty, about whether it will go up one degree, or one degree and a half, or half a degree, but there is total confidence that it will increase. So, there are many deniers – hard or soft ones – who hide behind this little uncertainty. If they tell you that the house you are in is going to collapse in a minute and you are going to die and then I tell you: "well, we don't know if it will be in a minute, or in a minute twenty... would you leave the building or not?". That is the uncertainty, of whether it will be in a minute or one and a half, but it is sure that it will collapse, there is no doubt whatsoever.

Are political decisions also included in model calculations? For example, if a certain decision is made in China to reduce CO_2 emissions or if diesel cars are banned in Germany – how does this enter into the model calculations and what does this mean for the simulation?

This is not included in the model calculations because we do not know what the future will look like. That means we have to imagine what the future could look like. And there are many scenarios for this. We don't include such concrete political decisions, because they can't be predicted precisely enough. But it is assumed, for example, that a society will actively pursue more climate protection in the future and emit less CO_2 or methane. Such scenarios, of which there are hundreds, can be on a local level, but also on a global level. It's called a spaghetti plot because there are an incredible number of lines that try to reflect the range of how humanity could develop – whether with a lot of climate protection or with less climate protection. There are very big differences between different countries, such as how many coal-fired power plants are built, but also what volcanic eruptions there could be and so on. It is clear that none of these courses will occur exactly, because we do not know what decisions the USA or China or other countries will make. Nevertheless, one of the lines will be able to describe the course approximately, because there are just so many. In conclusion, it remains to say that political decisions do not flow directly into the model, but indirectly.

I once read in the newspaper that the models are now so complex that the computers can no longer calculate it. Is that true? Would one have to simplify the models again, even if one would get less reliable statements?

No one has the model completely in his head, as the models do not consist of a long code, which is then calculated from A to Z, but that consists of very many modules, with which the attempt is made through basic research to come as close as possible to reality. There are a lot of process studies and measurement campaigns that try to check certain parts of such models, so that one becomes better in this one area, so that the whole model becomes better. Of course, the whole thing then becomes very complex at some point, but basically that is still not complex enough, because nature is even more complex. But it turns out that in the development of the last 30-50 years in this direction, there were no changes so strong that we would have been completely wrong. The increasing complexity confirms again and again the results of the past generations of models.

Impacts of climate change

What effects will climate change have in the future?

There are realistic scenarios that show an

increase in temperature between 0.5 and 1 degree, an increase in heat waves, which could become more intense and have an impact on mortality at a national level, but also at a global level and a change in precipitation levels. In the Mediterranean area, rainfall is expected to decrease. In the Iberian Peninsula, for example, there will be a reduction of rainfall around 40% south of the river Tagus. There will be a decrease in the area of South Africa and the Amazon, which will hinder the growth of vegetation and consequently the survival of the population in some areas.

Specifically, about the average sea level, there will be an increase of 1 meter (maximum), which means significant changes for low areas like Lisbon and New York, which will be flooded. Some islands of the Pacific will disappear completely.

Regarding the melting of ice caps, which corresponds to 1.7% of the total water of the globe, an increase of about 70% in sea level is expected, but it will not submerge the whole territory, since we have very high areas.
If the socio-economic scenarios that have been established come true, the worst predictions, the population will become much poorer on a global and European level. There will be an increase in asymmetries, there will be an increase in poverty, and it will be much more difficult to live on this planet.

Given the COVID-19 pandemic, what is the real impact on nature and to what extent can a few months make an impactful difference?

With the COVID-19 there was a substantial reduction in emissions. Only in Paris, there was a 70% reduction. There was a reduction in automobile traffic. If we make an energy transition in which we leave the paradigm of oil to electric, the electric one based on renewable energies, you will achieve a great reduction of gases.

The pandemic situation we are living through is an “opportunity” to rethink how we want to “restart” our lives. And “to solve a situation as complex as the one facing the world today, it is not enough for everyone to be better. The ecological conversion that is required to create a dynamism of lasting change is also a community conversion”.

Climate policy

Should international organisations make a greater appeal and pressure for more green policies all over the world, and in particular in the countries that contribute most to the climate crisis?

The European Commission and all European countries have concluded that emissions must be reduced. The European countries have coordinated the type of reduction that will be made. In Europe there is an awareness of the climate emergency and there is some consensus on the way forward. What has been observed in Europe is the economic transition from an intensive production system to an economy based on renewable energy technologies and this has brought economic benefits.

Some kind of agreement between developed and developing countries is needed to boost emerging countries’ progress in renewable energy, not coal-related energy. This will significantly limit emissions and to some extent mitigate all these problems.

It was an important point to note that developing countries increased their emissions. However, it must be taken into account that it is the multinationals established in some of these countries that do not respect the Paris Agreement.

Wouldn’t the first measure be the voluntary commitment of the States and the industry?

The voluntary commitment has not worked. What many industries have done is greenwashing: a green face wash as if they had a series of environmental commitments, but then they continue to invest in purely polluting businesses. States have sometimes

made strategies, but then application is so slow, or many times there is a lack of inspection officials to see how much is emitted, that they are very difficult to implement.

I believe that the winning triangle is legislation, personnel to execute that legislation and budget. And then also citizen commitment is important, so we are all willing and committed to accept those changes because if changes are imposed on us and we do not understand where the problem is, we are going to reject those changes. We have to understand them, demand them, ask for them and talk about them and above all promote them.

How can we improve our behaviour in everyday life to improve the situation with climate change?

Climate change is a proven fact. Global warming has caused serious changes to the planet, such as rising sea levels, extreme weather events, deforestation, disappearance of species. But as individuals we can slow down global warming by implementing small more sustainable actions within our community. Changes in the way you live your life – both big and small –can help you reduce your own personal carbon footprint, and also encourage policy makers to act for the good of the planet. Some daily habits can help to fight against climate change.

1. Reduce emissions

Use your car less, whenever possible, instead use sustainable transportation, such as bicycling, or use public transportation more often. In the case of long-distance travel, trains are more sustainable than airplanes, which cause a great deal of the CO_2 emitted into the atmosphere. If you are into cars, remember that every kilometre that you increase your speed will considerably increase CO_2 emissions and expenses. According to the EC, each litre of fuel that your car uses, equals around 2.5 kilograms of CO_2 emitted into the atmosphere.

2. Save energy

Take a look at the labels on your appliances, and never leave them on standby. Always adjust the thermostat for heating and air conditioning. By being careful how we use home appliances, we can save energy and, of course, money at the end of the month.

3. Put the 3 R's of sustainability into practice

- Reduce: consume less, more efficiently.
- Reuse: take advantage of second-hand markets, to give new life to items that you don't use anymore or find something that someone else has gotten rid of that you need. You'll be saving money and reducing your consumption. Bartering is also a practical solution.

- Recycle: packaging, waste from electronics, etc. You can save over 730 kilos of CO_2 each year just by recycling half of the garbage produced at home.

4. Reduce the consumption of meat and dairy products

In the EU, meat and dairy production is estimated to be responsible for 12-17% of total greenhouse gas emissions, while throughout the world, the global livestock industry produces more greenhouse gas emissions than all cars, planes, trains and ships combined. That doesn't mean that everyone has to become vegan or vegetarian - even a small shift in diets, with a reduction in meat and dairy products, and more plant-based foods instead, could reduce the pressure that agriculture places on the environment.

5. Avoid plastic

Plastic is the all-round material and is therefore present in pretty much every aspect of our lives. But the durability of the material (which also makes it so popular) is of course also its most drastic disadvantage: we are struggling to get rid of it. Plastic has found its way pretty much everywhere – on streets, in rivers, on the beach, in cosmetics, in wastewater, in our clothing, even in the air we breathe. And there is also a close connection between climate change and our massive global plastic

problem. Almost every plastic is produced from fossil fuels - and in every single phase of its life cycle, plastic emits greenhouse gases.

Many supermarkets in Europe support the ecological way and customers can use ecological bags, which are made of recyclable plastic, or paper bags and bags made of organic cotton.

6. Protect our forests and plant more trees
It has long been known how important forests both for the microclimate in individual regions are and for the global climate as a whole. They "feed" on CO_2 and convert the climate-damaging gas into oxygen, which is vital for our survival. A research team at ETH Zurich has compiled some fascinating figures: Two thirds of man-made CO_2 emissions could be removed from our atmosphere if we were to reforest 900 million hectares of forests worldwide. But we should not only focus on reforestation measures, but also stop the deforestation of huge areas at the same time.

How can industrial production be limited?

That is very complicated, especially since it depends on the demand from Europe. Europe has lowered its emissions, in part by relocating production to China, for example. So, demand should decrease, we should reduce consumption, especially of superficial redundant things and of all things that we are consuming at a very high rate. China has to create its own plan of where it wants to go. They now have their own plan for total decarbonisation by 2060, they want to be a kind of hyper futuristic nation that is ecological and at the same time deeply rooted in traditions.

Climate change can also be mitigated by changing agriculture, which has to be addressed differently, in the way people consume. There has to be a concern to consume seasonal products, to consume less, which will impact the reduction of industrial production.

Climate change denial

Which are the most popular arguments among people about global warming denial?
The fossil fuel industry, political lobbyists, media moguls and individuals have spent the past 30 years sowing doubt about the reality of climate change – where none exists. It is important to be able to identify the different types of denial. The below taxonomy will help to spot the different ways that are being used to convince you to delay action on climate change.

1. Science denial. This is the type of denial we are all familiar with: that the science of climate change is not settled. Deniers suggest climate change is just part of the natural cycle. Or that climate models are unreliable and too sensitive to carbon dioxide.

Some even suggest that CO_2 is such a small part of the atmosphere it cannot have a large heating effect. Or that climate scientists are fixing the data to show the climate is changing (a global conspiracy that would take thousands of scientists in more than 100 countries to pull off). All these arguments are false and there is a clear consensus among scientists about the causes of climate change. The climate models that predict global temperature rises have remained very similar over the last 30 years despite the huge increase in complexity, showing it is a robust outcome of the science.

2. Economic denial. The idea that climate change is too expensive to fix is a more subtle form of climate denial. Economists, however, suggest we could fix climate change now by spending 1 percent of world GDP. Perhaps even less if the cost savings from improved human health and expansion of the global green economy are taken into account. But if we don't act now, by 2050 it could cost over 20 percent of world GDP.

3. Humanitarian denial. Climate change deniers also argue that climate change is good for us. They suggest longer, warmer summers in the temperate zone will make farming more productive. These gains, however, are often offset by the drier summers and

increased frequency of heatwaves in those same areas. Deniers also point out that plants need atmospheric carbon dioxide to grow so having more of it acts like a fertiliser. This is indeed true, and the land biosphere has been absorbing about a quarter of our carbon dioxide pollution every year. Another quarter of our emissions is absorbed by the oceans. But losing massive areas of natural vegetation through deforestation and changes in land use completely nullifies this minor fertilisation effect. Climate change deniers will tell you that more people die of the cold than heat, so warmer winters will be a good thing. This is deeply misleading. Vulnerable people die of the cold because of poor housing and not being able to afford to heat their homes. Society, not climate, kills them.

4. Political denial. Climate change deniers argue we cannot take action because other countries are not taking action. But not all countries are equally guilty of causing current climate change.

