“Facilitating reflection on Responsible Research and Innovation”

|  |  |
| --- | --- |
| **Audience** | **Academic and non-academic HEI staff** |
| **Year of study** | **-** |
| **Number of ECTS credits** | **No ECTS credits awarded. Workload of approximately 15 to 20 hours.** |

TABLE OF CONTENTS

Syllabus ………………………………………………………..………………………………………………………..…………3

Train the trainers programme structure…………………………………………………………………………….5

Part 1: Reflecting the impacts of R&I …………..………………………………………………………..………….6

Part 2: Applying concepts of RRI …..………………………………………………………..……………………….12

Part 3: Facilitating reflection on RRI in Higher Education …………………………………………..……17

Surveys after implementation…………….……………………………………………………………………………22

Annexes

ANNEX 1. Transversal Scenario Guide……………………………………………………………………………24

ANNEX 2. Card Statements……………………………………………………………………………………………32

ANNEX 3. HEIRRI Problem-based Learning (PBL) Guide…..…………………………………………….38

ANNEX 4. HEIRRI Role Play Scenarios…….…………………………………………………………………….108

ANNEX 5. HEIRRI Cases…….………………………………………………………………………………………….131

Please remember that the resources at hand **can (and should) be adapted** to your specific needs and context. The HEIRRI resources have been **designed to be flexible**, so we encourage you to think about including **local cases**, adjusting the **timings** of the course to your needs, and also adapting some contents to your specific **field or discipline**.

**SYLLABUS**

|  |  |
| --- | --- |
| **Element** | **Description** |
| **Title** | Facilitating Reflection on Responsible Research and Innovation |
| **Cycle** | In-service training; not part of a study programme. |
| **Year of study** | - |
| **Number of ECTS credits** | No ECTS credits awarded. Workload of approximately 25 to 30 hours. |
| **Learning outcomes (LO)** | On completion of this workshop participants will be able to   1. apply concepts of Responsible Research and Innovation (RRI) to discuss the societal implications of research and innovation (R&I) developments; 2. and to outline how to promote reflection on RRI and related issues in higher education settings. |
| **Mode of delivery** | This is a full-day workshop combining an input lecture by the course instructor with in-class group work using a case example, presentations, and plenary discussions. |
| **Prerequisites and co-requisites** | Experience in or knowledge about higher education teaching. |
| **Course content** | In this workshop, participants will envision possible futures connected to R&I developments. They will reflect on strategies and ways how to steer these developments and their possible wider societal and environmental impacts using concepts of RRI. Then, the course will especially focus on how to integrate such reflection on issues of RRI into higher education teaching and training. Together in groups participants will develop different approaches and designs for teaching RRI to various higher education audiences. |
| **Recommended or required reading and other learning resources/tools** | RRI teaching and learning in higher education:   * Lang, A., Altenhofer, M., Wuketich, M., Griessler, E., & the HEIRRI consortium (2017). *HEIRRI Deliverable 3.2. Training Programmes*. Retrieved from http://heirri.eu/resources/deliverables * RRI Tools (web): RRI Toolkit. https://www.rri-tools.eu/search-engine * Tassone, V., & Eppink, H. (2016). *The EnRRICH tool for educators: (Re-)Designing curricula in higher education from a “Responsible Research and Innovation” perspective. EnRRICH Deliverable 2.3.* Retrieved 9 February 2017, from http://www.livingknowledge.org/fileadmin/Dateien-Living-Knowledge/Dokumente\_Dateien/EnRRICH/D2.3\_The\_EnRRICH\_Tool\_for\_Educators.pdf |
| **Planned learning activities and teaching methods** | First, participants will reflect and discuss an R&I case example presented by the course instructor in small working groups. In this exercise, they will deliberate on what constitutes a “responsible” progress of an R&I development and identify different perspectives on the case example. In plenary presentations and subsequent discussions they will exchange their findings with their colleagues. Second, concepts of RRI are introduced and the participants will have to re-visit their findings and further deliberate on them by referring to these concepts. Third, participants will have to develop approaches and concepts how to teach RRI in their higher education context. By doing so, they should draw on their own teaching experiences and try to link these with the concepts of RRI. |
| **Assessment methods and criteria** | In-service training; no assessment envisaged. |

“Facilitating reflection on Responsible Research and Innovation”

|  |  |  |
| --- | --- | --- |
| **Part 1** | **Activity** | **Duration** |
|  | Speed Dating | 30’ |
| R&I Case Example | 1h30’ |
| **Part 2** | **Activity** | **Duration** |
|  | Debate through Card Exchange | 1h |
| Introduction to RRI | 45’ |
| Enriched Presentations | 45’ |
| **Part 3** | **Activity** | **Duration** |
|  | Five Corners | 2h |
| Final Discussion | 1h |

**PART 1. REFLECTING THE IMPACTS OF R&I**

|  |  |  |
| --- | --- | --- |
| **Part 1** | **Activity** | **Duration** |
|  | Speed Dating | 30’ |
| R&I Case Example | 1h30’ |

Part 1 should start with a short briefing on behalf of the instructor, on what the workshop entails. This should be followed by a general introduction, with each participant stating who they are and what their field of study is.

**Activity 1. Multidisciplinary “Speed Dating”**

Speed Dating is a formalized [matchmaking](https://en.wikipedia.org/wiki/Matchmaking) process of dating whose purpose is to encourage people to meet a large number of new people. The idea of this activity is very similar.

**Goal:**

*The aim of this activity is for participants to be able to introduce themselves and explain why they are attending the course clearly and concisely in a short period of time and be understood*

**Learning outcomes:**

After this activity, the participants should be able to:

* To get to know fellow participants
* To raise awareness about communicating to people from different background/education

**Materials:**

* The participants are allowed to bring an object of choice to help them explain their project (no power point, nor other graphic support)
* Timer

**Description of the activity:**

For this activity, the instructor has to arrange the tables of the classroom so that participants can change quickly. The instructor has to assign half of the participants to remain seated, the other half should move over one chair for each round.

So, first the participants who are seated in the fixed place have 1 minute to introduce themselves and explain why they are attending the course on RRI to the other participants (the ones who change seats), which are acting as listeners and have 1 minute of question time. After that, they change the roles, the participants who have acted as listeners, now introduce themselves and explain why they are attending to the course. The participants who remained seated in the fix location act as listeners and have one minute to question. Also, the participants are allowed to bring an object of their choice to help them explain why they are attending a course on RRI and what they expect to gain from it. Each participant should repeat this process with 2 more participants of different research fields. The main idea of this technique is that with each “date”, based on the questions received from the listening participants, the participants should be able to improve on their delivery and contact with participants of other research fields.

**Total duration of the activity:** 30 minutes

**Teacher’s role: how can the teacher facilitate the activity?**

When the teacher explains the dynamic, it is important to communicate and control the timing of the activity, control the classroom space and be clear explaining each participant role and the objective of this dynamic.

**Activity 2. R&I case example**

**Goal:**

*The aim of this activity is for the workshop participants to discuss possible impacts of a R&I scenario and relate this to personal experience.*

**Learning outcomes:**

After this activity, the participants should be able to:

* Discuss the concept of RRI
* Generate a large number of ideas related to the presented scenario
* Asses the impacts that can come from an R&I development
* Reflect on how negative impacts can be anticipated and avoided
* Relate scenario content ideas with personal experiences

**Materials:**

* Transversal scenario video. Topics: Ageing/Food
* Coloured pens
* Cardboard

**Description of the activity:**

The instructor will show the workshop participants a short video related to RRI, on the topics of Ageing or Food, provided by HEIRRI. The video is a made-up case example that is based on R&I developments. See **transversal scenario video (AGEING/FOOD) and Transversal Scenario Guide.**

The participants should then divide into smaller groups, and elaborate and discuss what impacts the developments in the video could have in different areas and how these impacts could unfold. Participants are encouraged to come up with different visions of the future of the R&I development under discussion and different ways to steer the development in one way or another. The participants should identify the possible risks and benefits involved in the presented scenario. In doing this, they should be stimulated to reflect on what they would assess as a “responsible” progress, but also to think about what and how other societal actors might oppose or support their assessment and what other perspectives might occur in different societal contexts. In this task, it is important that participants do not need to come up with a consensual definition, but to open up their deliberation to diverging or contesting opinions and views and try to deal with them in constructive and cooperative ways. It is important for the participants to focus on the impacts of the scenario, the risks and benefits and how these should be anticipated and/or dealt with.

Participants should put down the main strand of their discussion as well as their findings on posters, flipcharts, or any other appropriate medium to display and present to their fellows.

***Adaptation possibility 1.***

*This activity can be lengthened, to introduce specific dialogue and discussion formats.* ***See programme “Facilitating Reflection on Responsible Research and Innovation”.***

**Total duration of the activity:** 1h30’

The duration of this activity can vary depending on the workshop’s purpose. It can be longer or shorter according to the importance given to getting to know and use the concepts of RRI.

**Teacher’s role: how can the teacher facilitate the activity?**

In this learning activity, the course instructor will have a rather passive role and will function as a moderator if necessary.

The participants, e.g. active researchers, lecturers, or study programme managers, might not be accustomed of being in the role of “students” doing reflection and discussion exercises anymore. However, the teaching approach is selected by purpose: the participants should experience first-handed how it is to deliberate in a group on the “responsibility” of R&I developments. Thus, they might become more sensitive with regards to the challenges such reflection entails, which is an important asset when later on teaching RRI in similar ways to participants. At the beginning of the workshop, the instructor should explain this rationale behind the course design in order not to cause disconcertment among the participants.

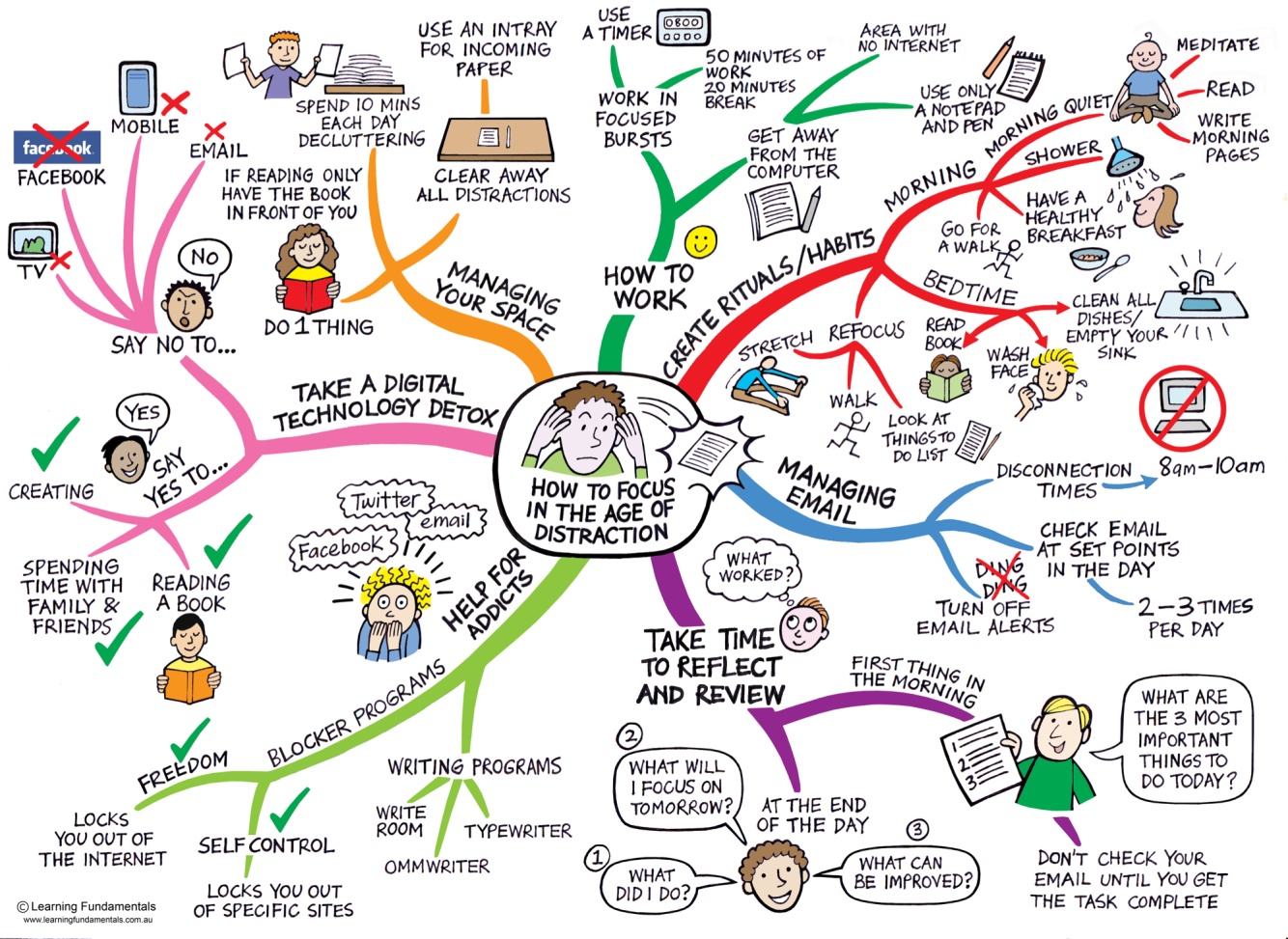
To guide this activity some of these tips are useful:

* When the teacher explains the dynamic, it is important to communicate and control the timing of the activity.
* It is also important to integrate all small group ideas during the sharing.
* The teacher can guide the discussion and promote the participation of all the members of the group in the discussion.

The teacher can suggest some examples for the participants’ presentations. This may make it easier for the participants to organize their key points while studying the cases, therefore helping them to make better presentations, by allowing them to be clearer and more concise.

Here are two suggestions for the participants to work with: **Mind Maps and Ishikawa Diagram**

**Mind Maps  
Concept:** this technique is used to explore a general idea, to obtain a holistic vision of RRI and also obtain a visual analysis so as to identify areas for improvement. The ideas in this methodology can be represented by words or by images. **Methodology:**  
1. Draw the main idea in the centre of the page.   
2. The key points related to RRI come out of the central image, like branches. From these key point branches, key images grow, representing the components of each key point. Each branch must have a word that associates the key image/images with the main idea in the middle. These are the associations.

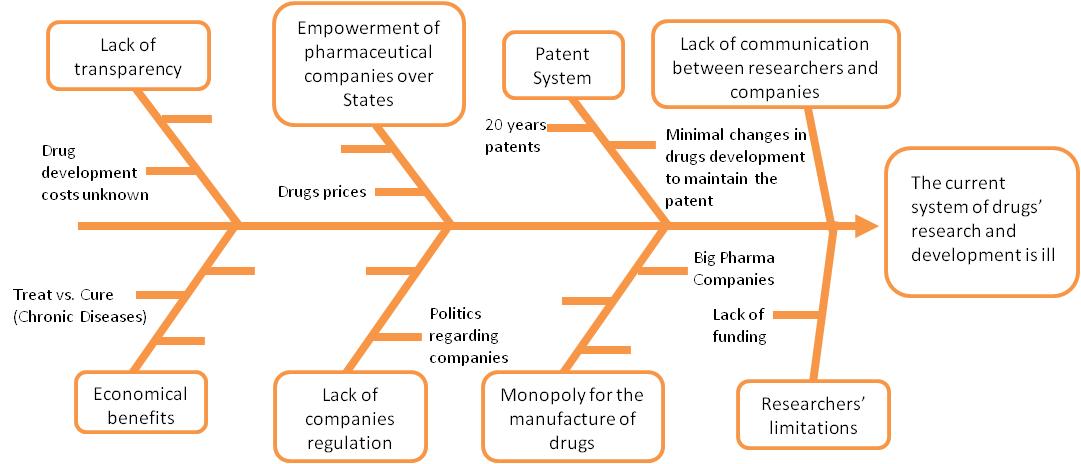
Here is an example of a mind map:

**Ishikawa Diagram**

**Concept:** This graphical technique allows one to appreciate the relationships between a subject or a problem, and its possible causes. It is useful to reorganize concepts and ideas tied to a project or case.

**Methodology:** The fish bone diagram is made up of a central spine that finishes with the main problem or subject. Along this central spine, other spines converge, and sub-spines from these. The objective of the fish bone diagram is to reorganize and identify all the factors that are related to the problem to be solved or the topic that is being studied. Once all the concepts have been identified, they have to be grouped into categories (1 to 6), which can then be expanded upon or modified. **Recommendations**  
**-** It is useful to ask questions to identify ideas and to reorganize them. Some of the basic questions may be: Why? What? Who? Where? When? How?  
- This diagram can be useful in various contexts: to expand a vision on a problem or subject, to analyse and identify solutions, to look for improvements, to modify procedures, to guide a project and to organize ideas. It is important for the participants to keep these graphical representations for the duration of the workshop, as they will be used again.