For example, 25 percent of the human-produced CO_2 in the atmosphere is generated by the US, another 22 percent is produced by the EU. Africa produces just under 5 percent.

5. Crisis denial. The final piece of climate change denial is the argument that we should not rush into changing things, especially given the uncertainty raised by the other four areas of denial above.

Deniers argue that climate change is not as bad as scientists make out. We will be much richer in the future and better able to fix climate change. They also play on our emotions as many of us don't like change and can feel we are living in the best of times – especially if we are richer or in power.

Some deniers maintain that climate change is not generated by humans because CO_2 is denser than air and remains low, so it cannot generate such effects. How would you refute such an argument?

CO_2 may be denser than air, but it will not stay because if not, we could not breathe. If it was really denser than nitrogen, oxygen, etc., what would happen is that it would be at ground level and we would not be here breathing and talking.

CO_2 is distributed in a non-homogeneous way in the troposphere, (the lowest and dense layer of the atmosphere), but obviously the point is that it is capturing that heat at the tropospheric level. It does not go up to the stratosphere, or the ionosphere, of course. In fact, in one of the evidences that supports climate change is that, from the troposphere to the stratosphere, what is called the tropopause, much less heat comes out, that is, it is retained within. The layers of the atmosphere are segmented in some way, like this famous ozone layer (which has nothing to do with climate change), so there you can see that the bulk of this accumulation of heat and the greenhouse effect occurs in the troposphere, but CO_2 does not stay at ground level. CO_2 is diluted, mixed and air also has circulatory components that go far beyond the determination by its own density, just like fluid issues. There are winds, currents, storms that go much further than whether the density is a little higher or a little lower.

Online resources

1. Intergovernmental Panel on Climate Change
2. Global Climate Change Vital Signs of the Planet, NASA (USA)
3. Climate Kids, NASA (USA)
4. Teaching climate, National Oceanic and Atmospheric Administration (USA) 5. Climate.gov Science and Information for a Climate-smart Nation
6. Eurobarometer Climate Change 2019, European Commission
7. Global Climate Change: What You Need to Know, Melissa Denchack, 2017, NRDC
8. Climate Change and You, European Commission
9. Causes and Effects of Climate Change, National Geographic, Youtube
10. Is it too late to stop climate change?, Kurzgesagt, YouTube
11. Climate change impacts in Europe, European Environmental Agency, YouTube

4.2 Genetically Modified Organisms (GMO)

Technique related

What does GMO mean? What is a GMO?

Genetically modified organisms (GMOs) are living organisms whose genetic material has been artificially manipulated in a laboratory through genetic engineering. This creates combinations of plant, animal, bacteria, and virus genes that may not occur in nature or through traditional crossbreeding methods. When we talk about transgenics in particular, we are talking about "*organisms that have in their DNA a part that is not of their species, which is of a different species*".

Most commercial crop GMOs have been engineered to withstand the direct application of herbicide and/or to produce an insecticide. However, new technologies are now being used to artificially develop other traits in plants, such as a resistance to browning in apples, and to create new organisms using synthetic biology.

How are organisms modified and how are these modifications selected?

It depends on the organism and the kind of modification desired. If one is talking about plants, the technique most commonly used is *Agrobacterium tumefaciens,* a bacterium that naturally infects the plants and transfers its own DNA into the one of that plant.

If we talk about animals or microorganisms, this is done differently. There are different vehicles to introduce the DNA of interest, such as a gene with a specific promoter (that is to say, a gene with a section that controls the expression of that gene or other related genes).

These modifications have to be later selected, because we need to be sure that the organisms are transformed, and this transformation is not 100% effective. In the past, selection genes that give resistance to antibiotics were used and therefore plants, animals and microorganisms were cultivated in environments that contain this antibiotic. The not transformed organisms could not survive and those transformed did. There are other selection genes which give organisms other easily noticeable properties for selection, such as fluorescence, by using a gene from jellyfish.

What is the purpose of producing GMOs?

There are several reasons. Namely, to produce organisms with extra properties of interest for humans. Modified organisms may have advantages compared to those that have not been genetically modified. For example: increased productivity e.g., crops that grow faster and with less fertilizer input.

Another objective may be to produce plants with desirable characteristics that they do not naturally possess, but which are beneficial when consumed. For instance, Golden Rice has a gene allowing the production of a precursor of vitamin A, a fundamental nutrient to correctly develop eyesight. There are populations in the far-east countries that live exclusively on rice, with no or little access to anything else and have serious eyesight problems, including blindness; so, this rice is a way to provide them with vitamin A. The idea of producing Golden Rice is already 20 years old but it was authorised just recently in 2019.

Currently, the only GMO produced in the European Union is a type of corn, called BT corn. It greatly reduces pollution by producing a protein that fights invasive insects, so when they eat its leaves, they die shortly. This avoids the use of external insecticides.

Another example: insulin, a molecule widely used to treat diabetes, is produced by GMOs. The current molecule used is therefore human insulin; this revolutionised the treatment of

diabetes at the time. Before then, insulin had to be extracted from animals, was very expensive and people with allergies had contraindications. In the future, GMOs might be used to produce edible vaccines. There are already lines of research that use plants for vaccine production. In fact, one of the vaccines for Ebola, tested in the last two outbreaks, was already produced in plants. However, most edible vaccines are not yet in use. This research was thought for countries where it is difficult to vaccinate the population. The main idea would be to get a fruit tree that could produce a vaccine directly in its fruits. This way the population would eat it and not go through the discomfort of taking the injection and saving money in the process. In summary, the aims with which GMOs are produced are diverse.

What foods contain GMO?

Overall, not many different types of foods are genetically modified. But of those foods that are, the GM percentage is high. For example, about 90% of corn, canola, soy and cotton grown in the US is genetically modified. Other GM crops in the US include alfalfa, canola, cotton, papaya, potatoes, eggplant, squash and sugar beets. A few other GM crops have been approved by the FDA, such as the Arctic Apple, which resists browning, and the Innate Potato, which also resists rotting.

While it's unlikely that the product you are buying on a regular basis is genetically modified, it's hard to find any processed foods without a single GM ingredient, because corn, canola and soy are so widely used in processed products, like cookies, juice, granola bars, cereal and frozen meals.

Are there genetically modified animals?

Yes, genetically modified animals exist, particularly for research purposes, especially mouses.

There is also a genetically modified salmon available that has genes that allows it to grow and develop faster and with less food, while being more resistant. Of course, this salmon is raised in closed only male tanks and made sterile. Therefore, if there is a leak it is not possible that their genes are passed onto wild salmons.

Another interesting case is that of mosquitoes. There are studies on mosquitoes that transmit malaria and also zika virus. These modified mosquitoes, unable to infect people, are used in geographical areas with zika problems, as in Brazil. When they are let go into the environment, they mate with the wild mosquitoes and their descendants die. Therefore, their population decreases, stopping the spread of the disease.

Potential risks

Are there problems with pollinating insects?

Regarding BT corn, a study was published some years ago connecting the death of monarch butterfly larvae and BT corn. However, studies published later on PNAS, indicate that there was no correlation between the production of this particular corn and these butterflies and other insects.

What care should be taken with GMO cultures? GMO plants cannot escape and destroy other plants. However, **there is a good chance that their genes may escape via pollen and pollinate other plants.** For this possibility to be reduced, crops are cultured several meters apart from other similar cultures. Besides, in the case of corn, it is known that corn pollen cannot pollinate other crops, only corn. Therefore, avoiding proximity with conventional corn fields may be enough.

Is there an interest in making GMOs sterile?

Connecting with the previous question, GMOs sterility is a requisite in order to avoid

hybridisation with other varieties. For the researchers there is no-hidden-economic-interest, especially because farmers are used to buying seeds in conventional farming as well.

What are the main issues of concern for human health?

The scientific consensus to date is that GMOs do not pose health risks to humans. GMOs have been heavily studied and new GM crops must go through an evaluation and approval process through the FDA. If the FDA doesn't determine they are safe, they won't reach the market.

The WHO says that because all GM crops are different, there shouldn't be a blanket statement about whether all GM foods are safe or not – but the organisation follows with "*GM foods currently available on the international market have passed safety assessments and are not likely to present risks for human health. In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved*."

While there are some studies that have reported potential health risks, a 2017 review of studies usually cited as evidence of adverse effects of GM food found that most of those studies were invalid due to conflict of interest, flawed study design or poor implementation.

Years ago, a scientist published an article highlighting potential health risks of GMOs. How did the story end? Are there updates?

The story ended with a stalemate. The study was conducted on laboratory mice. Humans are not mice, and the results we get on mice can't always be transferred to humans. Furthermore, the study also presented important methodological deficits, so much so that in other laboratories they were unable to replicate it. There is therefore no evidence that GMOs are harmful from the point of view of human health.

What are the environmental risks?

Environmental groups initially ridden the fear that GMOs were potentially harmful to health. There is no scientific evidence on this point. The environmental impact of GMO crops on which scientists are continuing to investigate is quite different. For clarity: the problem does not concern GMOs per se, but monocultures in general for which forests are cut down, etc. The only difference, if anything, is that some more pesticides and fertilisers appear to be used on GMO crops, but the environmental problem concerning intensive GMO crops are shared with conventional agriculture as well.

Have longitudinal studies been conducted to understand the effects of GMOs on health?

Longitudinal studies have been conducted following cohorts of people over long periods, trying to understand what impact there may be. It must be clear, however, that science never has a definitive answer. We may not yet have detected the problems caused by GMOs, given that the human organism is a complex system in which it is difficult to study the effect of something, excluding everything else. However, scientists – epidemiologists in particular – have investigative techniques that allow them to isolate certain factors. What we can say is that, to date, no one has found the "smoking gun" that traces GMOs to potential risks to human health.

Can some mutations that are produced in the laboratory also be produced in a more "natural" way, perhaps through crossing species?

Certainly. This is true and there are many examples. Just think of the varieties of wheat that have been obtained by crossing different types of grains. We must also consider a new factor: the new CRISPR technique makes what is produced "artificially" indistinguishable from what can also happen in nature since it allows DNA to be modified in a very precise way. An additional problem because it will be difficult to understand whether the mutation occurred naturally or not.

GMOs promised to reduce the use of fertilisers or pesticides. Instead, it seems to have increased.
This is certainly true. The reduction of fertilisers and pesticides was a promise that was not kept. Studies conducted in the United States confirm that more fertilisers and pesticides are used in GM crops than in traditional crops.

Policy and ethics related

Is European legislation on GMOs based on science?

In Europe, public opinion has a big impact on legislation. For example, producers have to declare in labels if the product contains over 0.9% of GMOs. There is no reason to establish the minimum on 0.9%, yet the fact that the "warning" is there may lead people to think there are problems with GMOs.

What rules are there and what conditions are necessary for a scientist or a laboratory to work with this material?
Two different situations must be distinguished:

- The use of GMOs to be consumed as food, even animal food.
- GMOs that are produced for research purposes only.

A lot of research is dependent on genetically modified organisms and to work with them, laboratories need to fulfil special conditions. These labs need to have special permissions depending on whether they are working with animals, plants or microorganisms. In the case of the EU, there are many directives that member states have to comply with in order to work with these materials.

How can science advance without exceeding ethical limits?

Nothing is impossible with a great deal of information. Information about the processes, information about the dangers. Only a well-informed population can control scientists. This is because scientists do not work alone, they are dependent on funds to continue their studies, and those funds come from governments that are elected by the people.

Behind GMOs there are many years of research and those that are approved are those that had advantages and could not be proved to be harmful.

From an ethical point of view, GMOs in general are not good or bad, that is case by case scenario. It is a different situation to talk about a genetically modified bacteria or to talk about a genetically modified mosquito.

However, if some GMOs are passed on to the environment, there is a risk of increasing resistance to antibiotics. But this risk is unlikely. The great danger is the passage not of the whole organism, but of the piece of DNA that can be transmitted. For example: bees can carry the pollen of a transformed plant. If this pollen pollinates a wild plant nearby there is the danger of this gene passing to the environment. In Europe genetic modification in humans is forbidden. And in order for any genetically modified crop to be accepted, it is necessary to go through a very detailed process. If approval is granted, it is valid for 10 years only. After this period, it is

necessary to go through the same process. **Should a product be labelled as genetically modified if it contains an ingredient that has been genetically modified?**

Labelling is required in countries including the 27 member nations of the European Union, Australia, New Zealand, Japan, Korea, Brazil and China.

However, since their commercialisation in 1992, the U.S. Food and Drug Administration (FDA) has rejected labelling of GMO foods in the USA.

Online resources

1. The necessary "GMO" denialism and scientific consensus, Journal of Science Communication.

2. Controversial medical and agri-food biotechnology: a cultivation analysis, Public Understanding of Science

3. Special Eurobarometer - April 2019 "Food safety in the EU"

4. Why Gene Editing Is the Next Food Revolution, National Geographic

5. U.S. Food and Drug Administration, Why Do We Have GMOs? U.S. Food and Drug Administration U.S. Food and Drug Administration YouTube channel

6. The Science of GMOs, Purdue University

4.3 Complementary and Alternative Medicine (CAM)

Are CAMs charlatanism?

Non-believers of complementary and alternative medicines place them at the level of charlatanism. One of the reasons why they classified CAM this way is because they have no scientific evidence to back them up and because CAMs follow principles different to those of conventional medicine. They might follow explanations that are not rational, such as in the case of acupuncture e.g., insertion of needles in certain energy points that stimulate energy. For the conventional physician the explanation would be the activation of nerves in the brain, rather than the establishment of energy. In the case of homeopathy, it is explained, for most physicians, as quackery, witchcraft or placebo. For example, in the 1990s, the Order of Physicians referred to homeopathy as snake oil, because the active ingredient of the drug is diluted numerous times that there is no active ingredient in the remedy capable of having an impact. However, according to homeopaths, water has memory and registers the action of the drugs.

What are the differences between traditional medicine and CAM? What can be considered as an alternative medicine?

Traditional medicine has a long history. It is the sum total of the knowledge, skill, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness.

The terms “complementary medicine” or “alternative medicine” refer to a broad set of health care practices that are not part of that country’s own tradition or conventional medicine and are not fully integrated into the dominant health-care system. They are used interchangeably with traditional medicine in some countries. Complementary health approaches include:

Natural products: This group includes a variety of products, such as herbs (also known as botanicals), vitamins and minerals, and probiotics. They are widely marketed, readily available to consumers, and often sold as dietary supplements.

Mind and Body Practices: Mind and body practices include a large and diverse group of procedures or techniques administered or taught by a trained practitioner or teacher. Yoga, chiropractic and osteopathic manipulation, and meditation are among the most popular mind and body practices used by adults. Other mind and body practices include acupuncture, relaxation techniques (such as breathing exercises, guided imagery, and progressive muscle relaxation), tai chi, qi gong, hypnotherapy, Feldenkrais method, Alexander technique, Pilates, Rolfing Structural Integration, and Trager psychophysical integration.

Other Complementary Health Approaches: Some complementary approaches may not neatly fit into either of these groups – for example, the practices of traditional healers, Ayurvedic medicine, traditional Chinese

medicine, homeopathy, naturopathy, and functional medicine.

Can placebo be curative? If it cures, why not use it?

It is necessary to distinguish between placebo and a placebo effect. A placebo is a substance or treatment that does not have an explainable biological effect on the disease. On the other hand, the placebo effect is the biological response to the administration of a placebo. Currently, the placebo effect is considered an integral part of the total effect that follows any therapeutic procedure along with others.

Any treatment that is performed has a part of effectiveness due to the placebo effect.

The placebo effect is still somewhat difficult to explain, but real and quantifiable. According to experts, to begin with, the initial expectation of patients is of vital importance. Of 100% effect of a drug, up to 50% may be due to the placebo effect and this is manifested in terms of the expectation's patients have about it. **In fact, there are doctors who have a placebo personality, that only because of how they treat they induce the improvement of the patient.**

Many factors have an influence in the placebo effect: from the doctor's speech (if they look in the eyes, if the message they give is positive…) to the physical characteristics of the drug. For example, the size of the tablet (larger, more effect), or the colour. And if instead of a pill it is an injection or a surgery, the effect is even greater.

Do alternative medicines really cure patients?

Worldwide, the idea of curative is being replaced by preventive and palliative. Just like the idea of treating acute pain is being replaced by the treatment of chronic pain. An area where conventional medicine has not been successful. Currently the British government includes acupuncture as a possible treatment for chronic tension-type headaches and migraines.

Are there any types of CAM that can be proved by scientific evidence?

Complementary and alternative medicine is not as well researched as conventional medicine, which undergoes intense research before release to the public. Practitioners of science-based medicine also discard practices and treatments when they are shown ineffective, while alternative practitioners do not. Funding for research is also sparse making it difficult to do further research for effectiveness of CAM. Most funding for CAM comes from government agencies. Proposed research for CAM is rejected by most private funding agencies because the results of research are not reliable. The research for CAM has to meet certain standards from research ethics committees, which most CAM researchers find almost impossible to meet. Even with the little research done on it, CAM has not been proven to be effective.

Studies that have been done will be cited by CAM practitioners in an attempt to claim a basis in science. These studies tend to have a variety of problems, such as small samples, various biases, poor research design, lack of controls, negative results, etc. Even those with positive results can be better explained as resulting in false positives due to bias and noisy data.

How can CAM be risky when it is based on nature? Can we harm our health using CAM without consulting with specialists?

Certain alternative medicine practices have been studied and have been deemed to be safe, and even effective. Others have not been heavily studied – and some have even been found to be harmful. However, the main risk is to drop out one's current treatment in serious diseases to use exclusively CAM.

In addition, just because something is "natural" does not always mean it is safe. A prime example is the herb kava kava (*Piper methysticum)*; this herb is often used to treat anxiety, but it can also cause liver damage. A good practice would be to discuss alternative treatments with your physician.

What about the placebo effect in animals? Because the tests that are done in homeopathy are also done on animals and babies.

Contrary to popular belief, there are no strong research results backing the placebo effect on animals.

Online resources

1. Safety issues in the preparation of homeopathic medicines, World Health Organization

2. Snake oil or science? Homeopathy in Europe, Euronews

3. Lecture Youyou Tu. The Nobel Prize Foundation.

4. The efficacy of herbal medicine –an overview, Fundamental & Clinical Pharmacology

5. The placebo effect: Amazing and real, Harvard Medical School

6. The Placebo effect in animals, Journal of the American Veterinary Medical Association

7. Alternative, or Integrative Health: What's In a Name? US National Center for Complementary and Integrative Health Complementary

8. Complementary and Alternative Healthcare: Is it Evidence-based? International Journal of Health Sciences

9. Why Alternative Medicine Cannot Be Evidence-based, Academic Medicine

4.4 Vaccines

How vaccines work

What are the known vaccines?
Diseases preventable by vaccination are infectious ones (viral or bacterial). Examples are vaccines against rotavirus and meningococcus B, which are tested, safe, internationally approved vaccines, but are not mandatory in many countries. There are also vaccinations that are internationally required., i.e., vaccines that must be administered in travellers' appointments, i.e., in international vaccination centres when we go to certain countries.

Yellow fever is an endemic disease in some countries and since we can only enter these countries by taking the vaccine, there is an obligation to take it. Hepatitis A is a vaccine that, in a lot of countries, is administered to people who travel to certain areas of Africa or some South American countries, but not to all. It is known that hepatitis A was a common disease in the 1960/70s, and people who were born until the 1960s do not need to take this vaccine, because they already had the disease. However, for those who were born later, it is recommended they get vaccinated when they are travelling.

Across Europe and other parts of the world national vaccination programs exist, whose schemes reveal the age at which vaccines are normally administered. There are variations between different countries. There are specific reasons though, why vaccines are given at certain ages and doses. For example, VASPR, vaccine against measles, parotitis and rubella. It is often given at 12 months because it has a component, ovalbumin, which can cause allergic reactions. Children at 12 months of age have already started eating eggs, so it is already known if they are allergic to it. Allergic reactions to ovalbumin are rare. The date of the beginning of vaccination, as well as the doses, are therefore not random but based on certain tried and tested criteria.
An example of this review is the tetanus vaccine that used to be given every ten years, but the period was extended lately, because it was realised that people still had immunity to tetanus.

How long does a vaccine take to be prepared?

The same time as other drugs (medicines) which are not vaccines. The rules of preparation are established at international level and go through several phases. A pre-clinical phase corresponds to the research phase (laboratory). Molecular studies, biochemical studies and characterisation are necessary. Then studies on cellular lines and later on animal models. Then moving on to the clinical phase, which involves humans and also has 3 to 4 phases.

The clinical phase consists of the 1st phase performed initially in some individuals, the 2nd phase performed in selected individuals and the 3rd phase, a true clinical trial. In this phase, there is a drug and there is a placebo, and they are administered "blindly". The doctors do not know to which patient they administer the drug in order to assess their response and if it is the intended one. The question of phase 3 studies not being representative is not correct, since the regulatory authorities, both American and European, are extremely strict in the requirements of the sample being studied. Randomised trials are mandatory and must be compared it not only with the placebo, but with the drug.

There can be a 4th phase. It is the one where the

drug and the vaccine are studied after they are already being administered in the community and after they are already being implemented in the clinical routine. In this phase possible drug interactions that had not been noticed are studied, as well as adverse reactions and side effects that went undetected until then. Phase 4 studies are fundamental. If phase 3 studies are done on a sample, something is always missed, and that is drug interactions. It is not possible to test in phase 3 and test all the medicines that exist. The patient's condition, if s/he had or has any illness, can influence their reaction to the vaccination. Phase 4 studies are also important for financial reasons. Cost-effectiveness studies are carried out and an attempt is made to see if this vaccine placed at community level will have the expected responses if the disease will really be eliminated. Safety is tested at all stages of these clinical trials.

As far as the pharmaceutical industry, most of the vaccines were invented dozens of years ago and therefore, patents are no longer valid. Therefore, the pharmaceutical companies that invented them do not profit significantly from them anymore. Vaccines are not the most lucrative means of pharmaceutical industries.

Who are the people who cannot get vaccinated for health reasons?

There are categories such as immunosuppressed (think of cancer patients, for example) who could develop complications. This is the category most at risk for which herd immunity is critical. They are the people who benefit from the "shield" formed around them by those who have been immunised with the vaccine. This is precisely why it is important to maintain high vaccination coverage. If the pathogen does not circulate, even people who are unable to get vaccinated are still protected. So, vaccination is above all an altruistic gesture.