Here is an example of an Ishikawa Diagram:



*This Ishikawa Diagram was created by 3rd Human Biology grade at Universitat Pompeu Fabra after viewing Investigación Médica: Houston, tenemos un problema*

*(https://www.youtube.com/watch?v=lD2hCCFVuxw)*

**PART 2. APPLYING CONCEPTS OF RRI**

|  |  |  |
| --- | --- | --- |
| **Part 2** | **Activity** | **Duration** |
|  | Debate through Card Exchange | 1h |
| Introduction to RRI | 45’ |
| Enriched Presentations | 45’ |

***Adaptation possibility 2.***

*Invite external RRI scholars or entrepreneurs. These guest speakers should present their own views and visions of RRI and talk about their experiences regarding the promotion and implementation of RRI.*

*The course instructor should then moderate a dialogue between the guest speaker and the workshop participants.*

**Activity 1. Debate through Card Exchange**

**Goal:**

*The aim of this activity is to introduce the concept of RRI to the participants by means of an initial debate on their visions and beliefs on what it means to them to be “responsible” in the processes of research and innovation.*

**Learning outcomes:**

After this activity, the participants should be able to:

* Analyse different statements related to “responsibility” in R&I
* Decide which statements they agree and disagree with
* Argue why or why not they agree or disagree

**Materials:**

* RRI card statements

**Description of the activity:**

This activity consists of a card game, in which the participants have to discuss amongst themselves which of the statements on the cards they agree with. It is an adaptation of the game “The Card Exchange: Introducing the Philosophy of Science”, which has been widely used, with diverse participant profiles, and has showed to be very useful to initiate reflection and to awaken interest on the subject at hand[[1]](#footnote-1).

The game can be carried out in different ways, depending on the size of the group and the amount of time available. It is important to highlight that, to carry out this activity, it is necessary to have more than one pack of cards statements, depending on the number of participants in class (so that they can all analyse a big number of statements and make a deeper reflection on responsibility).

*In a small group of participants (up to 25 people/ 4 to 5 packs of cards):* 1h minutes

The game begins with the handing out of cards to the participants (6 to 8 cards per participants). Then, the participants must be allowed some time to read the cards and to think which ones they agree with more, and which ones they agree with less. After that, they have some time to exchange the cards they don’t like with other classmates. In this phase, the participants are to be able to walk around the room to make the exchanges. The goal is for the participants to obtain the cards they like the most and to be rid of the cards they like the least. It is important to allow enough time for the participants to read and asses the cards belonging to their companions (a minimum of 10 minutes).

In the second phase of the game, the participants sit down and are given instructions (it is important that these instructions should not be given earlier on): they have to pair up, and each pair must select 8 cards that both participants agree on. Each participant should contribute with a minimum of 3 cards.

The third phase of the game consists in a repetition of the second phase, this time grouping together two pairs. Once they have selected another 8 cards, they are instructed to organize them. To conclude, participants are asked to write on a piece of a paper characteristics of:

* A responsible research and innovation process
* An irresponsible research and innovation process

Their conclusions should not only be based on what the cards say, but also on the topics that have been discussed in relation to the cards.

*In a large group of participants (more than 25 people/ more than 5 packs of cards):* 30 minutes

If the activity is carried out in a large group, it is recommendable to simplify. Groups of 4-5 participants should be formed and the cards are then handed out to the groups (8-10 per group). The participants receive instructions to select a minimum of 5 cards that all the members of the group agree with and to justify why they are keeping these cards. In this manner, the participants must discuss each card individually, and decide whether they want to keep it or not. They must then organize their selected cards. To conclude the activity, the participants are asked to write on a piece of a paper the characteristics of:

* A responsible research and innovation process
* An irresponsible research and innovation process

Their conclusions should not only be based on what the cards say, but also on the topics that have been discussed in relation to the cards.

Once this part of the activity is concluded, the participants are asked to **share their definitions** with the rest of the class. It is recommended to make these definitions visible to all the class: they can be written on DINA-3 paper in large writing and hung on the walls around the class. Another option is to use the app “mentimeter” (mentimeter.com), in which the participants can write their definitions with their Smartphone and project them in real time on a screen.

**How can the teacher facilitate the activity?**

The most important aspect of this activity is for the participants to be able to express what they think with honesty, and to be able to compare their opinions with their classmates. The more diverse the opinions of the participants are, the richer the reflection on the subject will be. In this manner, it is important for the teacher to play a neutral role and to not transmit to the participants the fact that there are positions that are more correct than others. The cards must stimulate debate amongst the participants, having to reach a consensus is just a pretext to force the debate, but it is not the goal of the activity. The main objective is for the participants to be conscious of their opinions on this subject, and for them to compare these with their fellow classmates. The teacher monitors the discussion and ensures that, by the end of the session, all participants have participated, that all have listened to their classmates and that nobody has monopolised the debate.

**Activity 2. Introduction to RRI**

For the introduction to RRI, **See PowerPoint presentation: Introduction to RRI.**

**Goal:**

*The aim of this activity is to provide the participants with a general view of RRI.*

**Learning outcomes:**

After this activity, the participants should be able to:

* Identify the main aspects of RRI
* Comprehend the general meaning of responsibility in research and innovation.

**Materials:**

* PowerPoint presentation: **Introduction to RRI.**

**Description of the activity:**

The teacher will give the participants a brief presentation on RRI.

**Activity 3. Enriched presentations**

**Goal:**

*The aim of this activity is for the participants to understand what RRI is and learn how to integrate an RRI perspective into their individual cases (education, scientific activity, professional career, etc.).*

**Learning outcomes:**

After this activity, the participants should be able to:

* Incorporate the new perspectives and knowledge acquired related to RRI into their prior presentation

**Materials:**

* Original presentation (mind map, Ishikawa diagram or other)
* Cardboard
* Coloured pens

**Description of the activity:**

For this activity, the course participants must improve the original presentations created in the first part of the workshop. They should revisit visions and ideas, how integration of RRI principles and implementation of activities supporting RRI could change the progress of development and how they could have an effect on the envisioned impacts. Participants can either work on the presentations already created or create a new one with the same structure.

**Duration of the activity:** 45’

**Teacher’s role: how can the teacher facilitate the activity?**

The role of the instructor during the construction of a clear idea of RRI is essential to the process. The teacher should facilitate the creation of clear presentations on behalf of the participants, well representing the idea of “responsibility” in an R&I process. The teacher’s contributions should encourage reflection on the aspects to be considered, but without manipulating the participants.

**PART 3. FACILITATING REFLECTION ON RRI IN HIGHER EDUCATION**

|  |  |  |
| --- | --- | --- |
| **Part 3** | **Activity** | **Duration** |
|  | Five Corners | 2h |
| Final Discussion | 1h |

**Activity 1. Five Corners**

**Goal:**

*The aim of this activity is for the participants to outline how to promote reflection and related issues in higher education settings.*

**Learning outcomes**

After this activity, the participants should be able to:

* Analyse different education methodologies to promote reflection on RRI
* Asses the possibilities and barriers of each education methodology
* Propose new ways of promoting reflection on RRI

**Materials:**

* 5 tables
* Teaching method examples:
  + Problem Based Learning
  + Role-Play
  + Cases
  + Theory
* Pros and Cons worksheet
* Coloured pens
* Timer

**Description of the activity:**

**Layout**

For this activity, the layout of the room is important. There should be a large open space in the middle of the room, with the activity concentrated in the corners. In this case, there should be five “corners”. In each corner, there should be a table, equipped with different coloured pens and two worksheets for pros and cons(more than one worksheet is recommended).

Each of the tables corresponds to an education methodology. An example of each of the methodologies can be used from the HEIRRI materials. The suggested methodologies to include are:

* Problem Based Learning. **See HEIRRI PBL GUIDE.**
* Role-Play. **See HEIRRI ROLEPLAY SCENARIOS.**
* Cases. **See HEIRRI CASES.**
* Theory. Suggested articles:
  + Michael Gibbons. 1999. Science’s new social contract with society. Nature, Vol.402, C81-C84
  + Jack Stilgoe, Richard Owen, Phil Macnaghten. 2013. Developing a framework for responsible innovation. Research Policy 42, 1568-1580.

The fifth table is for proposals.

**Methodology**

This activity is very useful with a group of participants in one classroom to explore concepts, ideas or content.

The course participants should be divided into four groups. Each of the groups will start at one of the education methodology tables, leaving the proposals table empty.

The groups can work together or as individuals. The participants are to analyse the materials provided in the first corner and think about the possible pros and cons of the methodology. Each participant (**or each group**) should then write down the pros and cons on the worksheets. After the ideas have been put down, they should fold the worksheet so as to hide their contributions from the other groups.

Participants are given approximately 25 minutes per table. Once the time is up and ideas have been added, each group should then move on to the following table and repeat the process.

In the case of the proposals table, instead of analysing a provided methodology, the participants are to suggest ideas of their own experiences as teachers on how to promote reflection on RRI in higher education.

Once all the groups have the round of the five corners, the worksheets will be collected for the subsequent discussion.

**Duration of the activity:** 2h

**Teacher’s role: how can the teacher facilitate the activity?**

The teacher should prepare the layout of the room before the activity begins. Also, the teacher should choose the examples to be provided before the workshop, and read them in detail so as to be able to help the participants during this activity if necessary.

It is important for the instructor to control the timing during this activity, ideally using a timer. The course participants should be given 25 minutes per table, so as to prevent the build up of one than one group at a single table.

The teacher should also be available to answer any questions or solve any doubts the course participants have related to the provided materials.

**Activity 2. Final Discussion**

**Goal**

*The aim of this activity is for the participants to discuss various methodologies to promote reflection on RRI as a group.*

**Learning outcomes**

After this activity, the participants should be able to:

* Analyse the suggested pros and cons for each methodology as a group
* Discuss each methodology in depth
* Assess the participant’s proposals as teaching strategies to promote reflection on RRI in higher education

**Materials:**

* Pros and cons worksheets
* Participant’s proposals worksheet

**Description of the activity:**

Once the 5 corners activity is finalised, the instructor will collect all the worksheets from the tables to be used in the discussion.

The participants should first analyse the given methodologies one by one, commenting and discussing their advantages and disadvantages as education methodologies to promote reflection on RRI. Then, they should look at the proposals from the participants themselves, and repeat the same process. It is interesting for them to decide on which could be the best methodologies for this objective in different contexts.

**Duration of the activity:** 1h

**Teacher’s role: how can the teacher facilitate the activity?**

During this activity, the teacher should moderate the discussion. It is important for the instructor to make sure that all the participants’ contributions are included in the discussion. The teacher should encourage participation from all the participants, so as to enrich the discussion with as many points of view as possible.

At the end of the session, it is useful for the instructor to collect all the contributions made during the workshop. These ideas can then be shared among the participants.

***Adaptation*** ***Possibility 3*** *(Additional assessment and ECTS credits)*

*In some contexts, it might be necessary to assess the achievements of the participants, grade them, and award ECTS credits on completion of the course. For example, PhD participants in a structured doctoral programme might also want to take courses to improve their teaching abilities, but need credits to meet their study programme’s requirements.*

*In order to receive credits for completing the workshop, participants have to hand in a final paper which builds on their insights and knowledge from the in-class exercises, to show that they achieved the defined learning outcomes. The participants have to hand in a final paper outlining a design for a higher education course on RRI considering their own institutional and scientific context, develop modules to introduce RRI as a cross cutting issue in existing courses, or propose another form of strategy (including concrete goals, practical steps, etc.) to facilitate and promote reflection on RRI in a higher education or research setting (e.g. within a research group or department).*

**SURVEYS AFTER IMPLEMENTATION**

The HEIRRI project has developed surveys for post-project application of HEIRRI training programmes and materials. These surveys follow the design used for pilot evaluation, with a few additional open-ended questions, based on adaptations, difficulties encountered and opinions on the future of RRI in education.

Please respond to the relevant surveys after using the teaching resource at hand:

1. Survey for **students**: <https://www.surveymonkey.com/r/3PBQYZN>

2. Survey for **teachers**: <https://www.surveymonkey.com/r/3P37NG7>

For public engagement events:

3. Survey for the **public** (museum events): <https://www.surveymonkey.com/r/36L8Z6R>

4. Survey for **facilitators** (museum events): <https://www.surveymonkey.com/r/3P6WY2V>

Please remember that the resources at hand can (and should) be **adapted to your specific needs and context**. The HEIRRI resources have been designed to be flexible, so we encourage you to think about including **local cases**, adjusting the **timings** of the course to your needs, and also adapting some contents to your specific **field or discipline**.

**ANNEXES**

* ANNEX 1. Transversal Scenario Guide
* ANNEX 2. Card Statements
* ANNEX 3. HEIRRI PBL Guide
* ANNEX 4. HEIRRI Role Play Scenarios
* ANNEX 5. HEIRRI Cases

**ANNEX 1. TRANSVERSAL SCENARIO GUIDE**

This is a guide to assist teachers in using the transversal scenario videos (“On ageing” and “On food”), in a higher education institution context. The videos are to be used to teach and learn about the concept of Responsible Research and Innovation (RRI).

**Transversal Scenario – AGEING**

**Topics:**

* Biomedical Research
* Politics and Gender Studies
* Psychology
* Environmental Sciences
* Economics and Socio-demography
* Technology
* Cultural Studies
* Public Health and Public Health Policies

**Learning Outcomes:**

* To discuss what Responsible Research and Innovation (RRI) is
* To relate research processes in their own field of study with the scenario
* To gain insight on how RRI can be applied to practical research
* To understand the role of responsibility in research processes
* To identify the potential impact of research on individuals, groups or society

**Reflection questions (to formulate after watching the video):**

* How can Biomedical research contribute to fighting the ageing process?
* Which would be the biological consequences of an extended life expectancy? How would that effect chronic diseases and their treatment?
* If life expectancy was extended, how would that effect the economy? Which model of public health policies would be implanted to support the growing population?
* How would technology contribute to this scenario? What new technological devices would appear in the market?
* How would this scenario impact urban planning?
* Would this scenario be environmentally sustainable?
* How would different countries and economies (developed vs. developing countries) approach the treatment for ageing? Could it result in new social inequalities?
* How would different cultures react to this new treatment for ageing? Would there be differences?
* What would be the risks and the benefits of this scenario? Are there nowadays alternatives to this kind of research?

**How can an RRI approach be implemented to research and innovation on ageing?**

**A real case example:**

*HackWithPeople[[2]](#footnote-2)* is an initiative that wants to rethink the way in which assistive technology is created and increase the quality of life of the ageing population. They want to achieve that by breaking economical, technological and specialization barriers.

This initiative has created a set of technological tools to co-create, together with the involved stakeholders, assistive solutions. With this initiative and this system of co-creation, the team has already successfully developed a fall detector and a prototype to recognise situations, among others.

More information about this initiative here:

<http://grasia.fdi.ucm.es/hackwithpeople/about.php>

**Script of transversal scenario video – “On Ageing”**

<https://youtu.be/geM3uCh4qYM>

SUSAN

I am going to retire soon. At least from this job, it’s been a long time. I have 2 kids, which is a lot nowadays, and 2 grandchildren. Family is an important part of my life. I want to spend more time with them. It is not common to have a united family nowadays. Well, I have many passions, I was thinking of becoming a musician but I will always be an expert in the field of health maintenance I guess. My name is Susan, I am still president of the Health Research Institute in the UK and I am going to retire soon. I do think about taking some time for a more creative approach to life, without the pressure I have now. It is not that I don’t like pressure but it is something that I’ve been doing for a long time. Well, in general terms, health maintenance is keeping your body at its optimal performance rate. Keeping it young and preventing it from ageing. The revolutionary idea was to attack ageing as a sickness. Metabolism is extremely complex, as are the number of pathologies derived from aging. We stopped attacking pathologies and we started solving these intermediate damages caused by metabolism. For instance, as we get older, many different types of errant and unwanted proteins, the chemical by-products of metabolism, build up and accumulate between our cells. Collectively these are known as forms of amyloid, a term that might be familiar to you in connection with Alzheimer's disease. We learned how to stimulate the immune system to attack these compounds. Some of the compounds were very difficult to digest for the immune system cells, but we solved the problem by using enzymes discovered in bacteria.

INTERVIEWER

And this is preventing people from ageing?

SUSAN

Well, not entirely, no. But it is slowing it down dramatically.

INTERVIEWER

Can you tell us how old you are?

SUSAN

I am 110 years old, and my life expectancy nowadays is 150, so I have 40 more years to go.

*Video CUT (TedTalks, news pieces, etc.)*

INTERVIEWER

Tell us: at the time aging therapies appeared, how did they affect the world?

SUSAN

They changed the world. Of course, for the good in my opinion. In a general sense, extended youth, new business opportunities emerged… Imagine for a moment, back in 2016, people were at the top of their strength for just 10 years, between their 20s-30s. I mean, we were not useful in evolutionary terms after our 30s, but now we are fertile for longer periods. This is a dramatic change in biological, philosophical and anthropological terms. The sense of hurry, of rush in our society... sickness related to aging was delayed. Of course, everyone needed psychological attention associated to the treatments to withstand this change.

INTERVIEWER

Were there also problems related with that change? Don’t you think that the economic situation nowadays, with poverty indicators rising, is a consequence of this change? Human rights associations are also addressing the need for some laws to regulate this unbalance. The wealthier and more powerful people are the ones who live longer. And nowadays there are still almost 1 billion people in the world that are poor and cannot access the treatment.

SUSAN

Yes, research is private and expensive, so there are many social differences. But this is starting to change and the technology is democratizing. The UN and the World Bank are trying to stipulate some common laws. And there are other issues that concern the governments. Governments were interested in increasing the “productive” life of their citizens by investing in public health, but it was a long-term bet, which is not popular with politicians. And elders stopped being elders anymore. We can take care of ourselves, take care of our children, grandchildren. And we have the wisdom of 110 years and a healthy body. We are of very big asset for our society.