What is group immunity?

The proportion of immune individuals in a population that can achieve the effect of group immunity. That is, the number of people that need to be vaccinated to make others who are not vaccinated protected. There are cases of people who are not vaccinated by mere choice, but there are other people that cannot be vaccinated because they have serious diseases such as immune deficiencies. If these people are not vaccinated, but the rest of the population is, they are safe.

What is vaccine efficacy?

Efficacy is related to the vaccine doses. It is known that a person who has had measles will never have measles again. So, if we had 94% of those people, the other 6% would not need to be vaccinated. The first dose of the vaccine for measles causes immunity in 95% of the people, but the other 5% are missing, that's why two doses are necessary to grant immunity to most people. The group immunity process is an indirect effect of the vaccine administration.

How long after taking a vaccine is one protected?

The protection is related to the vaccine efficacy. There are vaccines that protect from the first dose, but there are vaccines that need several doses. In general, the maximum immunity can be reached more or less two weeks after vaccination. This is in the general population, but in the case of risk groups it can be different.

Can drugs be 100% replaced with vaccines in the future?

No. The principle of fabrication is the same, but the vaccines aim to prevent the disease. Therefore, they are administered before the existence of the disease. The goal is not

to get sick. The medicines are therapeutic, they are curative. Therefore, they are administered when the disease is already installed. Although there are prophylactic drugs, with the objective of being administered to prevent the disease from happening, they apply mainly to non-infectious diseases.

To differentiate vaccines from other medications, the common types of vaccines are listed here:

• Attenuated microorganisms – attenuated viruses. They do not cause a disease, but cause a response, the memory response.

• Living microorganisms' fragments – composed of a portion of the virus and a portion of the bacteria.

• Inactive toxins – part of the bacteria that has been studied and inactivated and therefore is part of a vaccine. This toxin causes a response when one is in contact with a real microorganism, complete and activated.

There are also the combination vaccines, that is, in the same ampoule/injection there are several vaccines that can be administered together. This process allows less administration, less pain and more saving of resources.

Do vaccines eliminate the pathology or just leave it asleep, and can it become more resistant and manifest stronger symptoms again?

It depends on the diseases. For instance, measles, if we only have one dose of measles and if we are infected, we will hardly develop the most serious forms of the disease. We may develop the mild forms of the disease. It is known that with two doses it is a very rare occurrence. Another example is chickenpox. However, it is said that you only get it once in childhood, but there is another disease (shingles) that can manifest in adults and is caused by the same virus as chickenpox. In other words, our cells became infected, the virus lays dormant and suddenly, when we are adults, this microorganism becomes active again. What happens is that we have a disease caused by the same virus.

When the vaccine consists of a set of sleeping pathogens, is there a risk of some "waking up" and able to trigger the disease?
No. Unless the vaccines have been poorly developed. It can happen; however, all vaccines are extensively tested.

If a person is infected and then takes the vaccine, is it no longer effective? But could you avoid a second contamination?

This happens for most diseases, such as hepatitis. However, some studies for the HPV (human papillomavirus) vaccine say that even if a person is infected with HPV with a less serious type of virus, if they take the vaccine later and is infected with a more serious type it can be effective. Therefore, it depends on the type of virus and the type of disease and vaccine.

Does the vaccine prevent you from contracting the disease or developing the symptoms of the disease?

The peculiarity of the vaccine lies precisely in the fact that it also prevents the carrier status. The vaccinated person comes into contact with the pathogen, but the latter does not even have time to take root and therefore is not even housed in the organism of the vaccinated person.

Why is a "booster", i.e., a second dose given, for some vaccines?

Let's take an example with the measles vaccine. With the first dose, about 95% of children develop an immune response. To reach the remaining 5%, a second dose is needed to make the antibodies develop with certainty. Reinforcement is also needed to maintain long-term effects.

Will a vaccine against cancer appear in the next few years?

Cancer is a very complex disease that has very different causes. It has different levels of prevention and different treatments depending on the cancer. For example, the main risk factor for lung cancer is tobacco, the main risk factor of melanoma is unprotected sun exposure, therefore is not possible to prevent through a vaccine. However, it is possible to prevent cervical cancer with a vaccine, since it is caused by a virus – human papilloma, as well as to do its prevention from cytological screenings. There is also another type of cancer avoidable by vaccination, which is one of the forms of liver cancer, caused by the hepatitis B virus. If we are vaccinated for this virus, it is not possible to have liver cancer for this reason.

Communication and communication of risks about vaccines

Are all the side effects of vaccines known?

Considering that the vaccines in most national vaccination programs are old ones, have tens of years of experience and millions of people have been vaccinated around the world, it is possible to say that almost all of the effects are known. However, even after a long time, side effects are still registered and investigated by international and national institutions in order to be able to withdraw vaccines if necessary.

Is there a relationship between autism and vaccination?

There is not. In 1998, some authors launched the possibility of a connection between measles vaccination and autism. This study was replicated by other scientists around the world to try to understand what was happening and they did not obtain the same results. The first scientists were confronted and questioned. Initially it was believed that there was a confusion with the age at which the vaccine is administered and the beginning of the signs of autism. Later, it was proved judicially that there were conflicts of interest of the authors. They were discredited all over the world and the articles were taken from the magazines where they had been published.

Will pathologies that will appear in the future be more resistant to the point that a vaccine will not serve as treatment?

With the flu it behaves in such a way that there is a new vaccination every year. There is an update based on the characteristics of the virus of the previous year. In addition, it is necessary to think about the possible impact that climate change may have on hosts, vaccine recipients and on the microorganisms themselves.

Which actors besides journalists can and should educate people about vaccination? My doctor, for example, has never asked me about it.

Of course, other groups besides journalism should provide more information about vaccination. Starting, of course, with doctors, it is also good to have campaigns every now and then. Experience shows that such campaigns are successful. You can't just come across with facts and figures in the answers, but you actually have to convey the topic emotionally. And doctors in particular have a great responsibility to get this across. But unfortunately, there are also many doctors who are not so convinced themselves or forget it.

Ultimately, this is also a question of science communication. Younger doctors and researchers in particular approach the public differently. Perhaps this can improve the information situation between the public and science in the future.

What is the best way to change the minds of people who do not support vaccination?

Be aware if the effectiveness and success of vaccination that is happening in some countries may be contributing to the anti-vaccination movements. The WHO developed a guide for health professionals to teach how to respond to people who are against vaccination. It is difficult, but there are people with doubts, there are people who are hesitant, there are people who refuse due to faith and then there are the organised movements. These are the dangerous ones. It is fashionable to be different and question some certainties.

How would it be necessary to communicate and educate the public so that conspiracy theories about vaccination no longer appear or circulate?

This must be dealt with openly and early on. It is often the case that information about side effects is not communicated transparently enough. In the same way, one should point out the conspiracy theories. That's a double-edged sword, because you then have to repeat them in parts and offer them a platform. But there are good ways to not reiterate that too much. You may be approached by friends or family saying that they can imagine there is something to such conspiracy myths related to a certain issue. One thinks then perhaps one cannot take that seriously. But this is an attempt of people to understand the things that happen around them, this is a human need. And the fact that especially during the Corona crisis many of these conspiracy theories resurface is of course also due to the dimension of the whole thing, nobody knows where it came from, suddenly it was there, and half the world is in quarantine. So, you have to say it directly, but never forget to put the facts behind.

There is a very good website of WHO, it collects conspiracy theories about Corona, with pictograms the conspiracy theories are presented and then refuted with the presentation of the facts.

How many people have a negative attitude towards vaccinations and how to respond?

The main problem of vaccine deniers is that people often don't take them seriously and the negative attitude is reinforced by the fact that someone feels they are being laughed at or, in fact, not taken seriously. If you ask why someone doesn't want to be vaccinated and the answer is because it's poison, then you can explain that it's not poison. But if you make it sound like the person you're talking to is stupid, then it just reinforces the feeling. And that is very dangerous and can take a fatal development. There are few people who are actually against vaccines, but probably not as many as you might think. We also have to be careful not to artificially exaggerate the problem of the opponents of vaccination in the reporting, because in the end there may not be so many people who adhere to conspiracy myths and oppose vaccination. They are nonetheless serious groups that are organising and engaging in disinformation. That, in turn, needs to be mapped in the future.

COVID-19 vaccines (questions from May-December 2020)

Is there any vaccine against COVID-19 that is being done through antibodies from people who have already been infected?

There are more than 100 clinical trials of vaccines for COVID-19 at this stage. The expert believe they are all being made from the antigens of people who have been infected, but plasma administrations are also being tested, instead of full blood being only part of the blood of people who have been sick, in people who are healthy. The same is true for patients with leukaemia.

The British government had proposed to wait for the coronavirus epidemic to spread until it naturally reaches herd immunity. Is it a viable strategy?

Herd immunity is calculated as a function of the value of R0, that is, the spreading capacity of an infectious disease. Now, suppose that SARS-CoV-2 R0 is 3, which is an intermediate value, this would mean that 66% of the population would have to contract the disease and develop immune antibodies for the disease to stop circulating. The scientific community believes that this is an excessive share, given

the mortality rate of SARS-CoV-2. One study estimated the effects of applying this strategy globally to be 30 million deaths. It is, of course, unacceptable.

Is the vaccine for COVID-19 safe for us?

Yes, update research indicates the vaccines for COVID-19 have a very good safety profile. The U.S. Food and Drug Administration (FDA) has granted emergency use authorisation (EUA) for two COVID-19 vaccines. Both have been tested in large clinical trials. Data from the manufactures show that the known and potential harms of becoming infected with the coronavirus disease 2019 (COVID-19) outweigh the potential safety risks of the vaccines. There are many strict protections in place to help ensure that COVID-19 vaccines are safe. Like all vaccines, COVID-19 ones are going through a rigorous, multi-stage testing process, including large (phase III) trials that involve tens of thousands of people. These trials, which include some groups at high risk for COVID-19 (certain groups i.e. pregnant and lactating women were not included in vaccine trials), are specifically designed to identify any common side effects or other safety concerns. Even though the coronavirus vaccines were developed more quickly than other vaccines in the past, they have been carefully tested and continue to be monitored.

Online resources

1. PlayDecide: Vaccines, key tools for prevention, supported by Ecsite, the European network of science centres and museums

2. VAX! A game about epidemic prevention

3. The History of Vaccines: History of Anti-vaccination Movements, The College of Physicians of Philadelphia

4. BMJ: Wakefield's article linking MMR vaccine and autism was fraudulent

5. Which parts of Europe are likely to be most hesitant about a COVID-19 vaccine?, Euronews

6. Vaccines and immunisation, WHO

7. Vaccination, European Commission

8. European Vaccination Information Portal

9. Immunisation and vaccines, European Centre for Disease Prevention and Control

10. Vaccination, World Economic Forum

11. Herd Immunity: How does it work?, Oxford Vaccine Group

12. Vaccines for COVID-19, Center for Disease Control and Prevention (CDC)

13. Is the COVID-19 Vaccine Safe? Johns Hopkins Medicine

14. Coronavirus disease (COVID-19) advice for the public: Mythbusters, WHO

Annexes

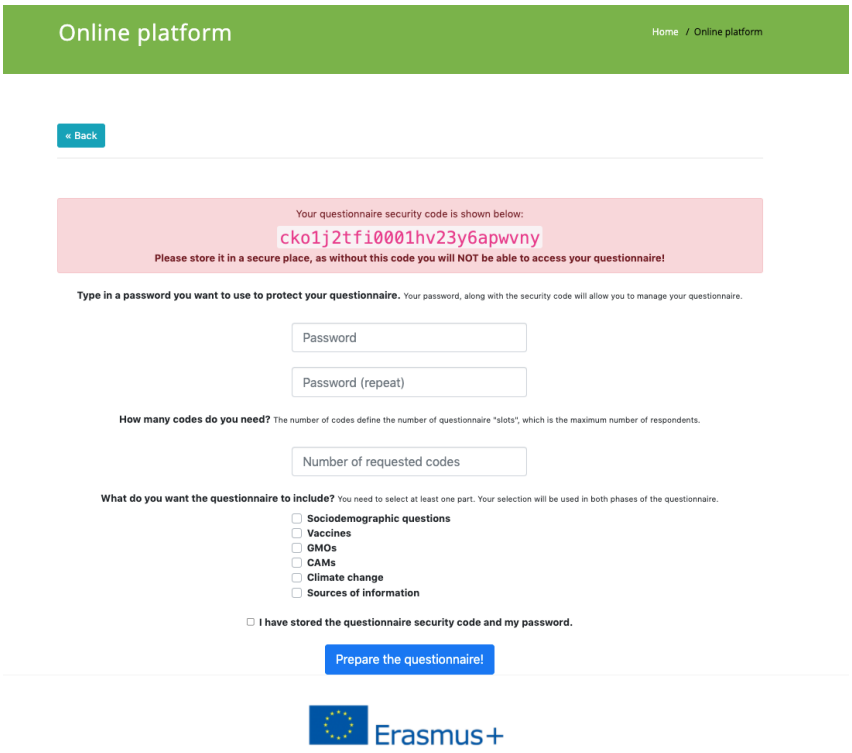
Annex 1. How to create and manage a questionnaire

1a. How to create and manage a questionnaire

Step 1: Enter https://persist.erasmus.site/platform/

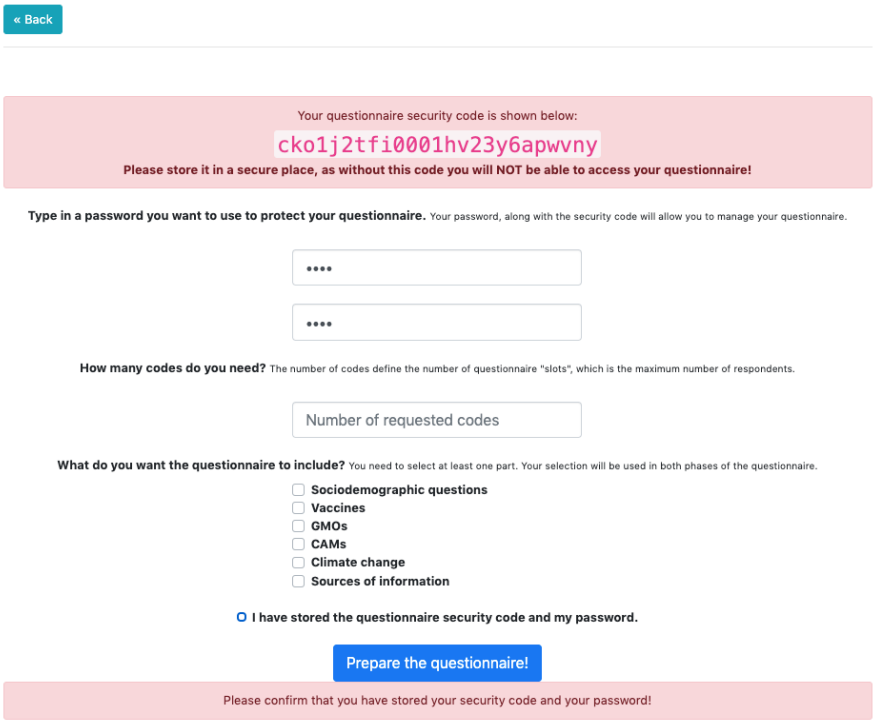
Step 2: Click on “Create (link)”.

The following page will appear:

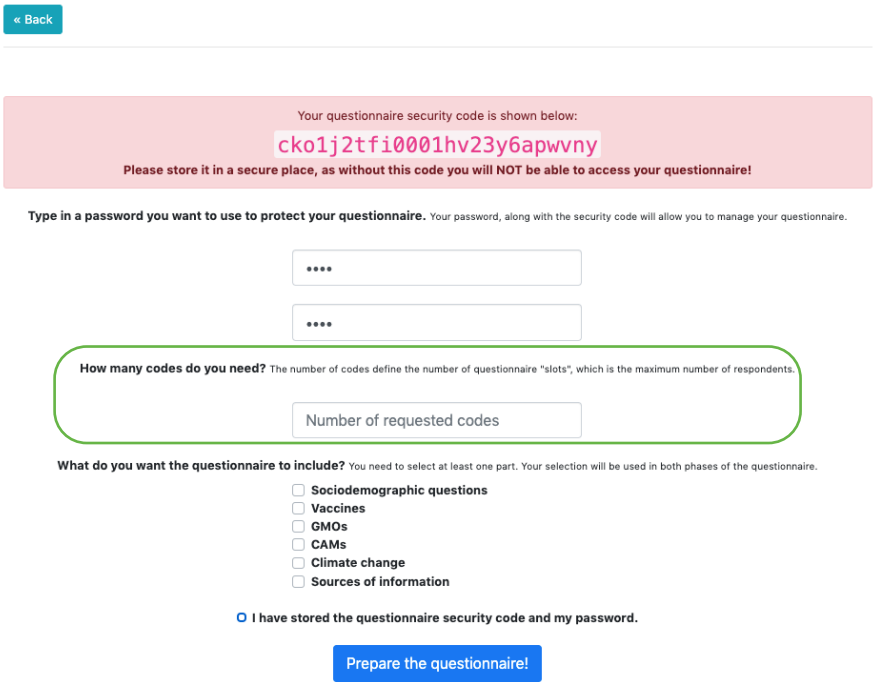


Step 3. Copy the code in a safe sheet.

Step 4. Create the password you want and save it along with the code.

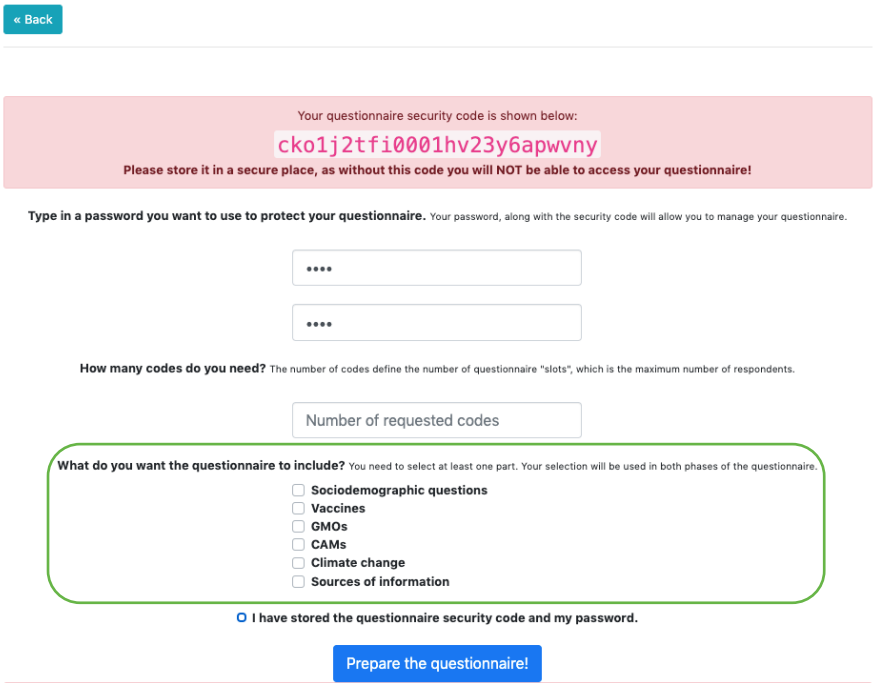


Step 5. Create the number of codes you need (it depends on the number of people participating).

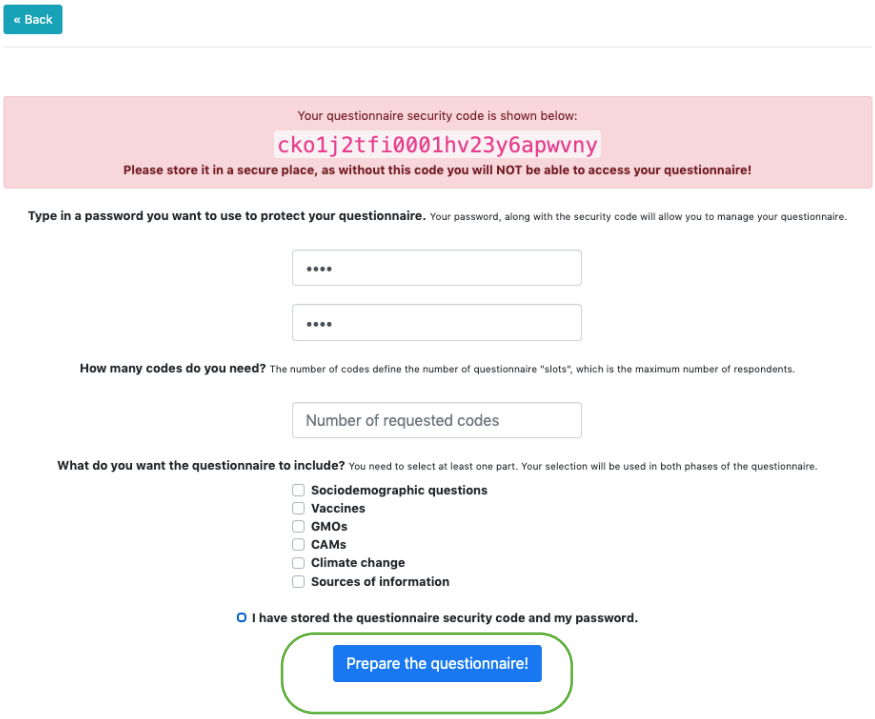


Step 6: Select the questions you want the questionnaire to include.