INTERVIEWER

One of the main problems nowadays is the availability of natural resources to feed the growing population. This scientific advancement has taken its toll on the environment.

SUSAN

Yes, but also new businesses have emerged to solve that, and there have been recent advancements, for example, underground farming to allow large areas for crops in countries with no more usable land, high efficiency seeds and also the imprint of protein that is replacing cattle raising in developed countries is decreasing CO2 emissions and making meat completely affordable.

INTERVIEWER

And on the human side, what has been the most difficult part?

SUSAN

For me, the most difficult part of this huge change was in the success rate of the therapies between different individuals. This meant that I lost a husband and also a son. There is still a large gap between the age expectancy of men and women and death is a very dramatic event in the western world now. Even more than it was before. Maybe we need more spiritual guidance now.

INTERVIEWER

What about the people who want to stay out of the therapy?

SUSAN

Well, if you think about aging as a disease, who wants to be sick? It is not part of a natural process. It is like defending not intervening in complicated births because dying in childbirth is natural. We are creating our own path on what’s natural.

INTERVIEWER:

Well, that is not my point, I was thinking about freedom of choice and maybe, the need to understand ourselves as humans, maybe from a philosophical point of view. I would like you to listen to the words of a philosopher from de XX century, if it is ok for you.

SUSAN

Of course, go ahead.

([Alan Watts words](https://www.youtube.com/watch?v=qK1BJkBJdtY))

**Transversal Scenario – FOOD**

**Script of transversal scenario video – “On Food”**

<https://youtu.be/te9qffJPgHE>

*Fermentation is an ancestral technology that has been present in all cultures and civilizations around the world. It has been essential for the preservation of food in seasons of scarcity. Historically it had a huge impact on the gastronomic culture and the flavour palette in different areas around the globe depending on food substrates, climatic conditions, and microorganisms present in a specific place. People developed skills to use microorganisms to convert food and established a close relationship with them.*

BERNAT

I am very interested on fermentation since I believe that it is a process with a huge potential from a gastronomical point of view. Lately I’ve been working on legumes and on finding innovative ways to transform them through this fermentation processes. My name is Bernat Guixer, I hold a PhD in organic chemistry and I work in a restaurant applying my scientific knowledge on the development innovative ingredients.

*Legumes are a significant source of**protein,**dietary fibre,**carbohydrates and**dietary minerals; and like other plant-based foods, contain no**cholesterol and little fat or sodium. But, even though their qualities seem so beneficial, in developed countries, this consumption is decreasing dramatically. In some places like Spain, the consumption has dropped 75% in 40 years.*

BERNAT

Why? Is it a matter of fashion? the market reality? the lack of time to cook legumes? We applied the process of producing tempeh through fermentation to local legumes and check if the output was interesting. The challenge was to apply the process of fermentation to white hocked beans that are cultivated in our region.

*Fermentation has always been linked to climatic conditions, especially when humans were not able to control them in a laboratory. Temperature, humidity and substrates of a region determined the varieties that naturally grew and the microorganisms available in the environment. On the other hand, every region has its cultural features and this two facts, for centuries, have linked culture and food.*

BERNAT

The fermentation process of tempeh is driven by a fungus that needs certain conditions of temperature and humidity. When these conditions are met, the fungus generates a mycelium that compacts the beans and starts transforming them. This is our starting point for the innovation. I am working in a scientific organization, but this does not mean that I can’t work with a scientific approach. I am applying my scientific knowledge to navigate in the process of developing new products that need to taste delicious but that can also be used in other fields. Also, this process started as an open source project in the Nordic Food Lab and has been published in a peer-review journal and shared in different conferences, so the information is available.

*There are serendipitous findings in culinary research. When low temperature cooking techniques are applied to tempeh, some interesting modifications happen. After a couple of days of low temperature cooking, the colour of the tempeh shifts from pale to orange, and the taste becomes sweet and with umami notes.*

BERNAT

We realised, that the shift of the product was significant and we coined a new name to avoid misleading the consumer. I’m finding imaginative ways to deliver interesting products to the kitchen, but also providing possible research topics that can be explored in collaboration with researchers in the academy. This product might have many other commercial uses that could affect many different stakeholders. The use of proximity crops instead of global ones like soy, would affect local producers. Restaurants, companies of processed food, private consumers... But beyond that it could affect the preservation of crop diversity. By maintaining the use of local seeds, using our ancestral varieties, we favour the survival of this seeds and we preserve the diversity of legumes.

*When think about soybean products, a global product in opposition to proximity seeds, the first thing that comes to mind are healthy food staples like tofu, edamame or soy milk. But in reality, a typical soybean is more likely to end up in a ham-and-cheese sandwich or a chicken nugget than a block of tofu. 70–75 percent of the world’s soy ends up as feed for chickens, pigs, cows and farmed fish. The remainder is used in a variety of industrial applications, including biodiesel production, or for direct human consumption.* Growth in demand is largely attributable to the increasing preference for meat among the growing middle class in emerging economies, which has brought with it higher demand for animal feed.

BERNAT

The product won’t be the cheapest of all if it is commercialized. This is for sure. I work in a company with commercial interests of course, but the restaurant is willing of spending money and time to develop technologies that will be later applied to consumer products or technologies. Thickening agents, for instance, is a culinary tool that has been used in hospitals to help people with difficult swallowing. I don’t know if these crop fields can affect other crops. And also, any fermentation process involving microorganisms has to be deeply analysed concerning safety to discard histamines or other harmful toxins. Maillard reactions in the cooking (that give browned food its distinctive flavour) can bring also carcinogenic by-products, as in many other cooked products in our everyday life. The cultural relationship that humanity has with cooking in not balanced in terms of gender. While women have been attributed the role of cooking in the majority of households, high cuisine is still a man’s world.

*In the field of food, professionals are concert not only about nutritional value but also about the appreciation of the product by society. There could be a synthetic meal perfect from the nutritional point of view that nobody liked. As human beings, there is a need to make meals enjoyable.*

BERNAT

We don’t have any information on the opinion of the public about our products but chefs are the ones concerned about what the consumers like. But not only that, they are stimulating the consumers with new flavours, new proposals and experiences. Do we need to take always into account the nutritional values of food? Or the enjoyment of food? Or maybe both? That’s were variety offers versatility.

The Roca brothers: the chef, the sommelier and the pastry chef of the restaurant, usually state that: “Traditions are legitimated avant-garde”, meaning that any present tradition was necessarily an innovation in the past, which people legitimated over time.

*Culinary avant-garde is challenging the gastronomy of today pushing its boundaries. Somehow it is a way to point topics that might need an update, as well as proposing ways and suggesting alternatives to improve the gastronomical world of tomorrow. And this may be really broad, from plating to considering approaches for food sustainability.*

## ANNEX 2. CARD STATEMENTS

The statements represent ideas related to RRI dimensions, either in favour or against to stimulate the debate. Cards from 1 to 13 correspond to issues related to diversity and inclusion, cards from 14-27 to openness and transparency, cards from 28-36 to anticipation and reflection and cards from 37 to 40 to responsiveness and adaptive change.

**CARD 1**

Public should be involved in decision-making processes of the development of emerging technologies

**CARD 2**

Public is not educated enough to be involved in decision-making processes of the development of emerging technologies

**CARD 3**

If we consider the values and needs of society in the research and innovation process, the research results are of a higher quality

**CARD 4**

Considering the needs and values of society in the research and innovation process can limit or divert the development of scientific knowledge

**CARD 5**

Public cannot participate in scientific research because it does not understand scientific language

**CARD 6**

Society’s opinion on research can be consulted, but not considered when deciding what should be investigated and how

**CARD 7**

Before starting a research process, it is necessary to consult with the actors that are affected, to find out their opinions and needs

**CARD 8**

Researchers should implicate themselves in the scientific education of citizens, for example they could include as an objective the creation of educational material in their research projects

**CARD 9**

Citizen science projects should be encouraged, in which anyone can participate, collecting or analysing data

**CARD 10**

Methods of citizen participation in scientific or technologic topics should guarantee that all social groups are represented (gender, population, social class, religion, politics, sexual orientation, etc.)

**CARD 11**

Research methods should contemplate diversity, for example when working with animal models, to not only work with male models, or when doing research with people, to represent different cultures

**CARD 12**

Stakeholders must be able to participate in the research process from start to finish, from the definition of what is being researched and how it is being researched to the assessment of results and possible applications

**CARD 13**

Research teams should be gender balanced because they work better

**CARD 14**

Any person should be able to consult and understand which research projects are under development

**CARD 15**

The information on research projects should only be available to the scientific community

**CARD 16**

The information on research projects should only be published once these have finished

**CARD 17**

Both positive and negative results of research projects should be published

**CARD 18**

The digital laboratory notebooks that scientists use in their research should be able to be consulted on a public platform

**CARD 19**

Only positive results from research projects should be published, as negative results are not of interest to society

**CARD 20**

Peer-review process should guarantee that the only people assessing if research is of quality or not are other researchers from the same field

**CARD 21**

Research and innovation results should be assessed by experts from different areas of expertise, to make the knowledge more valid

**CARD 22**

The uncertainties of a research project should not be shared with the persons implicated because these could generate mistrust towards science

**CARD 23**

It is important to share uncertainties of a research project with the interested parties

**CARD 24**

If the results of a research project imply negative consequences, the researcher should be held responsible

**CARD 25**

Research projects should include various disciplines to be more relevant

**CARD 26**

For an R&I Project to be considered of excellence, the team must be made up of the most prestigious scientists

**CARD 27**

Research teams that include scientific and non-scientific personnel (such as NGOs, stakeholders etc.) tend to have more socially relevant results than those that are formed solely by scientists

**CARD 28**

Before starting a research project a study should be conducted on the possible mid-term and long-term risks and impacts

**CARD 29**

It is not necessary to study the long-term risks of a research project or technological innovation because they are impossible to predict

**CARD 30**

All research or innovation implies certain risks and researchers should assume responsibility of those

**CARD 31**

If it is found out that a researcher has carried out ethically unacceptable practices, such as plagiarism or publication of false data, they should be forbidden to work as a researcher again

**CARD 32**

If a research project has important environmental impacts, it shouldn’t be carried out even if it has obvious benefits

**CARD 33**

Researchers should predict the possible misuses of their research results and assume responsibility for them

**CARD 34**

Researchers are not responsible for how their research results are used in the future

**CARD 35**

If the organization that finances my research asks me to rewrite the project conclusions to make them more convincing, I should accept so as to continue investigating

**CARD 36**

Scientific excellence should be measured according to the number of publications in prestigious scientific journals

**CARD 37**

During the progress of a research project, if it is detected that there is not a good response from the interested parties, the course of the research should be changed

**CARD 38**

If a large portion of the population does not agree with a technological innovation, for example the use of genetically modified organisms, research should not be continued

**CARD 39**

When a research project is started, the planning should be followed strictly, even if circumstances change, such as the appearance of a competing research group or a change in legislation that affects the results

**CARD 40**

The reasons to do research should be purely of scientific interest and not for the prestige of the researcher as an individual

**ANNEX 3. HEIRRI PROBLEM-BASED LEARNING (PBL) GUIDE**

**TABLE OF CONTENT:**

* Introduction to the Problem Based Learning Methodology
* HEIRRI PBL scenarios
* PBL scenario 1: The Island of Dr. Schultz
* PBL scenario 2: House of Climate Change
* PBL scenario 3: Male Contraception
* PBL scenario 4: A Voyage into the Past
* PBL scenario 5: Cyberville
* PBL scenario 6: The forgotten sleeping sickness
* PBL scenario 7: Deception
* PBL scenario 8: What’s your score?

**INTRODUCTION TO THE PROBLEM BASED LEARNING METHODOLOGY**

**Problem-based learning (PBL)** is an instructional learner-centred approach organized around the investigation and resolution of messy, real-world problems. Students work in small groups with a tutor that acts as a learning facilitator. PBL empowers learners to become problem solvers, seeking to identify the root problem and the conditions needed for a good solution and in the process, they become self-directed learners.

The key characteristics of the method described by Barrows are:

1. Students must have responsibility for their own learning, so students determine why they need to learn and which resources they will use to acquire the missing knowledge.
2. The problem simulations must be ill-structured and allow for free inquiry. Problems in the real world are ill-structured (or they would not be problems). A critical skill developed through PBL is the ability to identify the problem and set parameters on the development of a solution.
3. Learning should be integrated from a wide range of disciplines or subjects. During self-directed learning, students should be able to access, study and integrate information from all the disciplines that might be related to understanding and resolving a particular problem—just as people in the real world must recall and apply information integrated from diverse sources in their work. Multiple perspectives lead to a more thorough understanding of the issues and the development of a more robust solution.
4. Collaboration is essential. The point of self-directed research is for individuals to collect information that will inform the group’s decision-making process in relation to the problem. It is essential that each individual share coherently what he or she has learned and how that information might impact on developing a solution to the problem.
5. A closing analysis of what has been learned from working with the problem and a discussion of what concepts and principles have been learned are essential. Given that PBL is a very engaging, motivating and involving form of experiential learning, learners are often very close to the immediate details of the problem and the proposed solution. A final assessment about what has been learned and how they can use the information in future situations is necessary to consolidate the learning and ensure that the experience has been reflected upon.
6. Self and peer assessment should be carried out at the completion of each problem. These assessment activities related to the PBL process are closely related to the previous essential characteristic of reflection on knowledge gains. The significance of this activity is to reinforce the self-reflective nature of learning and sharpen a range of metacognitive processing skills.[[3]](#footnote-3)

**Teacher’s role**

The teacher’s role in PBL is to facilitate the students’ learning process, so their task is to stimulate group discussions and critical thinking, to generate an environment that is both comfortable for the students and in which all the members participate, to evoke the students’ prior knowledge, to provide the necessary tools for the students to build up their knowledge, to guide the students as to which sources to use and to evaluate the process and the results obtained. The teacher should avoid giving mini lectures and instead, orient the students through questions.[[4]](#footnote-4)

**Materials**

* PBL scenarios.
* Evaluation rubric.

**Description of the Activity**

*In a small group of students*

The PBL activity is organized in tutorial sessions with small groups of students (6 to 10 people). Each group has a tutor who takes on the role of learning facilitator.

For this module, we suggest working with different groups of students (depending on the number of students), with each group working on a different problem. In this way, in the final sharing session, students can discuss different approaches of RRI applied to different scenarios. However, there is also the possibility to have all the groups working on the same problem and sharing the different approaches to it at the end.

The resolution of a PBL exercise will be organised into the following stages:

**Session 1 (1h30)**

1. Presentation of the PBL Scenario. 15’. The session begins with the reading of the problem (or viewing/listening, depending on the format). It is recommended to allow some time after a group reading for each student to think of which questions the problem has evoked in them. Then, all the questions in the group are shared. It is recommended for one of the members of the group to write these questions on the blackboard or a similar medium, so all the participants can see them.
2. Brainstorming. 30-45’. It is important to give the students some time for brainstorming, so they come up with as many ideas as possible. During this stage, it is also possible to ask the students to come up with explanatory hypothesis for the questions posed, and for them to identify that which they need to learn to answer these questions.
3. Work plan: 30-45’. All the questions that have come up must be structured, grouping together those questions that are related. At the end of the session, the students should have a work plan for their research: which terms and concepts they need to clarify, which questions they want to investigate and which resources they will use to do so. They also distribute these tasks among the group members; the group can decide whether they want to divide up the topics or if they will all research the same one, but consulting different sources.

**Teacher’s role: how can the teacher facilitate the session?**

During this session, the tutor can help in defining the questions. Based on the questions formulated by the students, the tutor can help reformulate them so as to make them more specific or precise. The tutor can also help the student’s prior knowledge emerge, related to the studied scenario, making what they need to learn clearer. As to the learning resources, the tutor can also orient the students. The students are normally not directly provided with bibliography to consult, but they can be guided towards the type of source to use (handbooks, original papers, review papers, interviews with experts, etc.) or help them identify the areas of knowledge that their questions address. [[5]](#footnote-5)

Autonomous research**:** The students, individually or in groups, research the topic at hand. It is necessary for them to have a few days for this to allow them to go into detail on the topic.

**Session 2** **(1h30):**

1. Sharing the research: 1h. the students share the research they have done, the different sources they have consulted are contrasted and they try to answer the questions they initially posed
2. New work plan: 30’. Generally, after having delved into the problematic scenario and the group discussion, new questions arise. So, it is interesting for the students to ask themselves new questions, so as to go into further detail on the subject.

**Teacher’s role: how can the teacher facilitate the session?**

It is important for the students to have carried out a critical analysis of the sources of information they have consulted. In this manner, one of the tutor’s tasks in this session is to make sure this has been done, questioning the sources used and the student’s analysis of them, the tutor can help the group to further advance in the problem that is being studied. 63

Autonomous research**:** The students, individually or in a group, research the topic at hand. It is necessary for them to have a few days for this research to allow them to go into detail on the topic.