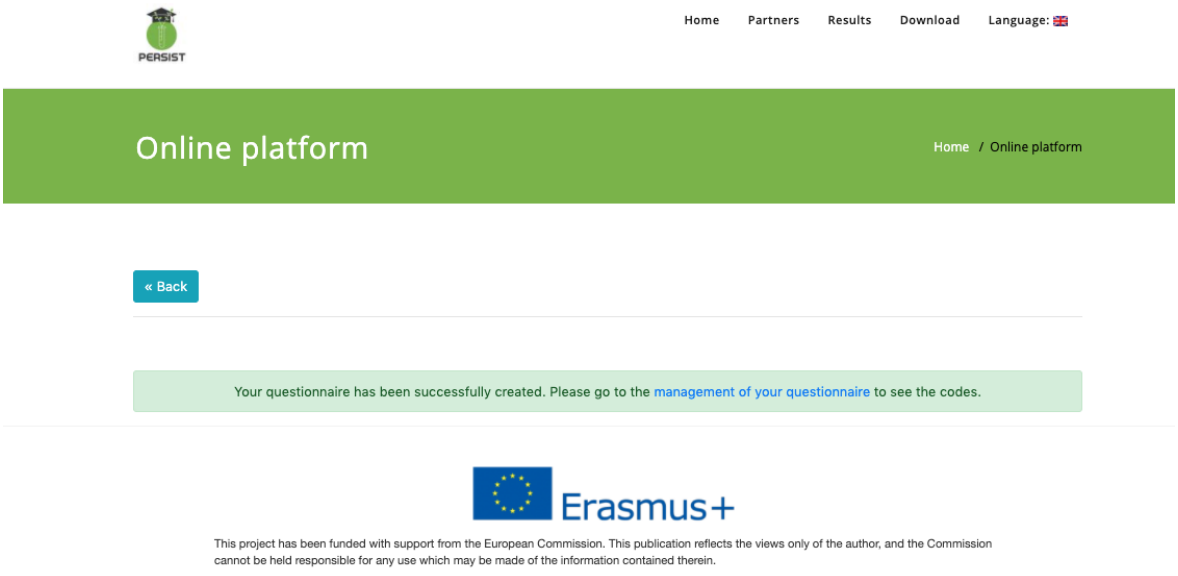
You can include questions only related to the topic of your activity, either climate change, GMOs, complementary and alternative medicines and vaccines; include also sociodemographic questions and questions about sources of information; or ,even, include questions not related to the topic of the activity to see if the training has any effect on them.



Step 7: Once you have clicked on the box stating you have stored the questionnaire security code and your password, click on ‘Prepare the questionnaire!’

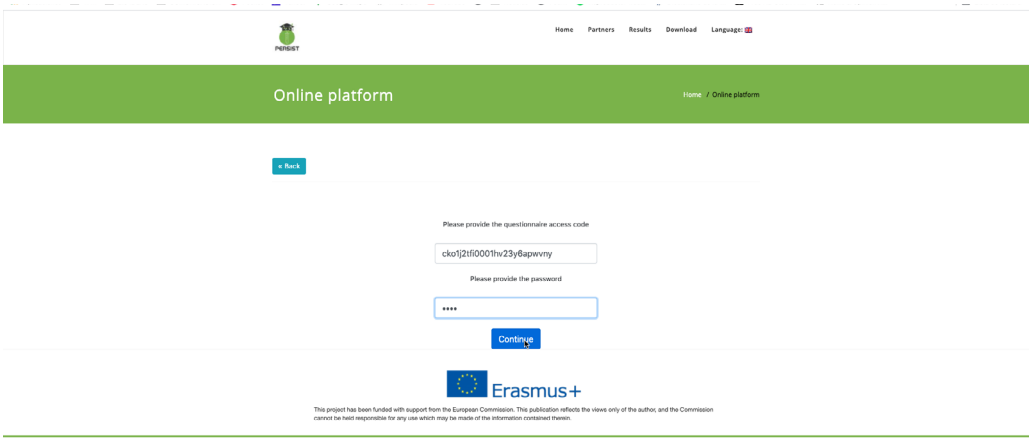


Step 8: Click on “management of your questionnaire (link)”.

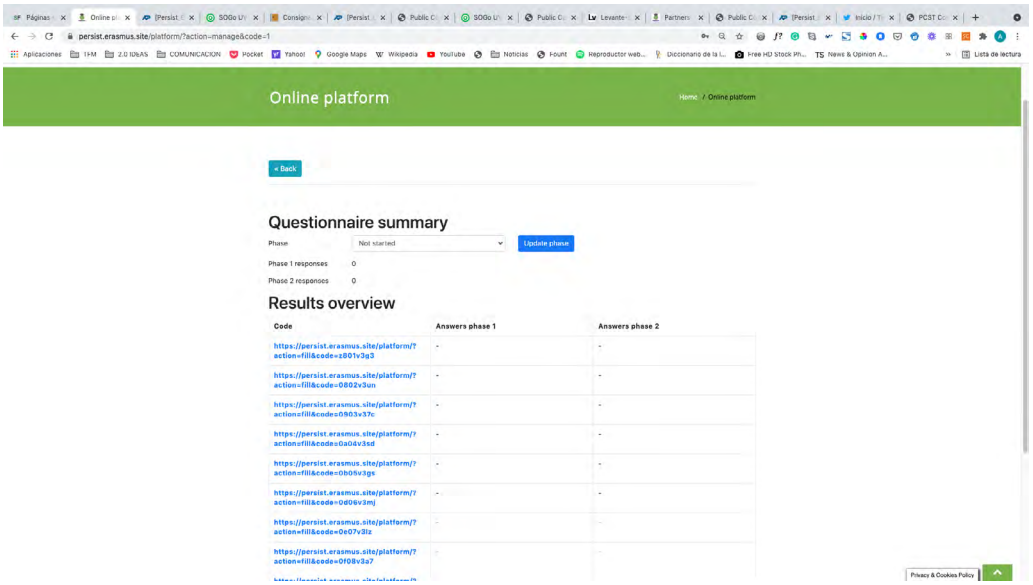


1b. Managing the questionnaires

Step 1: Paste the saved code and write your password. Then, click on “Continue (button)”.

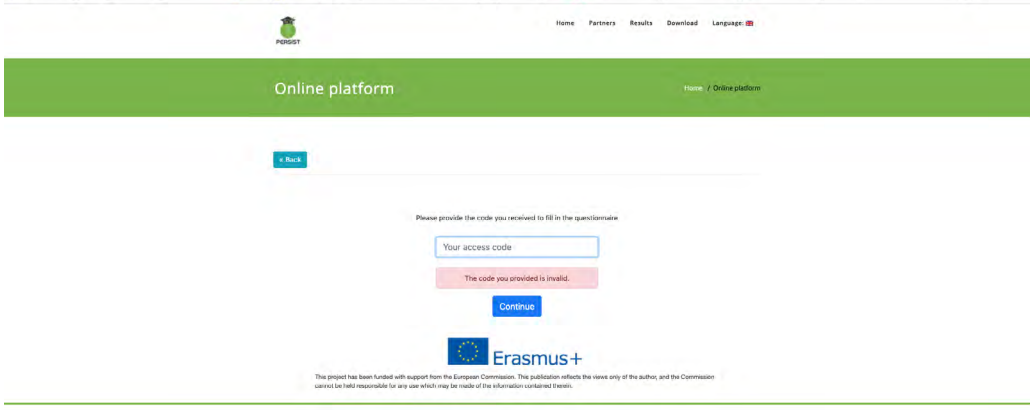


The following page will appear:



Step 2: Copy the links that appear in “Results overview” into an excel file with the registered students, so each student has a personal link. Include this link in the e-mail you will send them as a reminder of the activity with the instructions to follow. In annex 2, you will find information in how to send personalised e-mails easily.

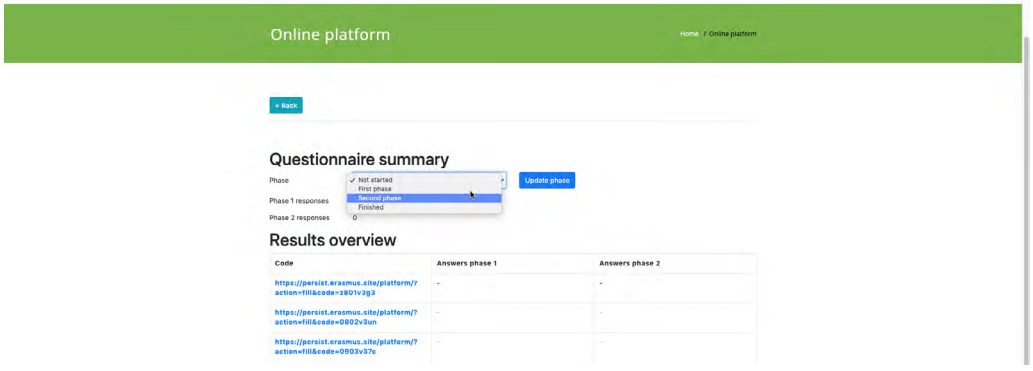
- ∑ Note that, in this moment, the questionnaire is created but not activated. Therefore, if somebody tries to enter with the code you provided them, the following message will appear:



Step 3: Before sending the e-mails to students, make sure to activate the questionnaire.

To do so, first click on “Phase (combo box)”.

Then, click on “First phase (list item)”.



After that, click on “Update phase (button)”

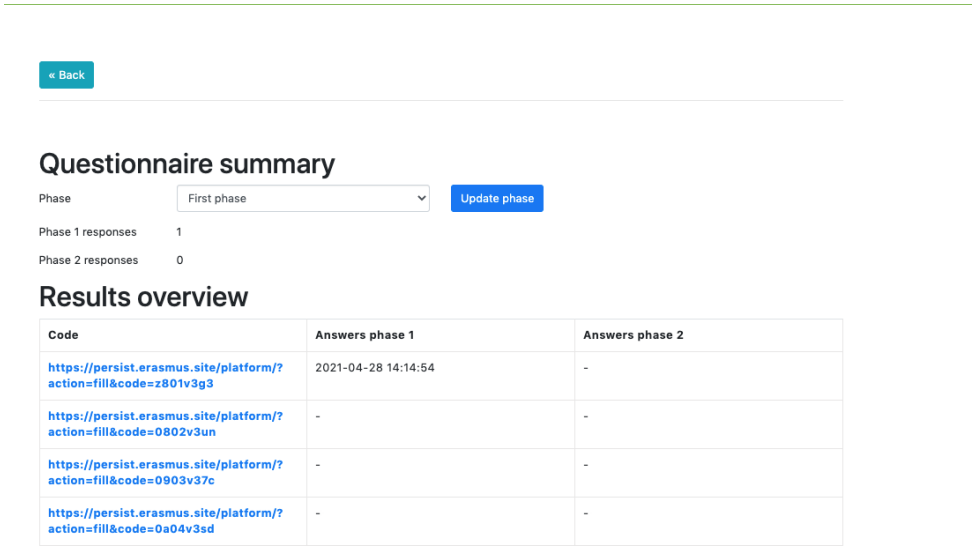
The questionnaire is now ready to be used!

Step 4: Once the students have answered the questionnaire, you will see the time and date of the responses in “Answers phase 1” box.

If a student hasn’t answered the questionnaire, track their code in the excel file you have prepared and send them a reminder.

Step 5: After the activities of the ScienceCamp have finished and before the students answer the questionnaire again. Activate the second phase.

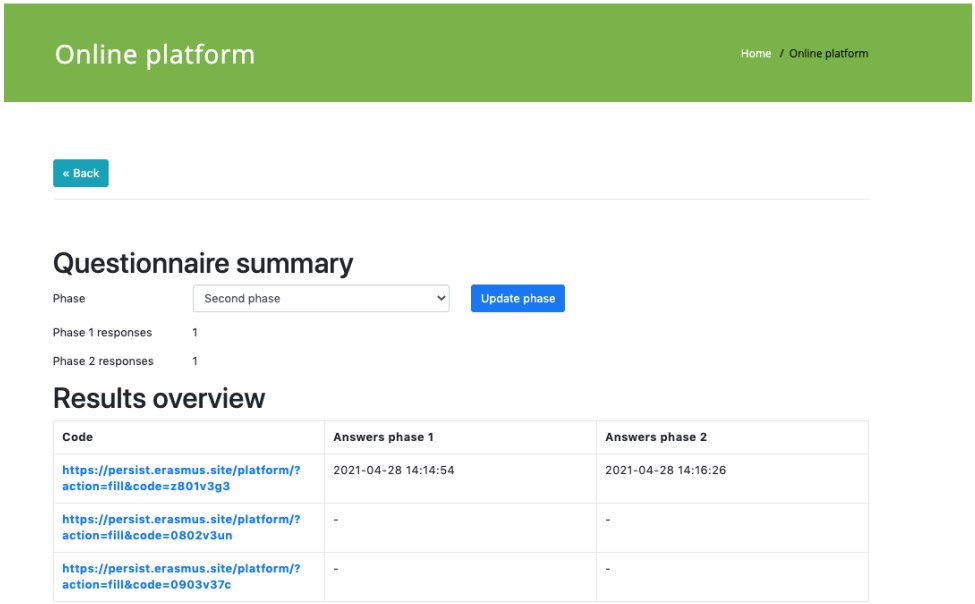
To do so, first click on “Phase (combo box)”.



Then, click on “Second phase (list item)”.

After that, click on “Update phase (button)”

Now students can proceed to the final answer of the questionnaire through the same link they already have.

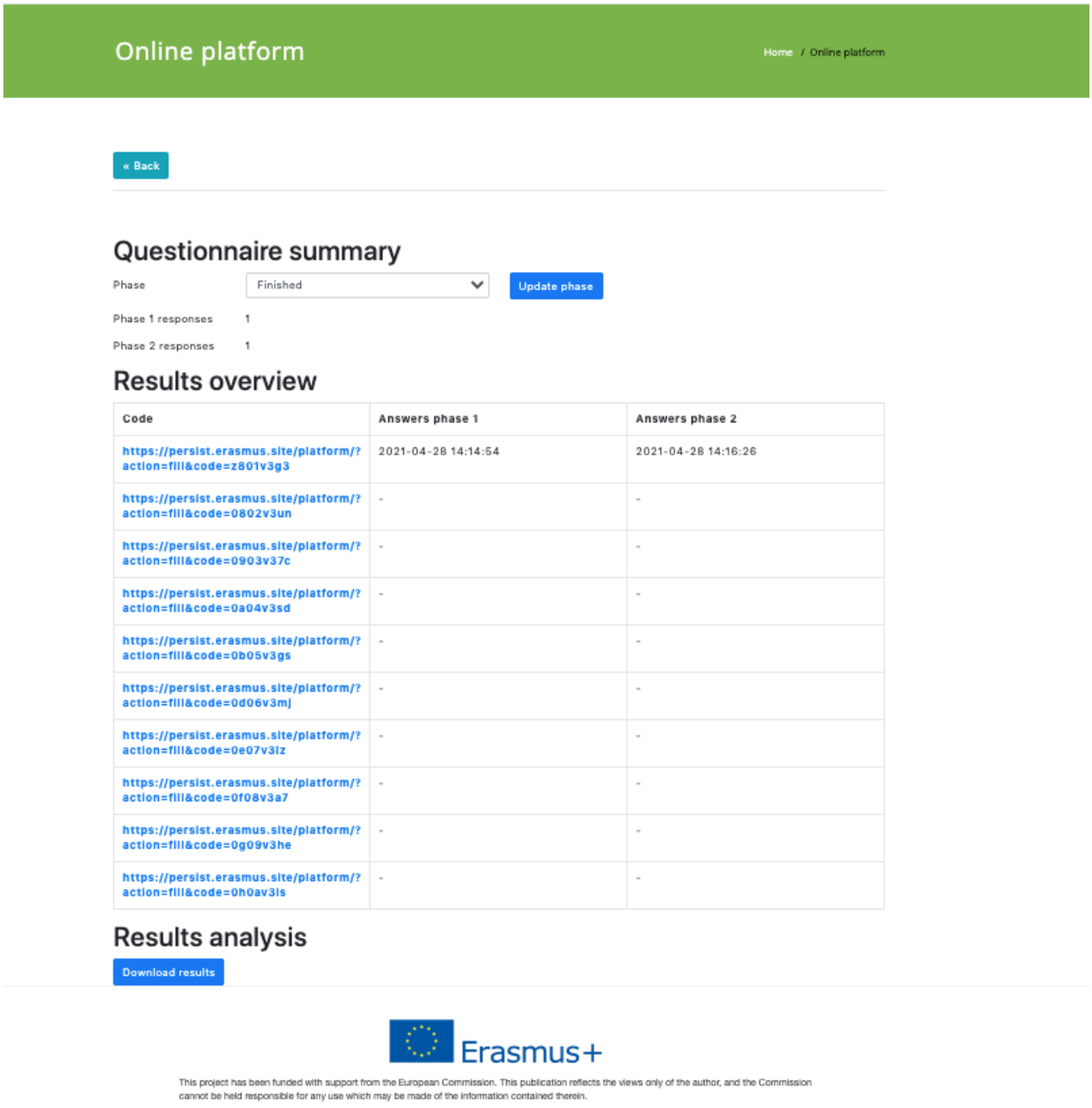


Step 6: Once the questionnaire has been answered, proceed to deactivate it.

To do so, first, click on “Phase (combo box)”.

Then, click on “Finished (list item)”.
After that, click on “Update phase.

Step 7: To download the results, click on “Download results (button)”.

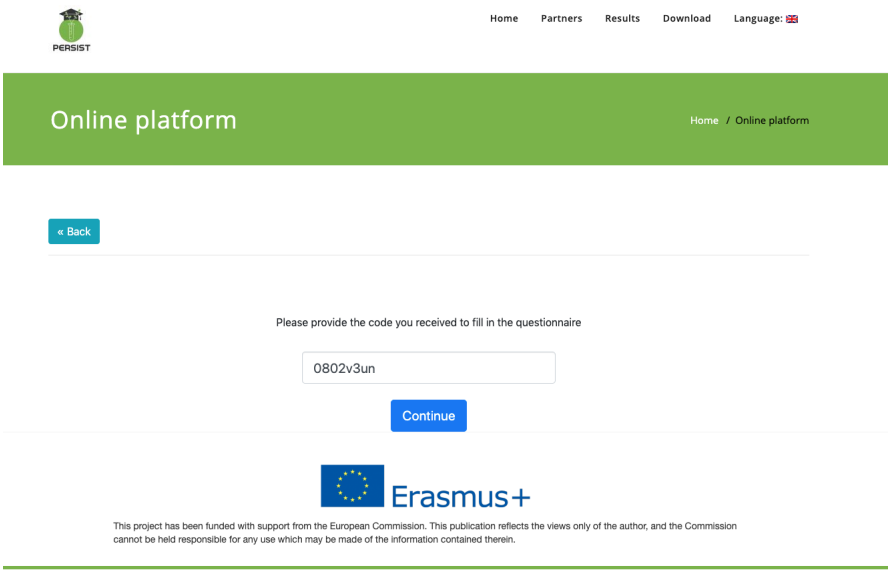


TIP: test the ICT platform use before the activity!

1c. Students use of the questionnaires

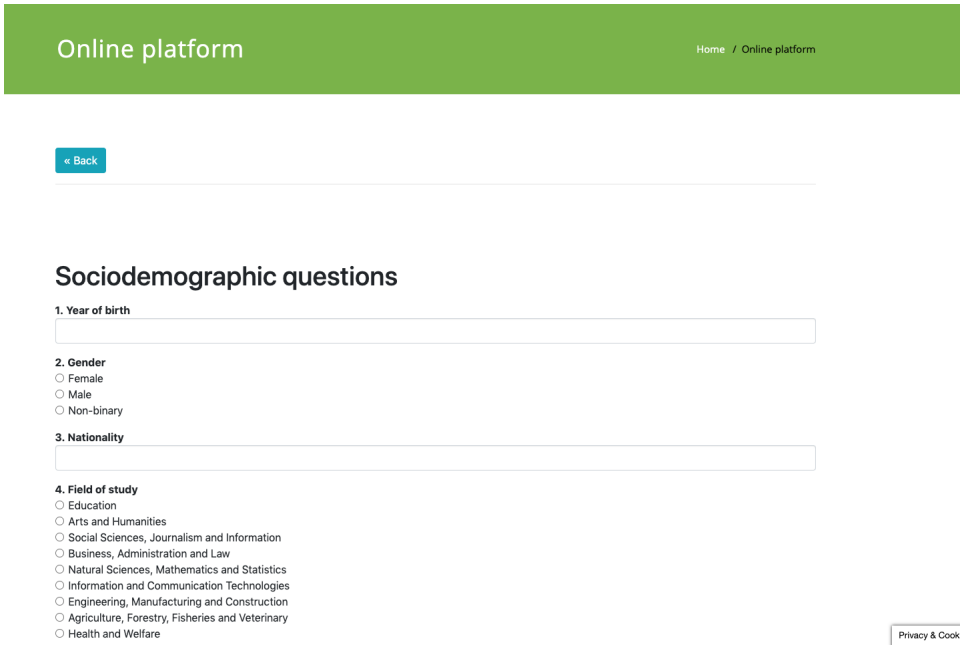
Step 1: Students must click on the personalized link you have sent them.

Step 2: The following page with their personalized code will appear.

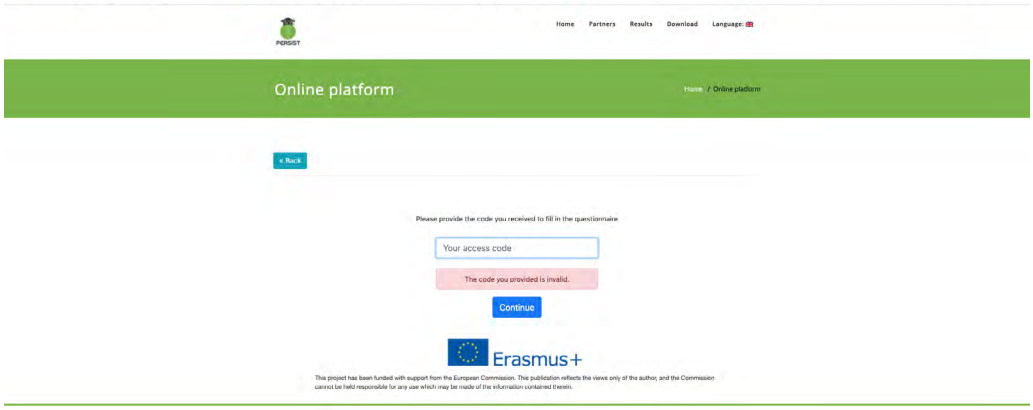


Step 3: Click on “Continue (button)”.