**Session 3** **(1h):**

1. Closing the problem: 40’. In the first part of the session, the students share the new research they have carried out and they come up with conclusions. These conclusions should be focused on answering the questions posed and/or proposing possible solutions to the problem identified. The process they have followed to analyse and solve the problem should be presented in the form of a group project after a few days (a report, an oral presentation, a mind map, etc.)
2. Auto-evaluation: 20’. After coming up with the conclusions on the problem itself, it is worth the while to reflect upon what has been learnt during the process and in which situations might this information be useful in the future. It is also recommendable to realize an auto-evaluation of the learning process, both individual and in the group.

**Teacher’s role: how can the teacher facilitate the session?**

The tutor should help the students synthesize that which has been learnt during the process of solving the problem, to identify the key ideas and to transfer this information into other contexts. The tutor must also help guide the development of meta-cognitive abilities, encouraging reflection on the learning process.63

**Session 4 (2h):**

1. Presentations: In finishing the PBL, the students’ groups are asked to give an oral presentation to their classmates, involving a discussion on the final conclusions. This presentation should be structured according to the questions posed upon analysing the problem. Each group presentation should not be longer than 15 minutes.   
   Presentations can be evaluated with the following rubric either by the teacher and the classmates for peer-assessment. We suggest sharing the rubric with the students at the beginning of the unit for them to understand what is expected by the problem analysis.[[6]](#footnote-6)

*In a large group of students (20 or more)*

In this case, PBL is also organised in tutorial sessions but with a large group (more than 15-20 students). The tutor acts as the learning facilitator of the whole class. If there is not the possibility to have one tutor for group and the activity has to be implemented with the whole class, the students will work in smaller groups (4-5) in the same classroom while the teacher walks around giving support to them, so the tutor acts as a multi-facilitator of different groups at the same time. In this case we suggest that each group of students has a different problem to discuss different approaches in the sharing session. The activities during each session are exactly the same as PBL with smaller groups. The tutor can distribute its time between groups and guide the small groups during the process. This kind of PBL requires a greater effort of the teacher because its difficulty of guiding different problems and groups at the same time, but it is also feasible and effective.

**Evaluation is a key element of PBL**

Given that the objectives of PBL are based both on knowledge and the process, the students should be evaluated in both these dimensions. Due to the fact that this method is centred on the learner, it is expected that the students should participate in the evaluation process.

To evaluate the process, it is recommended that the tutor assesses the students’ participation in the tutored sessions via an observation grid. This grid should also be given out to the students so they can use it to evaluate their own group classmates and themselves. The final participation evaluation of each student is the average between the own group classmates’ and the tutor evaluations.

To evaluate the acquired knowledge, it is normally done through the students’ presentations or through exams. In this case, it is recommended to evaluate the students via oral presentations with the whole group in class, as it has been previously described. Oral presentations can be assessed with the PBL rubric by the teacher and the peers. **PBL rubric for oral presentations**

|  |  |  |  |
| --- | --- | --- | --- |
| Evaluation criteria | Not achieved | Half achieved | Achieved |
| Identification of the RRI aspects | There is no evidence of the students having questioned the problem from an RRI perspective. | The students have questioned some relevant aspects of RRI related to the problem. | The complexity of the problem is recognized and key questions on different aspects of RRI related to the problem are asked. |
| Critical analysis and creativity | There is a superficial analysis of the problem, with no evidence or data.  No different approaches to the problem are considered.  The ethical principles related to the problem are not questioned.  The proposals to integrate RRI in the problem are not original. | There is a description of the problem and an evaluation of the risks and benefits, with some data.  Different approaches to the problem are described, but not justified.  Opinions on the ethical principles related to the problem are expressed.  Some original ideas on how to integrate RRI in the problem with the available resources are proposed. | The description of the problem and the evaluation of the risks and benefits are based on evidence and data.  Different approaches to the problem are described and well justified.  Different arguments regarding to ethical principles related to the problem are elaborated.  Disruptive ideas are developed to integrate RRI in the problem with the available resources. |
| Presentation structure and audio-visual support | Disorganised structure.  The quantity of information is not adequate for the established time.  The audio-visual support has errors in form or content and does not help in the comprehension of the presentation. | Clear and organised structure.  The quantity of information is not adequate for the established time.  The audio-visual support has some errors in form or content and on some occasions, does not help the comprehension of the presentation. | Clear and organised structure.  Good synthesis of information.  The presentation meets the established time.  The audio-visual support is clear, there are no errors in form or content and it is useful in improving the comprehension of the presentation. |
| Use of the information sources | Many of the sources are not reliable.  The sources are not referenced in the presentation. | Some of the sources are reliable and some are not.  Not all the tables and figures are referenced. | Different sources are used.  The sources used are reliable.  The tables and figures are well referenced. |

**Observation grid to evaluate students’ participation in PBL tutorials**

|  |  |
| --- | --- |
| RESPONSIBILITY | * Respect the timing * Shows knowledge on the PBL objectives * Seeks information and studies it |
| KNOWLEDGE CONSTRUCTION SKILLS | * Integrates the problem information into prior knowledge * Recognises the different dimensions in the problem * Shows the ability to form hypothesis * Collaborates in the construction of a work plan * Seeks relevant information and critically analyses it * Justifies comments with adequate references * Actively and pertinently participates * Well managed and organized time-wise * Takes action to correct weak points |
| ORAL COMMUNICATION | * Synthesizes the information * Presents the information in an organized manner * Clear and concise expression |
| COOPERATIVE WORK | * Contributes to organizing the discussion * Is tolerant with both equals and tutor * Waits for an intervention to finish before interrupting * Knows how to listen and receive criticism |

**HEIRRI PBL Scenarios**

In the following pages, you can find a set of PBL scenarios designed to learn different aspects of RRI. Each scenario is composed of the problem and the tutor guide.

Students will only receive the problem, through this it is expected that they will formulate questions that drive them to acquire the learning outcomes. In the tutor guide, just for the facilitator, there are some of developed questions that the students might formulate. In case they deviate a lot from learning outcomes, the tutor can use the reflecting questions to focus the discussion on RRI topics. This is just a guide, students can formulate different questions that are useful to discuss RRI topics, furthermore, the tutor or facilitator can think about and add more questions related to the scenario.

**PBL scenario 1: The Island of Dr Schultz**

* **A short story inspired by “The Island of Dr Moreau”, by H.G. Wells**

The small boat finally neared the island, and I could make out the shape of the trees and buildings. I had been looking forward to this assignment for weeks now, my first article for the science section. The recent organ crisis had forced the authorities to plough ahead with what was once their long-term plan, creating quite a stir. I was on my way to one of the few facilities in the world working with “chimaeras”.

They had asked me to write a story about the soon-to-be new “organ pool”. At the time, organ donations were at an all-time low. Organ donors were practically non-existent and the average human lifespan was about 95 years, so people who were donors were normally already too far gone. The solution devised by Dr Leopold Schultz, a developmental biologist, was to create organs from scratch, by growing them in animals. The ideal animal host was the pig, due to its size and similarities with the human race. As an emergency measure, many centres were authorised to work on this technique all over the world to maximise the research capacity. At that time, they were still in the experimental phase, eliminating the embryos before they were born. The centre I was visiting was on an island off the coast of Hawaii.

I arrived in the late afternoon; I stared up at the surrounding jungle before I was quickly ushered through the long corridors of the main building, straight into Dr Schultz’s office. He greeted me with a slow smile, and gestured towards a chair in front of his desk. The room was bare and there was nothing on the walls, only a small window behind the desk. “Welcome, Mr Larkin, we’ve been looking forward to your visit. Our research has been progressing rapidly, you’ll be glad to hear.” He had a slight drawl to his speech, seeming only half aware of what he was saying. “My assistant will show you around the labs tomorrow morning, it’s too late now”. And with that, I was whisked off to another room, my chambers for the next few days. Again, the room was almost empty, consisting only of a bed, table and chair.

They had left me dinner on the table, so I assumed I was to eat alone. That said, I highly enjoyed the dish of roast pork and vegetables they had left, and probably had one glass of wine too many, as I promptly fell asleep. I had strange dreams that night, of creatures in the jungle, and woke up feeling quite disoriented.

The whole morning went by in a whirlwind as I was given a tour of the massive building. Dr Schultz’s assistant showed me many different laboratories and equipment I couldn’t even begin to comprehend. He introduced me to a young scientist, Dr Diane Deacon, who was kind enough to explain what it was they were actually doing. She described the process they used, which consisted of injecting human cells, which are programmed to become a specific organ, into the blastocyst of a pig, so that these cells would go on to become a human organ growing inside a different species. The idea was to eventually allow these animals to grow to adult stage, at which point they would then be sacrificed and the organs removed ready for transplanting. I wondered if it was really necessary to kill an animal for every organ needed, but I soon lost that train of thought as I was rushed to the next laboratory.

I was left to myself that afternoon. I decided to wander the building on my own. After a while, I was decidedly lost. All the rooms, laboratories and corridors looked the same to me, and judging by what I had seen upon entry, the building was huge. There didn’t seem to be many people around, so I continued on my stroll, assuming that I would find someone eventually. I reached a door that appeared to be slightly different to the rest. There was a code pad next to the door, but it was slightly ajar. I opened it cautiously and was greeted by strong smells and animal noises. I stepped from a sterile corridor into an airy, sunny and very large room that looked a lot like a barn. Both sides of the large space were lined with pens, all of them containing pigs. I don’t know how many there were in total, too many to count. As I walked along, they all neared the fences, seeming rather curious and friendly. I got quite distracted and was soon scratching away at their necks and snouts, having a delightful time. I kept walking along, admiring all the different specimens, feeling quite awed at the number of animals. I couldn’t help thinking of the fate that awaited them, although I tried to brush the thought away.

As I neared the end of the barn, I noticed the pigs were younger. And the last pens were full of piglets! I couldn’t help smiling and making baby noises as I kneeled down to touch them, what funny little animals they are. As I was repeating the process at the last pen, I don’t know how long I had been in there by then, I noticed something strange. One of the piglets seemed a bit different. As the others rushed towards the fence sniffling and snorting, one stayed back. This behaviour made me look at it more closely; I worried it might be ill or injured. As soon as I did, I felt a shiver go down my spine.

The creature looked like a piglet, and at the same time, it did not. I found myself staring at its face, especially its eyes. There was something oddly disturbing about this animal, and I could not figure out what it was. I suddenly realised that the pig was staring right back at me, with what seemed like despair in its eyes, almost human. I instinctively got my camera out and took some photographs of the animal. Even so, I found I could not look at it directly any more, as I was filled with a feeling of revulsion.

I quickly retraced my steps and left the barn. I wandered the long corridors for some time until I eventually found my room. I closed the door behind me and sat down on the bed. I knew something was terribly wrong.

**TUTOR GUIDE:**

**Learning outcomes**

After this activity, the students should be able to:

* Understand the meaning of the concept “chimera” and the origin of the word
* Analyse the possible applications of this type of research
* Define the manner in which this research is carried out
* Evaluate the possible risks involved in this type of research
* Asses the ethical issues/impacts related to this type of research
* Examine the possible security measures to be implemented in this type of research
* Determine if this type of research is transparent and of public interest
* Investigate if there are possible alternatives to the solution sought by this type of research

**Reflection questions**

**How would you define a chimera? Which is the origin of the word?**

The origin of the word chimera, and the idea of a chimera can be traced back to Antiquity. The word used to describe a fabulous creature.

* In Greek mythology, the Minotaur had a man’s body and a bull’s head, and Pan was half man, half goat.
* Many Egyptian gods had a human body and a beast head, such as Sobek, Anubis, and Horus.[[7]](#footnote-7)

The Ancient Greek poet Homer depicted the mythological Chimera[[8]](#footnote-8):

“First, dire Chimaera’s conquest was enjoin’d;

A mingled monster of no mortal kind!

Behind, a dragon’s fiery tail was spread;

A goat’s rough body bore a lion’s head;

Her pitchy nostrils flaky flames expire;

Her gaping throat emits infernal fire.” (Homer 1836)

Another description can be found in the Theogony, where Hesiod describes Chimera67:

“She [Echidna] was the mother of Chimaera who breathed raging fire, a creature fearful, great, swift footed and strong, who had three heads, one of a grim-eyed lion, another of a goat, and another of a snake, a fierce dragon; in her forepart she was a lion; in her hinder part, a dragon; and in her middle, a goat, breathing forth a fearful blast of blazing fire.” (Hesiod 1914)

Nowadays, “chimera” describes a living organism that contains cells or tissues with different genotypes.66

Lensch et al. propose the following definition of ‘chimera’: “The term chimera […] indicates organisms comprised of cells from two or more individuals of the same or different species. Today, the most common usage describes cellular combinations at the pre-implantation blastocyst stage of development, […] also […] other entities created by introducing cells at later stages, including in adult recipients[[9]](#footnote-9),[[10]](#footnote-10).”

Another definition is proposed by Behringer: “A chimera is an individual composed of somatic and, in certain cases, germ line tissues derived from more than one zygote. […] If the donor tissue and recipient are of different species, then an interspecific or cross-species chimera is generated. 68,[[11]](#footnote-11)”

The UK Academy of Medical Sciences suggests this definition for chimeras:

Chimæras are formed by mixing together whole cells originating from different organisms. The new organism that results is made up of a ‘‘patchwork’’ of cells from the two different sources. Each cell of a chimæra contains genes from only one of the organisms from which it is made. (…) Primary chimæras are formed by mixing together two early embryos, or an early embryo with isolated embryonic cell types obtained from a different embryo or cultured stem cell line. The resulting chimæra has cells of different origins, in many tissues. Secondary chimæras are formed experimentally by transplanting (or grafting) cells or tissues into animals at later stages of development, including late fetal stages, post-natal or even adult animals. The donor cells are only present in a few tissues.67

**Which scientific fields could have a possible interest in animal-human hybrids? What advantages can you see in the creation of these chimeras?**

The main interest, which is also the one that is receiving the most attention, is the production of human organs in animals, which now seems possible due to recent technological progress. The objective of this research is to be able to provide organs for transplantation into humans, due to the severe organ shortage.1 In Europe in 2013, there were at least 60,000 people on the organ transplant list. 66,[[12]](#footnote-12)

There are other applications for the use of animal-human hybrids in research.

* To test the potential of human pluripotent cells. In this case, human cells are injected into a mouse morula, and the chimeric embryo is analysed shortly afterwards. These experiments are limited to early embryos (10 days), within the limit for research on human embryos). It is possible that central nervous system tissue containing both mouse and human cells could be found in this chimera. 68
* To study metabolic diseases in an aging population, such as the EU-funded project ‘Health and the Understanding of Metabolism, Aging and Nutrition’ (HUMAN). They want to create “humanised” mouse models with human donor liver and pancreas cells. This would allow them to study the functions of genes in human organs and how these can influence the risk of metabolic disease, in combination with factors such as diet. The project would involve two groups: very old and healthy individuals and individuals with metabolic diseases. This project involves maintaining chimeric animals until old age. 68, [[13]](#footnote-13)
* Animal-human hybrids have also been used for: research into human haematopoiesis, the development and function of the immune system, infectious diseases, autoimmunity, cancer, and regenerative medicine.
* They have also been used as research tools for the creation of vaccines against deadly diseases such as malaria, dengue, Hepatitis B, HIV and Hepatitis C.
* They have been employed for the study of the human cell development, maturation and migration.67

**How would an animal/human hybrid be created?**

In the case of producing chimeras for human organs, the animal (the carrier) would have to be altered genetically so as to inhibit the development of a specific organ or organs. Then, human iPSC (induced pluripotent stem cells), which can propagate indefinitely and give rise to any other cell type ion the body, would be injected into the blastocysts of these genetically altered animals. In this manner, the “missing” organ in the animal would be made up entirely of human cells, which should differentiate and spread throughout the body.66,[[14]](#footnote-14) In practice, the production of viable hybrid embryos has proven difficult using this technique.73

**What are possible risks involved in creating animal-human hybrids?**

As it is mentioned previously, pluripotent cells are a powerful type of stem cell that can become any cell type in the body. There is concern that these human cells, when combined with animal embryos, could develop into brain cells, sperm, or egg cells in the chimeras.66 This means that there is the risk, although minimal, of these pluripotent cells migrating in the animal host and possibly contributing to the formation of different organs or tissues in the animal.

iPSC cells should only be used when they are to replace cells or tissues that are absent due to a gene knockout. This limits the colonization of undesired organs or tissues by human cells, such as the brain. The risk of forming other organs is very small due to the fact that human cells are expected to be less competitive than pig cells, if they are in a pig microenvironment (the pig embryo), unless a specific cell type has been impaired by genetic means (the organ to be replaced).66

There is also the concern of zoonoses, described by the WHO as “any disease or infection that is naturally transmissible from vertebrate animals to humans.” It is thought that retroviruses integrated into the genome of some animals could be transferred to humans. There is the risk that human tissues developed in animal hosts could be the source of new zoonoses. The fear is that although the effects of theses retroviruses are known in animals, there is no way to predict what they could cause in humans. Also, there is the concern that human organs may become contaminated by residual animal cells or proteins that could later elicit a potentially harmful immune response in the organ receivers. 66

**What ethical issues are involved in the creation of animal-human hybrids?**

The main ethical issues involved in the creation of human/animal chimaeras are: animal welfare, human features, human consciousness and the production of human gametes.