Students will see the following page:



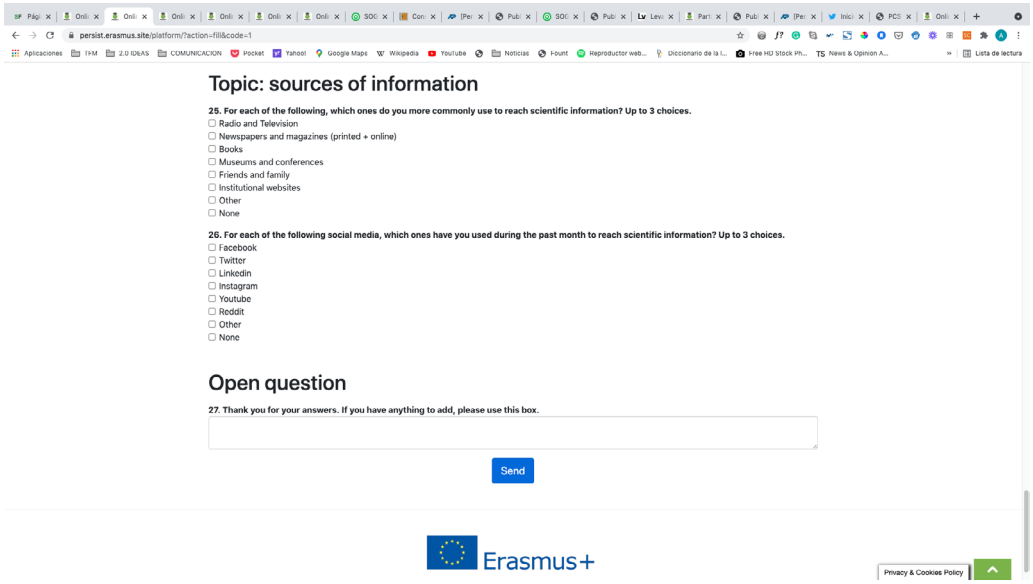
If the questionnaire is not activated yet or they have already answered the first phase and the second phase is still not activated, the following message will appear.



Tell students that if this happens, they should contact you.

Step 4: Answer the questionnaire.

Step 5: Once the questionnaire is completed. Click on “Send (button)”.



Annex 2. How to create personalized e-mails

As mentioned in annex 1, you can copy the links that appear in “Results overview” into a spread file with the registered students, so each student has a personal link. Here you can find a list of tutorials to help you send personalised e-mails easily.

Links to tutorials to send personalized e-mails

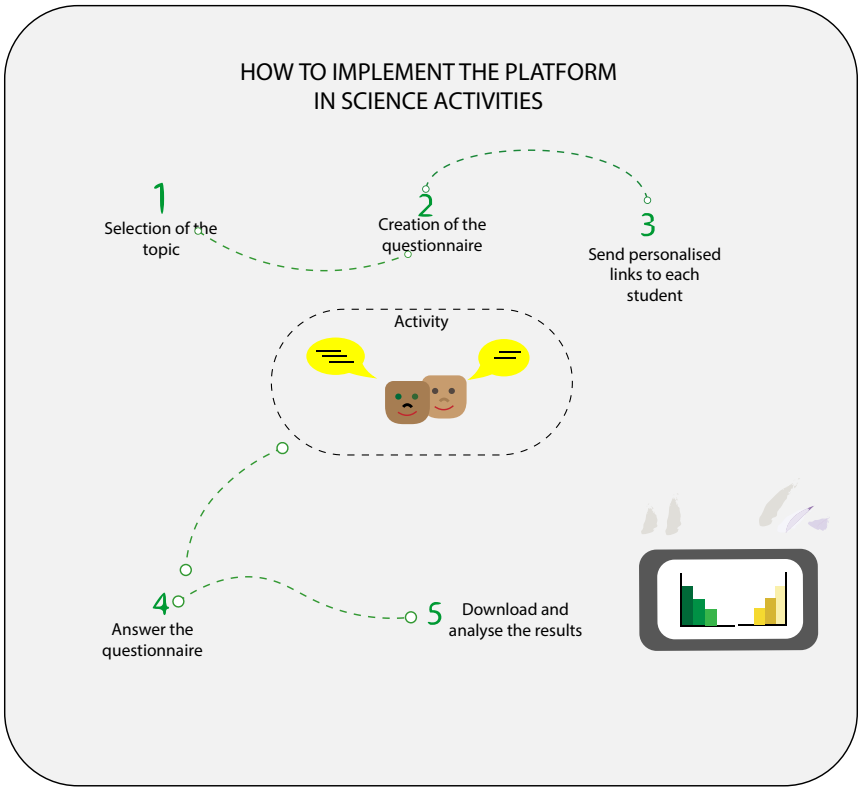
Operating system	E-mail service	Complementary tool (spreadsheet, word processor…)	Link to tutorial
Google Workplace	Gmail	YAMM Add-onn	Link
Windows	Outlook	Microsoft Word	Link
Mac	Outlook	Microsoft Word	Link

Annex 3. Activities to use the ICT platform

As mentioned in chapter 3, ScienceCamps are the activities designed in the framework of the project to validate the platform. The tool, however, can be implemented in a wide range of activities and events. Students just have to access the platform before and after the activity, so the changes in the level of knowledge, perception, beliefs and trust could be measured.

In this chapter some ideas of activities to use the platform are presented. All activities can be carried out face-to-face or online. The adaptions needed in each case are presented.

General steps for preparing any activities using the platform



TIP

You can check the students that have answered the questionnaire through the platform.

LEVEL

Highschool and university students, 14 + years old

Virtual Science Camp (VSC)

1h 30 min.-2h
modality: online.
Participants. Min. 8; max. 40.
All areas of study

What does it consist of?
Students watch a video on the topic before attending the activity and are asked to formulate some questions related to it.
An expert on the topic gives a short talk, followed by a Q&A section. A statement related to the topic is presented. Students are divided into 4-8 people groups and assigned a stance to defend (in favour or against the argument). The spokesperson of each group presents the arguments they have found in favour or against the argument and a general debate is held.

Key learning objectives

To understand the relevance of science topics in society

To organise ideas and discuss them in public

To appreciate both sides of a debate

Resources

Videoconferencing software

Video of the topic

Expert on the topic

Possible adaptations

The video and the beforehand questions are optional (they provide basic information and help to revitalise the Q&A section and the debate)

The expert can also participate in the final debate by giving their comment to the arguments found during the in favour/against group discussion.

Instead of one statement to defend, more statements can be presented, or they can find arguments against or in favour of the topic in general.

If it is not possible to count on an expert participating, you can also introduce the topic by using the resources in this book.

Students can be asked to reflect on the relevance of the different science topics to their lives/area of studies/future professions and discuss it with their peers.

To take into account

- The video and the beforehand questions are optional (they provide basic information and help to revitalise the Q&A section and the debate)
- The expert can also participate in the final debate by giving their comment to the arguments found during the in favour/against group discussion.
- Instead of one statement to defend, more statements can be presented, or they can find arguments against or in favour of the topic in general.
- If it is not possible to count on an expert participating, you can also introduce the topic by using the resources in this book.
- Students can be asked to reflect on the relevance of the different science topics to their lives/area of studies/future professions and discuss it with their peers.

ScienceCamps

1h 30 min.-2h.
modality: face-to-face
Participants Min. 8; max. 40. All areas of study

What does it consist of?
Similar to VSC but face-to-face.
Students watch a video on the topic. An expert on the topic gives a short talk, followed by a Q&A section. A statement related to the topic is presented. Students are divided into 4-8 people groups and assigned a stance to defend (in favour or against the argument). The spokesperson of each group presents the arguments they have found in favour or against the argument and a general debate is held.

Key learning objectives

To understand the relevance of science topics in society

To organise ideas and discuss them in public

To appreciate both sides of a debate

Resources

Computer

Projector

Video of the topic

Expert on the topic

Possible adaptations

Similar to VSC

You can also create a whole morning event in which all 4 topics are discussed, these will give students a further insight into different science topics and their connection to society.

Students can be asked to reflect on the relevance of the different science topics to their lives/area of studies/future professions and discuss it with their peers.

Open Forum (OF)

Flexible
Modality: online and face-to-face.
Participants:The activity can be done individually, in pairs or in groups of three students.

What does it consist of?
A moderator introduces one issue and collects ideas, suggestions and proposals. Open forum enables students to post and reply to comments, suggestions, and questions asynchronously or synchronously.
It is possible to use the OF to provide a platform on which students can communicate with each other.

Key learning objectives

To reflect on a socially controversial science issues
To organize ideas and share them
To exchange opinions in a respectful way

Resources

In the case of synchronous online creation, the forum can be developed with the use of padlet.com or slido to facilitate the proposal of ideas and comments during the forum

Possible adaptations

Students can be asked to reflect on the relevance of the different science topics to their lives/area of studies/future professions and discuss it with their peers.

Convert science content into an infographic

Flexible
modality: online and face-to-face.
Participants:The activity can be done individually, in pairs or in groups of three students.

Students have to read a text (it could be a scientific paper or a piece of science news) and express the main ideas using an infographic. Afterwards, they explain the content to their colleagues.

Key learning objectives

To understand a piece of science news and be able to explain it.
To organise ideas and discuss them in public.

Resources

Computer

APPs or online software programmes like canva.com, PowToons, Genial.ly

Possible adaptations

Each group could be assigned one topic and assess whether there are changes in knowledge, perception, trust and beliefs or not depending on their role, if they have read the content and later explained to the students or if they have just listened to the explanation of their classmates.

All groups could have the same science content so the different portrayals on the issue can also be discuss in class.

Students could also, instead of creating and image, record a piece of news for TV.

Role-play debate

1h
modality: online and face-to-face.
Participants: Min 8, Max.40
All areas of study

What does it consist of?
A hypothetical but plausible situation is described to the students participating in the debate. Students will play the role of people who may be affected by the decision. The final goal of the activity is to reach an agreement by exposing common arguments.

Key learning objectives

To understand the implication of science on daily life

To organise ideas and discuss them in public

To appreciate both sides of a debate

Possible adaptations

A trial with all professionals involved could be represented (the jury, the judge, testimonies, advocates…)

Instead of hypothetical situations, some real situations could be discussed after viewing pre-selected videos in which the situation is represented.

To take into account

- You may need to reorganise the classroom in order to facilitate the discussion. Students should be able to watch their colleagues at any moment.
- Depending on the level and the topic discussed, each of the roles may need to be explained and described. It may be useful to hand out to each participant a description of the main things to take into account (interests, worries, possible personal consequences in their daily lives...).

Debate about controversial science news

1:30 h-2.h
modality: online and face-to-face.
Participants: 4 groups of 4-5 students

What does it consist of?
The teacher selects some pieces of news about the same topic from different perspectives. Students are divided into groups of four students. Each group receives news from a point of view. After reading them, they gather arguments and afterwards they start a debate with the other groups.

Key learning objectives

To understand a piece of science news and be able to explain it.

To organise ideas and discuss them in public.

Resources

Science news, which should be pre-selected.

Annex 4. Examples of sources for the questionnaires

Eurobarometer surveys on science and technology	Series of multi-topic, pan-European surveys undertaken for the European Commission in which surveys related to climate change, vaccines, biotechnology and science and technology can be found. Link
Wellcome Global Monitor 2018.	World's largest study into how people around the world think and feel about science and major health challenges. Link
Manual de Antigua (RICYT) (Spanish)	Guide to stablish a common methodology and practical recommendations for the implementation of national surveys on public perception of science and technology. Link

https://persist.erasmus.site/ict-tool/