Animal welfare – Some consider that experimentation involving pigs is already strictly regulated in order to avoid unnecessary animal suffering. In this manner, the fact that chimeric animals are raised for the purpose of human organ culture should not cause more ethical debates than raising them for consumption or other types of research.66 On the other hand, the fact that the animals are to be raised with the sole purpose of carrying the human organs until the required size, and are to be sacrificed on the day of the transplant provokes different reactions. The number of animals it would require having a decent sized organ pool raises animal welfare concerns.66

Human features – It is argued that an injection of iPSC into animal embryos could somehow affect the physical appearance of said animal. This is explained by the capacity of these cells to develop into any kind of tissue. The creation of human/animal chimeras blurs the boundary between two species, and induces questions on human identity.66

The idea of this boundary being crossed causes certain resistance in the general public. Even so, although the idea of mixing human and animal genes is not often considered by the public and the notion of creating a chimera does not seem real to the general public, it is already a standard practice in science (for example in some of the research fields mentioned above).66

Human consciousness – Also related to the capacities of the iPSC, there is certain concern over the possibility of animals developing some level of human consciousness, due to human cells migrating to the brain and developing into neuronal tissue. One chimera study reported that mice containing human glial cells in their brains were seen to perform much faster in memory and learning tests than the control group of mice. This raised the question if these “humanized” mice might be cognitively enhanced.[[15]](#footnote-15)In other animals, these effects could be much more noticeable.

Questions arise such as:

Could a significant contribution of human cells to the animal brain modify the characteristics of the recipient species? Would this affect the evaluation of the moral status of the animal, especially in the case of large animals, such as pigs and particularly nonhuman primates?

If the presence of human cells in the brain of an experimental animal resulted in some form of human consciousness, the creation of animal/human hybrids would be considered ethically unacceptable. This is because one of the considerations to distinguish animals from humans is based on consciousness.66

Human gametes - Humanization of animals bearing human organs could also result in the production of human gametes. Human embryos could be created using these gametes. The worst-case scenario would be that a pig producing human sperm could accidently mate with a sow or vice versa.66

Another ethical concern is the protection of the human subjects involved in the clinical trials. This is related to the risk of zoonoses, as the effects on humans are still not known.66

Also, there is certain debate about the subject of “human dignity”, referring to the fact that creating these hybrids would give the animals a human status, “human dignity”, and would therefore have to be treated as such.67

**Why should security measures be implemented?**

Security measures must be implemented strictly to minimise all the risks mentioned above, and to avoid as many ethical grey areas. In this manner, to prevent the worst-case scenario of a humanized pig brain (or another animal), it is essential to define a maximal limit of human chimerism in the animal brain that should not be exceeded.66

For example, the U.S. National Research Council and the Institute of Medicine recommended limits on chimera research in 2005[[16]](#footnote-16),[[17]](#footnote-17), including that no human stem cells can be added to primate embryos and that animal human hybrids not be allowed to breed. The current NIH guidelines state that breeding animals in which human stem cells might have formed gametes is prohibited, and human-primate experiments are forbidden. Even so, there is no rule that prohibits the injection of human iPSC into animal embryos and allowing the chimeras to develop.66 Aside from gestation attempts in human and non-human primate surrogates, all other chimera research is potentially allowable, although always subject to review by the appropriate animal research and stem cell committees.74, 72

One form of prevention could be to genetically modify human iPSC so as to make them incapable of differentiating into neural cells in the animal hosts, or to include “suicide genes” that would activate in the case of neural differentiation.66 At the same time, pigs with human organs could all be sterilised, to prevent their reproduction, and further minimise the risk of breeding with human gametes. Similarly to the inhibition of differentiation into neural cells, the human iPSC could also be genetically modified so as to prevent their differentiation into gametes, or also include “suicide genes” to be activated in the case of germinal differentiation.66 To further impede the possible breeding of human/animal hybrids, it is essential for the conditions in which the animals are held and used for experimentation to be very secure and isolated, to avoid any escapes and also possible zoonoses transmission.

Researchers believe that the percentage of human cells that are to be injected into animal blastocysts should be lower than 1%, in this manner the risk of creating animals, piglets, with human features is supposedly very low. So, a maximum threshold of human cell contribution should be established before the experimentation and then be strictly implemented. Also, it would be recommendable to perform pre-birth diagnoses on the animal hosts so as to detect any possibility of appearance of human features. Ultimately, only foetuses without any human feature would be allowed to term.66

**Are the motivations for this research transparent and in the public interest?**

The creation of human/animal chimeras, the production of human organs in animal hosts, not only raises ethical issues, but also legal issues. This research is subject to different to different legal frameworks in different countries.For example, the case of a researcher wanting to experiment with generating human pancreas in pigs in Japan who had to relocate the research group to the USA due to Japanese opposition.75 Here are some examples of the regulations in different countries: 66

In France, the law stipulates that the creation of a chimeric human embryo is forbidden. It also forbids the introduction of allogeneic or xenogenic cells into a human embryo. However, the law is unclear about whether it is illegal to introduce human cells into animal embryos.

In the UK, it is not forbidden to create an animal chimera by grafting human embryonic cells or embryonic cell lines into animals. Even so, transferring a predominantly human embryo into an animal “foster” mother is forbidden.

The German law prohibits combining a human embryo with animal cells, but not the introduction of human cells into an animal embryo. The German Ethics Council highlights the importance of finding a balance between expected medical benefits, respect of animal welfare and the need for an interdisciplinary scientific discussion on the subject.

The US National Research Council and the Institute of Medicine recommend limits on this type of research, among them that no human stem cells be added to primate embryos and that animal human chimeras not be allowed to breed.

In Japan, the law currently limits research on human animal chimeric embryos, by not allowing the development of these embryos beyond the appearance of the primitive streak and their transfer into an animal uterus.

As mentioned before, there is no rule that prohibits the injection of human iPSC into animal embryos and allowing the chimeras to develop.66 Aside from gestation attempts in human and non-human primate surrogates, all other chimera research is potentially allowable, although always subject to review by the appropriate animal research and stem cell committees.72,74

**Are there alternatives to this solution?**

To able to justify the development of human organs in animals, there has to absence of medical alternatives.66

There are other means to be considered that may be possible in the near future: pig organs could be used for xenotransplantation. There is current research into the prevention of organ rejection or zoonoses transmission, by deletion of the main pig genes responsible for xenogeneic organ rejection. Also, breeding pigs in which all the porcine retroviruses have been inactivated. Another possibility is the differentiation of human iPSC in vitro for cell based therapies for various diseases. In this field, a recent advance was the exploitation of iPSC self-organising properties in vitro, to form “organoids”, 3D tissue with therapeutic potential.66

At the same time, we need to consider if there are other ways to improve the current availability of viable organs for donation.

**PBL scenario 2: House of Climate Change**

**Episode 02 Season 1**

*The Administrator of the U.S. Environmental Protection Agency (EPA) is waiting outside, just in front of the door to the office. The President is in a meeting with the Vice President about some news headlines, so the EPA Administrator has been told he cannot go in yet. He is nervous, it has only been two months since he was given the position of EPA Administrator, and it is well known that the President has a difficult character. Today they have to talk about a slightly prickly subject.*

- We’ve finished now! Mr. Petersen! Come in, we’re waiting for you! – He hears from inside the office.

*Petersen goes into the office. Wow, it has changed a lot! The gold curtains in the office ooze a crude and vulgar glamour.*

- Sit, Petersen, sit. And what did you say you wanted to talk about today?

-Well, we have a never-ending list of subjects...we need to decide which are the environmental priorities for the EPA so we can start establishing measures and regulations.

-Ah well...so, you’re the expert, where do we start?

- The first item of the day is climate change.

- Climate change? – The President brusquely interrupted Petersen – Lies...

- Well, according to some scientific studies the effects of climate change are getting ever more serious: the atmosphere and the ocean have warmed, the amounts of snow and ice have diminished, sea level has risen... The current level of CO2 in the atmosphere is 400 ppm and we could say that...the safety level is 350 ppm. – Petersen is uneasy, he knows how little the President likes this subject.

- Oh really? This is what scientists who don’t have a clue about anything say...they don’t want to be a part of the gas and petrol revolution that will bring jobs and prosperity back to the North Americans. This trash don’t want us to be the most prosperous country on Earth, they don’t want us to rebuild our roads, or our schools, or the public infrastructures...they want to ruin us! They are anti-Americans! – The Presidents, livid with rage, seems like he is at one of his party’s meetings. Petersen tries to hide his disagreement; it isn’t the first time he is present during one of the President’s speeches with airs of superiority.

- Mr President, I’m sorry for insisting, but if we don’t act immediately, the levels of CO2 emission will go up 70% by 2050. – Petersen is shaking; disagreeing with the President is synonymous with being fired. – Maybe it isn’t necessary to slow down the gas and petrol revolution that you mentioned, but we could collaborate... There are alternatives: for example, renewable energies, hmm, what do you think?

- So now it turns out that the EPA administrator is a HIPPIE! Are you from Greenpeace or what? – The President’s face keeps getting redder...

- Wait, I haven’t finished, there are more alternatives. Have you ever heard of CO2 capture? It seems to be quite efficient, although it has certain costs. Besides, Mr. President, Europe is pressuring us...

- Always Europe... They can’t stand that we are a world power and they aren’t. I don’t understand why the devil we have to listen to some countries that aren’t even capable of coming out of a crisis that started 10 years ago. They’re inventing all of this; can’t you see that, Petersen?

- I’m not sure that they’re inventing it, Sir. Europe has decided on a 180 billion Euro budget for Climate Action projects for 2014-2020.

- Very well Petersen. Let’s talk in economical terms; I think we’ll understand each other better. So, what do you propose we do to keep the annoying European Commission happy?

- Well, we could look into these alternatives that I mentioned earlier. I think that CO2 Capture could be an option.

- And what is this?

- CO2 Capture and Storage is a process that consists in separating CO2 from the industrial and energy sources, then transporting this CO2 to geological formations where it is stored, and in this way it is isolated from the atmosphere in the long term. It is actually a technology that allows us to mitigate Climate Change during some time.

- Let’s get to the point, how much money are we talking about?

- Well, it is expensive technology. But there are more things to have in mind: let’s say it has certain risks and certain benefits. On one hand, it greatly reduces the CO2 emissions and it seems like it is one of the few alternatives to the situation we find ourselves in now. On the other hand, there are some inconveniences related to CO2 storage, and also, the general public’s opinion is contradictory. So… - Petersen doesn’t know how to say it – Money has to be invested, meaning that we would have to pay the countries that store the CO2.

- That what? So we don’t only have to pay for the technology, we also have to pay other countries? Are you mad? Do you think I will give North American money to Asians? Or even worse, to Africans? Do we look like charity givers? This will ruin me, what do you think the true North Americans will say of all this? – The President’s face isn’t red anymore, his skin is now a violet colour, and his eyes are coming out of their orbits.

- Hmm I don’t know what the true North Americans will say about this, but I have already told you that society’s view on this subject is contradictory; there are various perspectives on the problem.

- Mr. President! – The President’s Image Consultant enters the office. –It is time for your weekly tanning.

**TUTOR GUIDE:**

**Learning outcomes**

After this activity, the students should be able to:

* Discuss the purpose of CO2 Capture and Storage research.
* Analyse the possible applications of CCS.
* Define the manner in which CCS research is carried out.
* Discuss who is taking part in CCS research process and implementation.
* Evaluate the possible benefits and risks involved in CCS technology.
* Asses the possible impacts related to CCS technology.
* Argue if CCS technology is socially acceptable.
* Investigate if there are possible alternatives to the solution sought by CCS technology.

**Reflecting questions**

**Why is research on CO2 capture and storage (CCS) being carried out?**

Effects of climate change are becoming more serious. In fact, the concentration of CO2 is close to 400 ppm, while safe levels are around 350 ppm. Also, the global political systems seem to be paralysed to reach an international agreement to reduce the Greenhouse gas emissions.[[18]](#footnote-18) In the report “Intergovernmental Panel on Climate Change (IPCC)” written in 2014 they stated:

“Warming of the climate system is unequivocal, and since the 1950s many of the observed changes are unprecedented over decades to millennia. The atmosphere and the ocean have warmed, the amounts of snow and ice have diminished, the sea level has risen, and the concentration of green gases has increased.”[[19]](#footnote-19) Scientists have understood that it is time to act, and as combustion of fossil fuels is increasing and the development of renewables is still marginal, research is focused on mitigation options in short and long term, such as CO2 capture and storage, to act against climate change, stabilise the present level of greenhouse gases and bridge the gap to more long term sustainable solutions.77

**Why is CO2 capture and storage research relevant for society?**

The Tragedy of the Commons, formulated by Garrett Hardin, states that: “The individual benefits as an individual from his ability to deny the truth even though society as a whole, of which he is a part, suffers.”[[20]](#footnote-20) Climate Change is a good example of this economic theory: the gains of exploiting a limited resource and consequently emitting CO2 are conferred to a few; but the consequences, in this case of climate change, affect society as a whole. Because of the benefits of the few, there is a lack of incentive to limit or reduce this resource, so, as some studies have predicted, if there is not a collective action and society does nothing to act against climate change, we, as a whole, are potentially extending the impacts onto generations even further into the future.[[21]](#footnote-21) Some nations are trying to reduce carbon and the use of fossil fuels and CCS is presented as a transition technique to abandon the fossil fuel era as well as a temporary solution/mitigation of the Climate Change effects.80 In fact, the International Energy Agency (IEA) has declared that in the current context of an increase in fuel consumption the costs of reducing the global CO2 emissions in 2050 to 2005 levels will be a 70% higher if CCS is not used.4 So, as in the present context, the causes and effects of climate change are dispersed in time, the agency is fragmented and institutions are inadequate to provide solutions, research in CCS is seen as a possible solution to solve the current situation and avoid the worse effects of Climate Change.80

**Are the motivations to do this research transparent in the public interest? Who is taking part in the decisions process?**

For the public in general and many stakeholders, CCS, which has been a recurrent topic in policy agendas, is a rather unknown technology, which is a barrier for the discussion of large-scale CCS technology research and implementation.77 As some studies present, the public awareness of this technology is low and the perceptions of the general public are influenced by the information provided, how CCS is framed, and which level of trust the public has regarding the information provider.[[22]](#footnote-22) Other studies, Upham and Roberts (2010), have found that if the public is given little information without the chance to ask their concerns, which seems like what has happened up until now, their perspective is dominated by uncertainty and a negative perception of the technology, not willing to give support to CCS.80As Gough and Boucher explain in their article: “Including the opinions and values of lay citizens will require additional effort to enable a diverse population of actors to engage in, and take into account of, the ethics of CCS in decision making and process. Future Climate Change impacts and CCS risks are uncertain, so the trust in actors and the process of decision making is key to the social acceptability of adopted mitigation pathway.”80

However, there is a lot of literature examining societies’ view of CCS. CCS communication researchers have suggested to partner CCS developers with credible partners such as environmental NGOs to increase the publics’ trust within the technology and its possible risks and benefits.[[23]](#footnote-23) Despite this situation, it seems that CCS decision making and process has not had an effective public engagement because Institutions in European countries have not favoured the early communication and engagement in this technology. According to Breukers and Upham: “Local stakeholders are given the opportunity to respond to ready-made plans without having the chance to discuss and influence project design and location.”[[24]](#footnote-24)

**Which are the risks and benefits of this technology? How will the risks and benefits be distributed?**

The main benefits of the CCS technology are related to the decrease of the atmospheric levels of CO2 and the establishment of energy practices that are better for the environment and the resulting climate change mitigation. On the other hand, the risks of this technology are related to the potential leakage of CO2 from geologic sinks or storage sites, which could result in significant release of CO2 into the atmosphere and also cause harmful effects on human health. There is a lot of controversy related to this issue, in fact, the benefits can be realised over a finite period, also, the effects can persist over a very long period of time and, probably, with the application of this kind of technology, there will be an extension on fossil fuels use.80

Costs and benefits of CCS technology are unequal, as it happens with CO2 emissions. Costs are associated to the storage and are local, short term and shouldered by vulnerable populations; while benefits, associated to Climate Change mitigation, are global and long term. So, in this context, the balance between costs and benefits is connected to social, financial and intergenerational justice. CCS technology will allow humanity to continue to use fossil fuels while reducing emissions, this will directly affect future generations who will manage the storage sites, if a climatically problematic legacy has not been created. Furthermore, host communities, financed and compensated by developed countries and identified as the new growing economies, could suffer CCS’s risks and impacts related to health and the safety of the environment for the profit of the whole society. 80

**What impacts of this technology can be anticipated?**

The future ecologic impacts of CCS technology are related to CO2 leakage. Local terrestrial and marine ecosystems could be harmed close to the injection points of this technology. Also, some geological and hydrogeological impacts could be produced in the longer term.[[25]](#footnote-25) Concerns surrounding geological storage include the risk of seismic activity causing a rapid release of CO2, part of the possible harm to people and wildlife in the vicinity. For storage sites under water, there are concerns about chronic exposure of marine ecosystems to high CO2 levels.[[26]](#footnote-26)Furthermore, there are more possible risks apart from ecological and climate destabilization. In fact, there is also the possibility of a financial risk: future conditions could cause greatly increased carbon prices. Also, there are political risks too: institutions with an interest in CO2 storage may manipulate the regulatory environment in their favour.85

**What are the alternatives to this kind of technology?**

Regarding the IPCC 2015 report: “CCS is the only technology which can reduce emissions on a significant scale from fossil fuel power plants and these industrial processes. It is also important to note that renewable technologies are not mitigation substitutes to CCS in the industrial sector. To achieve the global goal to limit temperature increases to no more than 2°C, the scale of change and the level of low-carbon technology deployment are enormous. All emissions reduction solutions are necessary, in all sectors of the economy.”[[27]](#footnote-27)

According also to Webbersten et al. (2014), the only solution in the short run to counteract Climate Change and reduce CO2 emissions is CCS. In the long run, there has to be a transition to greater resources efficiency, where renewable energies play the most important role.77

These are some examples of reflecting questions that can be used to introduce students to the reflection on responsibility and scientific advances. However, we have added more useful questions, extracted from the article from Boucher and Gough (2012), *Mapping the ethical landscape of Carbon Capture and Storage*, to promote a deeper reflection.

-Does CCS conform to the suspected interests of future generations and is it of greater benefit to less advantaged generations?

-Does CCS conform to the interests of all social groups and is it of greater benefit to less advantaged social groups?

-Does CCS conform to the suspected interests of nonhuman species, valued environmental qualities such as biodiversity and ecological sustainability?

-Does the technology conform to the provision of appropriate environmental services for all?

-Does CCS conform to an appropriate distribution of rewards, incentives and liabilities (including the financial opportunity cost investing in other technologies; demand reduction and other production options)?

-Does CCS provide some benefits to any actors?

- Does CCS prevent harm to any actors?

-Does CCS affect any actors’ capacity for self-determination and freedom to shape their own understandings and decisions?

-Is information disseminated about CCS accurate, thorough and sufficient and does it come from appropriate and balanced sources, communicated with sufficient transparency?

-Does CCS conform to the actors being responsible and accountable for the consequences of the risks they take?

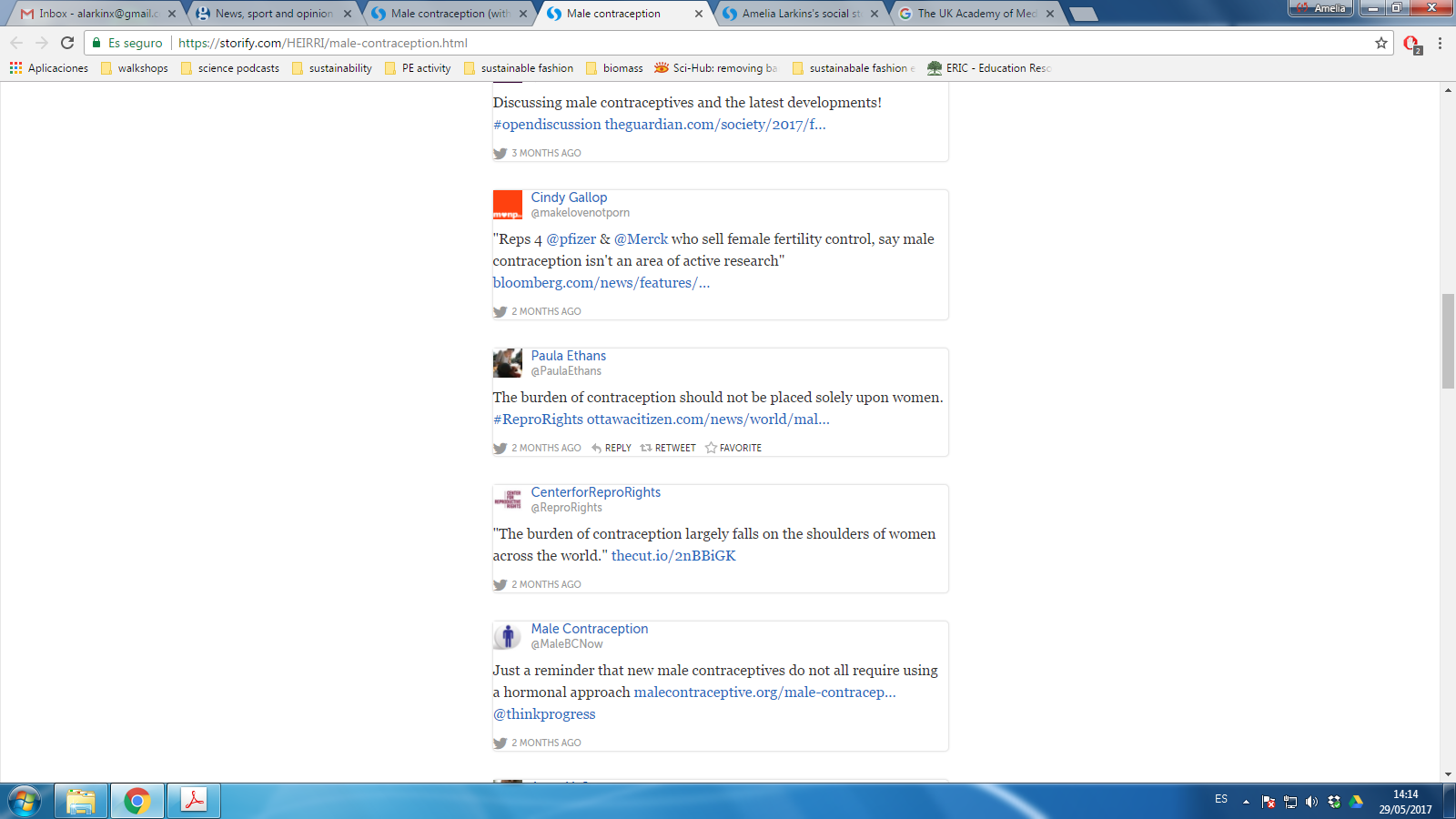
-Are scientific, technical and engineering practices and knowledge of a sufficient standard to ensure the effective, safe and reliable operation of CCS developments?

-Are managerial, regulatory and legal practices and knowledge of a sufficient standard to ensure the effective, safe and reliable operation of CCS developments?

-Does CCS deviate from or transform any social understandings or human values regarding what is right and what is the right way to progress, deal with problems and search for solutions?

-Does CCS deviate from or transform any social understandings or human values regarding nature, natural processes or human relationships with nature?[[28]](#footnote-28)

**PBL scenario 3: MALE CONTRACEPTION**

****

This scenario is a “storify”, a collection of tweets from the beginning of 2016 from various sources related to the topic of Male Contraception. To view the full version, see:

[**https://storify.com/HEIRRI/male-contraception.html**](https://storify.com/HEIRRI/male-contraception.html)

**TUTOR GUIDE**

**Learning objectives**

After this activity, the students should be able to:

* Explain the history of male contraception research and development
* Investigate the current options of male contraception in development
* Examine the different types of male contraception
* Analyse the advantages and risks involved
* Asses the gender balance in this field of research
* Evaluate other possible ethical implications of this type of research
* Discuss the advantage or not of involving the general public in this kind of research
* Determine the current state of this research in the world, and the possible challenges it faces

**Reflection questions**

**When did research into male contraceptives first start? Why are researchers doing it?**

There has been much improvement in modern female contraceptive methods, but there are still unmet needs for family planning in women. It is essential for countries to provide modern contraceptives, high quality services and improve the access to these services. In this manner, we can allow people to achieve the desired number of children, beneficial to women, families and society. So as to achieve this goal, the development of contraceptive methods for men is a priority. At the moment, the options for men are the condom and vasectomy (a minor surgical procedure which is considered irreversible).[[29]](#footnote-29)

The condom was invented over 400 years ago, and since then no other reversible options for men have been developed.[[30]](#footnote-30) Even though testosterone was first developed and studies for therapeutic use in the 1930s89, clinical trials for the first hormonal male contraception began in the 1970s.88

Many countries started developing new male contraception in the 1970s, supported by government agencies, including China, India and the United States. Hormonal male contraception trials were promoted by the World Health Organization (WHO), the United States National Institute of Child Health and Human Development and other organizations.[[31]](#footnote-31)

**Have there been any advances in this research?**

At the moment, the male contraceptives available to the public are a vasectomy (which is a minor surgical procedure considered irreversible) and the condom (which has a high user failure rate).88 Current developments in this field include long-acting injectable and transdermal gels, also new androgens that may have both androgenic and progestational activities.88

A number of studies have confirmed that there are methods for male contraception that can be achieved with androgens alone or together with progestins that have contraceptive efficacy comparable to current female hormonal methods. These studies included a trial in China that involved over 1000 couples who received injectabletestosterone undecanoate. These studies also confirmed that in most men, if not all, hormonal male contraception is reversible.90

The development of male contraception has been supported by the World Health Organization, Contraceptive Research and Development program, the Population Council and the Contraceptive Research Branch of Eunice Kennedy Shriver National Institute of Child Health and Human Development during the last decade. They support male contraceptive clinical trials in new orally bioavailable androgens and a transdermal method. Also, they support research into identifying and developing new methods of male contraception.90

**What types of male contraception exist?**

There are two main types of contraception, hormonal and non hormonal.

Hormonal methods are the closest to reaching the market, they are based on administering androgens alone, or combined with progestins.91 These methods have proven effective and are generally accepted by both partners. Researchers target: differentiation of germ cells, maturation of sperm, factors inhibiting sperm motility and function.[[32]](#footnote-32)

Some male hormonal contraceptives work by using utilize hypothalamic–pituitary–gonadal negative feedback, which suppresses spermatogenesis, without causing hypogonadism.89 In the 1990s, two important studies, led by the WHO, proved that if spermatogenesis is suppressed and there is a very low level of sperm output, the contraceptive efficacy in males is as effective as female hormonal methods. This can be achieved by administering exogenous testosterone.89,90 Subsequent studies have focused on shortening the suppression phase and improving rates of severe oligozoospermia. This research has combined testosterone-based male hormonal contraceptives with progestins.89 It has been demonstrated that sperm suppression is enhanced when testosterone is combined with progestin.89 Also, progestins allow reduced levels of androgens, without compromising their effectiveness. This can reduce undesired side effects such as acne and male pattern hair loss. 89

Non hormonal methods are often more appealing to the general public. There are a number of non hormonal targets being investigated. This is due to the advance in the understanding of molecular and cellular mechanisms of the regulation of spermatogenesis and sperm maturation. These techniques target a specific protein. They are in preclinical stages and have a lot of promise, but clinical studies have not been started.90 Also, there are new mechanical approaches to vas occlusion that are in development, one of which is similar to a reversible vasectomy.91

Currently, there is a non hormonal long acting reversible contraceptive for men in development. It consists of hydrogel that can be implanted into the vas deferens in the male, thus preventing the passage of sperm. Studies in rabbits have proved it is efficient, durable and it has a rapid onset.[[33]](#footnote-33)

The history of contraceptive use in women can help guide contraceptive development for men, suggesting that daily methods may often be preferred, but long-acting methods are very likely to be more effective. Current male hormonal contraceptives in development want to provide multiple options for patients, with ongoing development of daily gels, long-acting injections and implants lasting up to 1 year.89

**Which are the advantages of research into male contraception?**

Additional male contraceptive options could have significant and important public health benefits by preventing unplanned pregnancies.89 Male hormonal contraceptive options have been studied in over 2000 men, with normal spermatogenesis. Once the administration of contraceptives was stopped, these men returned to normal testicular function, including normal spermatogenesis. This means that hormonal methods are considered to be reversible.89

**What about the risks?**

So far, no trials to date have exceeded 2.5 years of use, limiting the understanding of long-term risks and benefits. Moreover, clinical studies conducted over the last several decades point to areas requiring further study.89

On administering testosterone, there were side effects such as acne, oiliness of skin, weight gain, decrease in HDL cholesterol, increases in haematocrit and haemoglobin and sleep-related breathing disorders.88 Even so, as mentioned previously, it has been proven that testosterone combined with progestin gives better results and reduces the possibility of side effects.

Asian men respond more effectively than men of other races to male hormonal contraception methods. Ethnic variation means that hormonal contraceptives are not equally as effective in all men, although the mechanisms of this variability are still unknown.89

The risk of temporary recovery of spermatogenesis in men on a daily contraceptive with ‘typical use’ may limit the effectiveness of this contraceptive option. This is due to the large difference in effectiveness between the ‘perfect use’ of contraceptives and the ‘typical use’.89

**What is the gender balance when it comes to contraception? Is it balanced?**

Unintended pregnancies are an important health risk worldwide, with significant social, health and economic impacts. These unplanned pregnancies can lead to an increase in abortions, which expose women to an increased risk of death or health problems in many countries.89 Many of these unwanted pregnancies can be avoided by the use of contraceptives. In a study that surveyed over 9000 men in nine countries and four continents, in 55 to 81.5 % of couples, both partners were involved in selecting the method of contraception.88

The development of reliable, reversible and affordable male contraceptives which can be used by millions of sexually active men is important. This would allow men to participate in family planning and enhance reproductive health of the couple.91 There is a significant gap in the contraceptive options available to mean and women, especially in effective reversible choices for men.[[34]](#footnote-34) Both men and women have the option of condom use, as there are both male and female condoms.

Women at present rely on methods such as different forms of the contraceptive pill, other various hormonal options and sterilization.[[35]](#footnote-35) In the last decades, there have been many advances in reversible hormonal contraceptive options for women, such as pills, patches, injections, intrauterine devices and implants.89

On the other hand, men have the options of: coitus interruptus, abstinence or vasectomy (which is irreversible).94

So, the development of new methods of contraception has been mainly female-directed. Even so, despite this one-sided approach to contraceptive provision, a third of couples that practice contraception world-wide use a male method.[[36]](#footnote-36)

**What are other ethical implications of male contraception development?**

The majority of male hormonal contraceptive trials have only involved men with normal baseline semen analyses. Because of ethical considerations, the inclusion of men with subnormal sperm motility, morphology or concentrations has been avoided in the majority of studies. This is due to the risk of subsequent infertility in using an experimental contraceptive. Potential users of these contraceptives are more than likely to include men with subnormal sperm parameters. Only one trial to date has looked at the effect of a potential male hormonal contraceptive on sperm concentrations of men with subnormal sperm parameters.89

**Has the general public been consulted on this topic? What is the public opinion on male contraceptives?**

According to recent surveys, over 50% of men would accept a new male contraception method and their female partners would trust them to take a contraceptive.88 The method with the highest acceptability is a daily pill or a monthly injectable.88 44 to 83 % of men would use a male contraceptive pill, which was a higher number than the injectable. Acceptability was varied amongst the men involved in the study, and it was seen to be influenced by their knowledge of other contraceptive methods and their cultural background.88

In another study, mentioned before, which involved 9000 men in countries and four continents, 28.5 to 71.4 % of men surveyed expressed willingness to use a new male method of contraception with wide variation among different racial and ethnic groups. The attitude towards a new form of contraception also varied according to the relationship status. In a study in England both men and women had favourable attitudes to a male contraceptive pill. Although women had a more positive attitude to the new male pill, they had less trust that men would use it effectively. Men in a stable relationship had a more positive attitude toward a male pill than those in casual relationships.88

In addition, recent international surveys suggest widespread interest in a reversible male hormonal contraceptive in communities of varied races, religions and ethnicities.89

**What is the current state of contraception and research into contraception in the US and EU?**

One of the major obstacles for the development of male hormonal contraceptives has been a lack of funding to support clinical trial efforts. 89

At the moment, male contraception is limited to withdrawal, abstinence, condoms and vasectomy. Studies have shown that male methods account for over 10% of contraception use worldwide, and 25% of contraception use in developed countries.89 However, research has shown that both men and their female partners are willing to use novel methods, including hormonal contraception, provided it is effective, reversible and well tolerated.91 Even so, the pharmaceutical industry has deserted the field of research in male contraception, partly because of unclear registration requirements and partly because of a perceived lack of acceptability and profitability.91

Over the last decade, pharmaceutical and biotechnology companies have halted research and development of male contraceptives. The reasons for this are unclear. Some suggest that it may be due to concern about limited financial returns, safety regulation problems, religious opposition, general bias that family planning is a “female issue” etc. 89

**What are the challenges?**

Progress in the field of male contraceptives has been slow, even though there have been studies that support the acceptability, safety and efficacy of a male hormonal contraceptive. The two major challenges, from a scientific perspective, are the lack of consistent efficacy among all the users of a contraceptive and the possible challenge of multiple agents involved (as some methods require combining different delivery modalities). The high regulatory bar for safety must also be taken into account, greatly diminishing support for male contraceptive development in recent years.89

**PBL scenario 4: A voyage into the past**

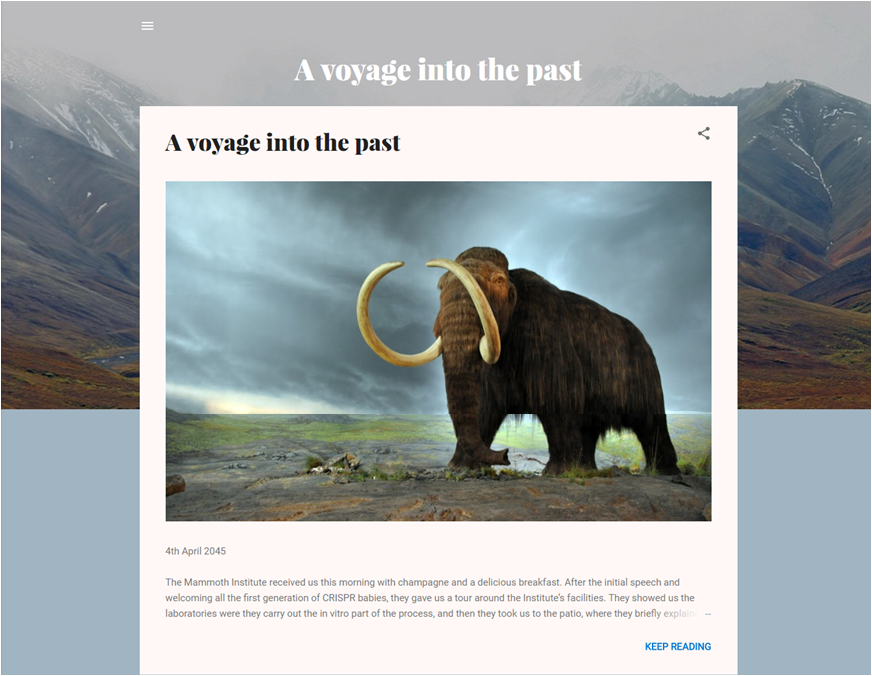
**4th April 2045**

The Mammoth Institute received us this morning with champagne and a delicious breakfast. After the initial speech and welcoming all the first generation of CRISPR babies, they gave us a tour around the Institute’s facilities. They showed us the laboratories where they carry out the in vitro part of the process, and then they took us to the patio, where they briefly explained the areas where they keep female Asian elephants. They have them divided into two groups: the ones that are waiting to be impregnated, and the ones who are already pregnant. We finished off the day with a formal dinner; the guests included all the people who collaborated on the development of our generation. It was really interesting to share our experiences with them.

**5th April 2045**

At 7 o’clock this morning, the guides who work at the Institute drove us in their jeeps to the outer part of the facilities. After an hour in silence, we finally saw the herd. The females and their mammoth offspring, guided by the matriarch, were grazing around the tundra. The amount of food these animals eat is incredible, the moose and the caribous actually looked a bit wary. It was quite impressive to see the first generation of mammoths being reinserted into their original habitat. It’s hard to believe that animals that were extinct 10.000 years ago are so well adapted to their current environment. When we got back inside the Institute, they saw us off with another fantastic dinner. It was a real experience for the first CRISPR babies to be able to see the release of the first generation of mammoths.

See the scenario link here: <http://heirripblcrispr.blogspot.com.es/>



**TUTOR GUIDE:**

**Learning Outcomes**

After this activity, the students should be able to:

* Discuss the purpose of CRISPR research.
* Analyse the possible applications of CRISPR and its relevance in society.
* Discuss who is taking part in the CRISPR research process and implementation.
* Evaluate the possible benefits and risks involved in CRISPR technology.
* Asses the possible impacts related to CRISPR technology.
* Argue if CRISPR technology is socially acceptable.

**Reflecting questions**

**Why is research on CRISPR being carried out?**

CRISPR is a powerful gene editing tool that can alter the genes of a wide range of organisms with relative precision and ease. In fact, this technology offers a new perspective and a set of possible applications in the biomedical research field that were considered science fiction a few years ago. This is why CRISPR seems too good for society to refuse.[[37]](#footnote-37) According to Jasanoff et. al (2015) in *CRISPR Democracy: Gene Editing and the Need for Inclusive Deliberation: “*Scientist have a right to “push research to limits” and that restraint is warranted only where the research entails technically defined risks like endangering public health. This reflects not only the desire to satisfy curiosity but the hope that progress in knowledge will produce victories against diseases.”96 CRISPR has opened a big set of possibilities in research: generation of customised genes and cell therapy, more targeted treatments, and direct editing of disease causing genes in human embryos and it has become one of the scientific revolutions of this century. 96

**What are the possible CRISPR applications? Why is CRISPR research and its applications relevant for society?**

CRISPR genome editing technology has allowed scientists to consider a whole raft of projects that seemed impossible few years ago. CRISPR applications are as varied as agriculture, drug development or de-extinction of animals. Here are some examples of the multiple CRISPR applications.[[38]](#footnote-38)

-Disease control: Scientists think that CRISPR could be useful in different areas of the agriculture and livestock field. One example that is being studied is to use CRISPR to counteract the loss of honeybees around the world, which is mostly cause by diseases and parasites, or also to create pigs resistant to viral diseases.97 Furthermore, CRISPR could be used to manipulate embryos’ DNA and prevent human heritable diseases from being passed on.[[39]](#footnote-39)

-Making drugs: the CRISPR technique can be used, for example, to produce vaccines that are suitable for the population allergic to eggs. Also, it can be an advance for pharmaceutical companies because of the potential use of creating drugs using domesticated animals: The EU has approved a goat that produces an anti-clotting protein in its milk.97

-De-extinction: Some research groups are studying how to use CRISPR technology to restore extinct species. One example of this application is carried out by a Harvard research group whose aim is to transform endangered Indian elephants into woolly mammoths or cold resistant elephants.97

-Vector Control: CRISPR technology gives a new perspective on the idea of genetically modifying mosquitoes to prevent the spread of diseases such as dengue o malaria.97

-Better Food Production: CRISPR technology can be used to produce transgenic animals for human consumption with better properties and avoid the cull of animals.97

-Improving pets: Some companies are using this technology to customise pets according buyers’ requests.97

-Disease Model: CRISPR technology has been used in biomedical research to study some diseases, such as the influenza virus, and also creating new animal models.97

Some of these various applications are more controversial than others; in fact, CRISPR has opened up a new field of study focused on the ethical implications of this technology. However, the possible medical advances related to this technology seem relevant to society. As Jasanoff et. al (2015) explain in their article, in the case of the US, 10% of the population are rare genetic disease carriers. CRISPR offers a new possibility in medicine to save individuals and families from fatal economic, psychological and health consequences of this kind of diseases. CRISPR brings promises of salvation to patients suffering from incurable conditions.96

**Who is taking part in the decision process?**

Although many experts have appealed for a CRISPR public debate, and taking into account that possible future applications are related to human genome modifications, the decisions on how far CRISPR should go have to be accountable to society as a whole, however there has not been a practical debate yet.96,[[40]](#footnote-40) CRISPR is one of the most revolutionising technologies of the last decades in science but also in society. Due to its potential, its applications and its benefits and risks, the ethical implications of this technology have to be analysed. This analysis should be done, not only by scientists or politicians, but by the broad public to decide its acceptance.[[41]](#footnote-41) Furthermore, the call for broad public dialogue has to respect the possible ideas from the public that may differ from the experts’ about how to live with emerging technologies. As Jasanoff et. al (2015) explain in their article: “The impulse to dismiss public views as simply ill-informed is not only itself ill-informed, but is problematic because it deprives society of the freedom to decide what forms of progress are culturally and morally acceptable. Future deliberations on CRISPR should actively rethink the relationship between science and democracy.”96

**Who will benefit from this research? How are the benefits distributed?**

As it seems, CRISPR might produce different therapies for human diseases as well as other scientific advances. A big number of individuals will benefit from them, but only if they have access to these treatments.

The unfair distribution of health resources is well known by the scientific community, however, in their point of view, science is not in charge of solving economic and political problems. The finality of the contract between science and society is to provide new knowledge. According to Jasanoff et. al (2015): “These days it is expected (and indeed required by law) that publicly funded discoveries with economic potential should be commercialized: science, in this view, best serves the public good by bringing goods to market. CRISPR is no exception. A patent battle is taking shape between the University of California, Berkeley and the Broad Institute, with predictions that upward of a billion dollars in royalties are at stake.”96 In this context, it is possible that biomedicine’s commercial potential prioritizes developing treatments for affluent patients or developed countries than public health needs.96

**Which are the risks and benefits of this technology?**

The main benefits of CRISPR technology are related to medical applications, which promise a very precise personalised medicine, bridging the gap between genetic information and disease therapies.100 Furthermore, CRISPR represents an advance in science due to its potential to control diseases transmitted by mosquito vectors such as dengue, malaria or the sleeping sickness, by changing the mosquito to make it sterile, and cover, in this manner, a public health problem.[[42]](#footnote-42)

On the other hand, all these technology applications have costs or risks. In first place, editing the genome counteracts natural selection in population and the diversity of human variants. The consequences are not predictable and cannot be anticipated yet, since variant alleles may have important advantages in different contexts and situations. Furthermore, the benefits described before could lead to an ecological destabilisation and produce unpredictable repercussions in ecosystem equilibrium.100

The specific example of the PBL scenario, un-extinction, would raise some risk-benefits questions, and this wide range of questions emerge in every possible CRISPR application. In this case risks are related to the ethical concerns of resurrecting an extinct species, the ecological problems that can result from introducing these new species into the environment, the legal restrictions of un-exctinct animals, etc.100

**What other impacts of CRISPR can we anticipate?**

It is a difficult issue to strike the balance between CRISPR for the public good and private benefit. Risk assessment away from the social context can produce a disparity in health and health care access.96 Furthermore, as Daniel Kevles argued: “the likely adoption of genetic technologies like CRISPR for pursuing eugenic selection had largely shifted from government programs to consumer demand. Methods of selecting against particular genetic conditions were in more widespread use in 2015 than ever before, but the public understood their use to reflect individual choices rather than state coercion.”[[43]](#footnote-43)This situation reflects ethicists’ concerns, which suggests that an unequal access to such technologies could lead to genetic classism. Also, genome editing will pass on for generations through the germ line and this situation could produce unintended and unpredictable consequences.98

These are some examples of reflecting questions that can be used to introduce students to reflection on responsibility and scientific advances. However, here we add more useful questions, extracted and modified from the article Grunwald (2011), *Responsible Innovation: Bringing together Technology Assessment, Applied Ethics and STS research*, to promote a deeper reflection.

-Which social groups are affected by CRISPR? Could or should these social groups help decide about responsibility in CRISPR applications?

- Do the questions under consideration concern the policies or can they be delegated to groups or subsystems? What consequences would a particular distribution of responsibility have for the governance of CRISPR technology?

-What is responsible and what is irresponsible in CRISPR technology development? Is there consensus between the affected and involved actors?

-What is the hypothetical worst scenario of CRISPR technology impacts?[[44]](#footnote-44)

**PBL scenario 5: CYBERVILLE**

Scenario: PODCAST

Can modern information and communication technology sustainably improve quality of life and community living?

Participants:

* Representative from information-technological company, Purple (JH)
* Town mayor (A)
* Smart city researcher/expert (K)
* Town inhabitant1: older person (L)
* Town inhabitant2: young student (engineering/audiovisuals) (J)

On this week’s episode of This European Life, CYBERVILLE, we bring you a story that is happening right now. The town of Cyberville is about to become a real-life laboratory, a large-scale communications and technology experiment. The town has teamed up with Purple, and together they are turning the whole town into what we call a “Smart City”.

Today on our show, we want to understand what exactly a “Smart City” *is*, and what do the inhabitants of Cyberville think about it. We are joined by a representative from Purple, Jack Harrison (JH), the mayor of Cyberville, Antonia Gladders (A), a renowned expert on the subject of Smart Cities, Kieran Monkeith (K), and two inhabitants of Cyberville: Laia Codina (L), who is 76 and a 23-year-old engineering student, Julia Solervicens (J).

Smart Cities are something that is on everyone’s mind. As the Internet of Things comes online — especially in light of recent remote hacking incidents of “Things” like a baby monitor and a car — we can’t help thinking that as every aspect of our lives becomes fully networked, we have to increasingly address issues of privacy, security and system vulnerabilities.

Let’s start off the debate by asking Kieran to introduce us to the concept of Smart Cities.

K: We define Smart Cities as the systematic application to and pervasive penetration of cities by information and communication technologies. The purpose is to use urban informatics to improve the efficiency of services for the community.

Let’s see what our mayor thinks of the situation…

A: So, in what ways is Purple thinking of turning Cyberville into a Smart City?

And from Purple…

JH: Well, our idea is to mainly focus on transport and health. We are especially interested in improving the public transport system in the town, with the aim to improve traffic and the citizen’s experience. As to health, we would like to centre our work on improving quality of life for the more elderly citizens.

Now let’s give our citizens a voice!

L: And how do we know that we can trust you? Won’t you be putting cameras into my house?

JH: Well Ma’am, that’s not exactly the idea…

K: Let me try and explain better Mrs. Codina. What Purple would like to do is to improve the communication between elderly citizens and hospitals for example, so if there is a problem or an emergency, the service could be much better.

L: I still don’t trust them. I don’t want anybody coming into my home…

A: Don’t worry Laia, I will make sure nothing of the sort happens. My first and only concern is the wellbeing of this town, and I will not allow such an invasion of privacy.

And our young student seems keen on the subject too…

J: I’m interested in the technology you use for this kind of projects. How will you manage to get the oldies to participate and learn how to use it?

L: Respect, girl!

JH: It will be very basic, easy to use and won’t cause any problems. Also, it won’t be invasive at all. Benefits for everyone involved!

K: One of the main ideas is to able to control people’s blood pressure from their homes. Blood pressure can be monitored and automatically recorded in an online-diary in a home-telemonitoring process performed by the patients themselves. These diaries can then be accessed by the doctors at the local hospital.

L: And how would that help anyone?

A: Well, I think it would highly benefit the hospitals and patients, as many short and possibly unnecessary visits would be avoided, clearing up many hours and saving a lot of time.

J: How would this work exactly?

JH: We have an online system in which the patients could enter their data. They can also add other information apart from their blood pressure, such as diet, medication, activities etc, so they can be very closely monitored.

L: I don’t think I’d be very good at that…

A: I’m sure we can all figure it out together; I think it’s a wonderful idea.

L: And who can look at my information? I don’t want my nosy neighbour Rita knowing what I had for lunch!

K: The whole idea of this new technology is that all personal information is private and can only be accessed by a patient’s doctor. It is highly unlikely that your neighbour Rita would be able to hack the system…

J: But people can hack anything nowadays! I read about it on techfreaks.com.

JH: Don’t worry, Orange has very strict privacy laws and very efficient security systems. It will be virtually impossible to damage or access the system we are going to set up in Cyberville.

A: In fact, we are ready to begin installation of the household systems next week. And soon after, we will offer a short course for those of you who would like to start using it. Everyone can get involved!

J: Wait, does this mean that this has already been approved? The project is going ahead?

JH: Oh yes, Mayor Gladders signed the contract months ago! We are full speed ahead!

J: But this is the first I’m hearing of it!

K: Sometimes it’s better to surprise the citizens, getting people involved in the decision-making process often causes more problems than solutions. This way, the main innovations have been decided by experts and no one has to worry about anything.

JH: The transport improvements are already installed too, we’re just waiting for the go-ahead from the mayor.

L: WHAT? PEOPLE ARE ALREADY SPYING ON EVERYTHING WE DO?

J: Mayor, this is unacceptable! Nobody knows about this! I’m going to organize a university strike…

L: And I’m going to tell everyone at Monet’s Café!

A: No, please, I made this decision to benefit you all! You’ll see, you’ll love it!

**TUTOR GUIDE:**

**Learning outcomes**

After this activity, the students should be able to:

* Understand the meaning of the concept “Smart city”
* Analyse the possible applications of Smart Cities
* Reflect upon the reason for the creation of a “smart city” and its possible benefits
* Evaluate the possible concerns or risks of “smart cities”
* Asses the ethical issues/impacts related to this topic
* Determine if this type of research is transparent and of public interest
* Discuss the importance of involving the general public in the decisions related to “smart cities”

**Reflection questions**

**How would you define a “Smart City”?**

The concept of “Smart City” has been defined in different ways. Here are some examples:

“The systematic application to and pervasive penetration of cities by the Information and Communication Technologies (ICTs)” [[45]](#footnote-45)

“Territories with high capacity for learning and innovation, which is built-in the creativity of the population, their institutions of knowledge creation, and their digital infra-structure for communication and knowledge management.” [[46]](#footnote-46)

“Cities which have embraced ICT as a development strategy, being pioneers in embedding digital infrastructure and systems into their urban fabric and utilising them for entrepreneurial and regulatory effect.” [[47]](#footnote-47)

There are two broad understandings as to what makes a city smart, keeping in mind many different definitions of a “smart city”. The first is the concept of “everywhere”. This refers to the notion of pervasive and omnipresent devices built in to the fabric of urban places. Some examples are: fixed and wireless telecom networks, digitally controlled utility services and transport infrastructure, sensor and camera networks, building management systems... These are used to observe, manage and control the flows and processes in a city, often in real-time. Also involved in “everyware” are the devices used by the citizens themselves, such as smart phones, to engage with and navigate the city. These devices also produce data about the people using them, such as their activity and location.

The second understanding as to what makes a “smart city” is that its economy and governance is driven by innovation, creativity and entrepreneurship (carried out by “smart people”). In this case, ICT are important as a platform for the realisation of these new innovations and ideas. 106

According to Hollands, there are five main characteristics that make a “smart city”:[[48]](#footnote-48)

* widespread embedding of ICT into the urban fabric
* business-led urban development and a neoliberal approach to governance
* a focus on social and human dimensions of the city from a creative city perspective
* the adoption of a smarter communities’ agenda with programmes aimed at social learning, education and social capital
* a focus on social and environmental sustainability 107

**What are some of the main applications of “Smart Cities”?**

“Smart cities” have many different applications, some are related to the day-to-day life of urban citizens and some are related to the efficient management of urban infrastructure systems. The data that is collected contributes significantly in helping urban infrastructures to operate more efficiently. There are various examples, such as in electricity systems, waste water, general waste, buildings, transport...

The generation of data and its subsequent analysis allows for the creation of new services to be offered to the citizens of a smart city.104 One of the most common examples are those that are traffic related. For example, cameras and transponders placed around a city will send information on the movement of vehicles around a transportation network. This data will help monitor the flow of traffic, thus allowing for the adjustment of traffic light sequences and speed limits, also permitting the automatic administering of fines for traffic violations. Another use for the same camera system could be related to police activity in a city. Police could monitor live images so as to be able to react more efficiently and directly, by allocating appropriate resources to specific locations. Also, by using a sensor network all around the city, environmental conditions data could be collected to measure levels of air pollution, seismic activity etc. 106

Here are some more examples of technologies provided by a “smart city”, compiled by Kitchin.[[49]](#footnote-49)

|  |  |
| --- | --- |
| ***Domain*** | ***Example technologies*** |
| Government | E-government systems; online transactions; city operating systems; performance management systems; urban dashboards |
| Security and emergency services | Centralised control rooms; digital surveillance; predictive policing; coordinated emergency response |
| Transport | Intelligent transport systems; integrated ticketing; smart travel cards; bikeshare; real-time passenger information; smart parking; logistics management; transport apps; dynamic road signs |
| Energy | Smart grids; smart meters; energy usage apps; smart lighting |
| Waste | Compactor bins and dynamic routing/collection |
| Environment | IoT sensor networks (e.g., pollution, noise, weather; land movement; flood management); dynamically responsive interventions (e.g., automated flood defences) |
| Buildings | Building management systems; sensor networks |
| Homes | Smart meters; app controlled smart appliances |

**Why do you think there is a tendency towards Smart Cities?**

The perspective of the inhabitants of a city tend to be that of wanting a more efficient system, but also a more sustainable and resilient urban system. In short, the citizens want a better quality of life. 104

Kitchin outlines a series of “promises” about “smart cities”, that they: 108

* Will tackle urban problems in ways that maximize control, reduce costs, and improve services, and do so in common-sense, pragmatic, neutral and apolitical ways through technical solutions.
* Will create a smart economy by fostering entrepreneurship, innovation, productivity, competiveness, and inward investment.
* Will enable smart government by enabling new forms of e-government, new modes of operational governance, improved models and simulations to guide future development, evidence-informed decision making, and better service delivery, and by making government more transparent, participatory and accountable
* Will produce smart mobility by creating intelligent transport systems and efficient, inter-operable multi-modal public transport, better and dynamic routing, and real-time information for passengers and drivers.
* Will make smart environments by promoting and creating sustainability and resilience and the development of green energy.
* Will create smart living by improving quality of life, increasing choice, utility, safety and security, and reducing risk.
* Will produce smart people by creating a more informed citizenry and fostering creativity, inclusivity, empowerment and participation.

The idea exists that “everyware” will give a more cohesive and smart understanding of a city. This could improve efficiency and sustainability; this interconnectedness should improve the performance of public services. It also provides a supporting infrastructure for business activity and growth and stimulates new forms of entrepreneurship. 106

**How is a town/city adapted to become a Smart City?**

For an urban space to become “smart”, it means that it the infrastructures and users in this space must be equipped. This involves many systems with which to collect data, such as sensors and cameras. This will allow the collection of data from GREEN infrastructures (tress, parks, etc.), BLUE infrastructures (water pipes etc.) and GREY infrastructures (disposable waste, disposed waste, waste water pipelines, water treatment plants, etc.). At the same time, data can also be collected from the buildings in the urban space, for example on their energy consumption. 104

**What are the main concerns about Smart Cities?**

According to Finger et Al, “The citizens, the nongovernmental organizations, civil society more generally, as well as city administrators and especially city politicians have not yet fully appropriated what digitalization of urban infrastructure systems does and, potentially, could or could not mean for them.”104

There are important concerns as to what living in a “smart city” could mean for the privacy of the citizens and also what privacy harms could come from the sharing, analysis and misuse of urban big data. Also, there are concerns related to the security of the technology involved. This includes the consequences of a possible hacking, theft or data breach for the citizens involved.108

The main concerns are more to do with automated forms of data generation. People are less concerned about the directed and volunteered data provided, considering it to provide useful insights into city life, helping to better understand and manage a city. There is concern related to the automated forms of surveillance, sensor networks and “the internet of things”. Also, people are worried about them or objects being traced. 106

Some examples of automated forms of surveillance are: traceable “smart cards” to be used in public transport, automatic number plate recognition (scanned by cameras) to discern the owner of a vehicle and provide input to intelligent transportation systems, automatic meter reading and automated monitoring of public service provision, such as chips on rubbish bins to detect whether the waste has been collected or not. 106, [[50]](#footnote-50)

Moreover, there are a large number of objects and machines all around cities that are part of “the internet of things”, carrying out their work automatically, communicating their use and if mobile, traceable. These include automatic doors, lighting and heating systems, security alarms, wifi router boxes, entertainment gadgets, television recorders, and so on. These objects or machines can send data between them. At the same time, people are constantly using mobile phones or tablets, with built in GPS systems that can be traced. 106

All these forms of data transmission are growing at an alarming pace; by 2013 over ten billion objects were connected to the in internet of things, with this set to rise to over 50 billion by 2020. [[51]](#footnote-51)

Kitchin outlines a series of “perils”, that about the effects of “smart cities”. 108

* Treats the city as a knowable, rational, steerable machine, rather than a complex system full of wicked problems and competing interests.
* Promotes a strong emphasis on technical solutions and overly promotes top-down technocratic forms of governance, rather than political/social solutions and citizen-centred deliberative democracy.
* Solutions treat cities as ahistorical and aspatial and as generic markets, promoting one-size fits all technical fixes rather than recognising local specificities.
* The technologies deployed are positioned as being objective, common-sense, pragmatic and politically benign, rather than thoroughly political, reflecting the views and values of their developers and stakeholders.
* Promotes the corporatisation and privatisation of city services, with the developers of smart city technologies capturing city functions as market opportunities which are run for profit rather than the public good, and potentially create propriety technological lock-ins.
* Prioritises the values and investments of vested interests, reinforces inequalities, and deepens levels of control and regulation, rather than creating a more socially just and equal society.
* The technologies deployed have profound social, political and ethical effects: introducing new forms of social regulation, control and governance; extending surveillance and eroding privacy; and enabling predictive profiling, social sorting and behavioural nudging.
* The technologies deployed potentially produce buggy, brittle and hackable urban systems which create systemic vulnerabilities across critical infrastructure and compromise data security, rather than producing stable, reliable, resilient, secure systems.

**What are the ethical implications of Smart Cities?**

Three issues that can be related to the “smart city” phenomenon, described by Finger et al, are:104

* *Technology* *push or demand pull?*: the idea that smart cities are being pushed into development new ICTs, without allowing for real needs and demands of the citizens to be heard, that could possibly be solved with technology.
* *Consumers or citizens?* This refers to the fact that the promotion of “smart cities” most often comes from the operators, who are pursuing their own commercial interests. The objective of these operators is ultimately to produce services they can sell to consumers, instead of services that are in the public interest.
* *Leadership*: this issue is concerned with the fact that the ideal situation would be for civil society and their political representatives to “adapt” their concept of “smart city” to their public policy objectives, instead of being driven by technology vendors.

**Are the motivations to do this research transparent in the public interest? Who is taking part in the decisions process?**

Research derived from the collection of data from “smart cities” is not always open in nature. Some of the data is generated by local governments and some is generated by private companies.[[52]](#footnote-52)

**PBL scenario 6: The forgotten sleeping sickness**

The Sleeping Sickness is a potentially mortal disease caused by parasites transmitted by infected tsetse flies.

During 2014 there were 3796 cases of this disease and 21 million people at risk. If this disease isn’t treated, it is inevitably fatal.

The story of this disease started 25 years ago. Back then, the sickness disease was the leading cause of death in African villages. The only available treatment, a drug called melarsoprol, was a by-product of arsenic, and it was practically poisonous. During the nineties, hope arrived in the form of the approval of a new and safer drug, eflornitina.

*T. Brucei* and red blood cells, Parasite museum, Tokyo

“During 2014, 3796 cases were registered. The total is estimated to be around 30000.” World Health Organization (WHO)

Unfortunately, a few years later, the pharmaceutical company responsible for the production of this drug, Marion Merrell Dow, came to the conclusion that it wasn’t profitable and they stopped its production. The company’s research and innovation department started to investigate into new applications for the compound and they discovered that it played a part in the inhibition of the appearance of facial hair. In this manner, they put eflornitina back on the market, as a cosmetic product, with great success. However, the people affected by the sickness disease were still without this treatment, with only melarsoprol available.

Nowadays, the organization DNDi (Drugs for neglected disease initiative) is investigating how to improve the treatment for this forgotten disease.

**TUTOR GUIDE:**

**Learning objectives**

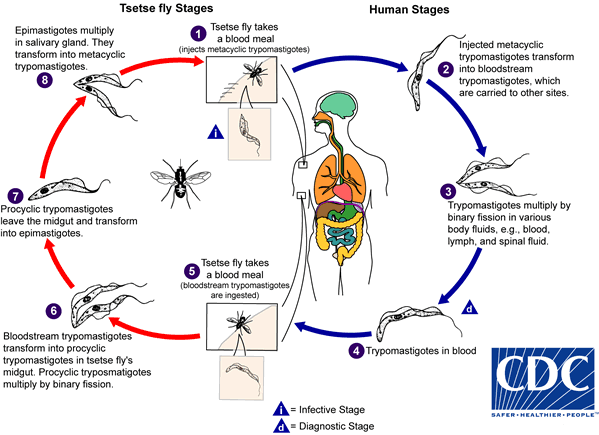
After this activity, the students should be able to:

* Describe the parasite and its life cycle
* Describe the symptoms, diagnosis and treatment for the sleeping sickness
* Describe the drugs used for its treatment and the current lines of research related to the cure for the sleeping sickness
* Identify the epidemiology of the sleeping sickness
* Identify the actors involved in the research, innovation and development process. Discuss which criteria are used to decide on the research, innovation and development of pharmaceuticals
* Determine the ethical acceptability of scientific research in the development of new drugs
* Propose alternative governance models to assure RRI in health, such as the DNDi
* Discover other forgotten diseases
* Identify the actors involved in the application for and obtaining of patents
* Analyse the pros and cons of the patent system
* Discuss the meaning of open source and the possible benefits

**Reflection questions**

**How would you describe the parasite and its life cycle?**

According to the WHO, “human African trypanosomiasis, also known as the sleeping sickness, is a parasitic disease which depends on a vector for its transmission. The parasites involved in this disease are protozoa from the genus *Trypanosoma*, which are transmitted to humans through bites from the tsetse fly (genus *Glossina*) that have become infected from feeding from other humans or animals that were hosts for the parasite.”

**Life cycle**

**Which are the symptoms, diagnosis and treatment for the sleeping sickness?**

**Infection and symptoms**

According to the WHO, “The disease is mostly transmitted by bites from the tsetse fly, but there are other ways in which people are infected:

* Mother-to-child infection: the trypanosome can cross the placenta and infect the fetus.
* Mechanical transmission through other blood-sucking insects is possible; however, it is difficult to assess its epidemiological impact.
* Accidental infections have occurred in laboratories due to pricks with contaminated needles.
* Transmission of the parasite through sexual contact has been documented.

In the first stage, the trypanosomes multiply in subcutaneous tissues, blood and lymph. This is also called haemo-lymphatic stage, which entails bouts of fever, headaches, joint pains and itching.

In the second stage the parasites cross the blood-brain barrier to infect the central nervous system. This is known as the neurological or meningo-encephalic stage. In general, this is when more obvious signs and symptoms of the disease appear: changes of behaviour, confusion, sensory disturbances and poor coordination.

Disturbance of the sleep cycle, which gives the disease its name, is an important feature. Without treatment, sleeping sickness is considered fatal although cases of healthy carriers have been reported.”

#### What is the disease management for the sleeping sickness?

According to the WHO, “disease management is made in 3 steps:

* Screening for potential infection. This involves using serological tests (only available for *T.b.gambiense*) and checking for clinical signs - especially swollen cervical lymph nodes.
* Diagnosing by establishing whether the parasite is present in body fluids.
* Staging to determine the state of disease progression. This entails examining the cerebrospinal fluid obtained by lumbar puncture.

Diagnosis must be made as early as possible to avoid progressing to the neurological stage in order to elude complicated and risky treatment procedures

The long, relatively asymptomatic first stage of *T. b. gambiense* sleeping sickness is one of the reasons why an exhaustive, active screening of the population at risk is recommended, in order to identify patients at an early stage and reduce transmission by removing their status of reservoir. Exhaustive screening requires a major investment in human and material resources. In Africa, such resources are often scarce, particularly in remote areas where the disease is mostly found. As a result, some infected individuals may die before they can ever be diagnosed and treated.”

**Which are the drugs used for its treatment and the current lines of research related to the cure for the sleeping sickness?**

According to the WHO, “in the first stage, the trypanosomes multiply in subcutaneous tissues, blood and lymph. This is also called haemo-lymphatic stage, which entails bouts of fever, headaches, joint pains and itching

In the second stage the parasites cross the blood-brain barrier to infect the central nervous system. This is known as the neurological or meningo-encephalic stage. In general, this is when more obvious signs and symptoms of the disease appear: changes of behaviour, confusion, sensory disturbances and poor coordination.”

Also, “the drugs used in the first stage (haemo-lymphatic stage) are safer and easier to administer than those for second stage (the neurological stage). Also, the earlier the disease is identified, the better the prospect of a cure. The assessment of treatment outcome requires follow up of the patient up to 24 months and entails laboratory exams of body fluids including cerebrospinal fluid obtained by lumbar puncture, as parasites may remain viable for long periods and reproduce the disease months after treatment.

Treatment success in the second stage depends on drugs that cross the blood-brain barrier to reach the parasite. Such drugs are toxic and complicated to administer.

In total five different drugs are used for the treatment of sleeping sickness. These drugs are donated to WHO by manufacturers and distributed free of charge to disease endemic countries.”

**Drugs used in first stage treatment:**

* **Pentamidine:** discovered in 1940, it is an antiprotozoal and antifungal agent from the aromatic diamidine drugs group. The mechanism of action of pentamidine is unknown and it can vary, depending on the organism being treated. Pentamidine can interfere with the incorporation of nucleotides in the DNA and RNA. It may also inhibit the oxidative phosphorylation and the biosynthesis of DNA, RNA, proteins and phospholipids. Last of all, pentamidine can have antagonistic actions towards folates (by inhibiting the synthesis of folates, thus preventing the synthesis of DNA and RNA). It is used for the treatment of the first stage of *T.b. gambiense* sleeping sickness. Despite non-negligible undesirable effects, it is in general well tolerated by patients.
* **Suramin:** discovered in 1920, it is an antihelmintic drug which inhibits enzymes that intervene in the parasite’s metabolism of DNA and protein synthesis. It is used in the treatment of the first stage of *T.b. rhodesiense*. It provokes certain undesirable effects, including urinary tract and allergic reactions.

**Drugs used in second stage treatment:**

* **Melarsoprol:** discovered in 1949, it is used for the treatment of both forms of infection. It is derived from arsenic and has many undesirable side effects, the most dramatic of which is reactive encephalopathy (encephalopathic syndrome) which can be fatal (3% to 10%). Melarsoprol is a pro-drug (meaning that once it has been metabolized, it turns into the active ingredient) which is metabolized into melarsen oxide, its active form. This form incatives the pyruvate kinase, thus inhibiting the energy production chain in the parasite. It is highly toxic as it also acts upon the host. An increase in resistance to the drug has been observed in several foci, particularly in central Africa. It is currently recommended as first-line treatment for the *rhodesiense* form, and as second-line for the *gambiense* form.
* **Eflornithine:** this molecule, less toxic than melarsoprol, was registered in 1990. It derives from ornitithine, and it inhibits the enzyme ornithine decarboxylase, thus inhibiting the synthesis of polyamines such as spermine and spermidine. It is only effective against *T.b. gambiense*. The regimen is complex and difficult to apply.
* **Nifurtimox:** It started to be used in 1965. It is a 5-nitrofuran which generates free radicals that react with the nucleic acids of the parasite, making them break. The host’s cells are protected from the free radicals by the presence of additional enzymes such as catalases, peroxidises, superoxide dismutases and the antioxidant glutathione.

 A combination treatment of **nifurtimox** and **eflornithine** was introduced in 2009. It simplifies the use of eflornithine by reducing the duration of treatment and the number of IV perfusions, but unfortunately it has not been studied for *T.b. rhodesiense*. Nifurtimox is registered for the treatment of American trypanosomiasis but not for human African trypanosomiasis. Nevertheless, after safety and efficacy data provided by clinical trials, its use in combination with eflornithine has been included in the "*WHO List of Essential Medicines*" and is currently recommended as first-line treatment for the *gambiense* form. Both drugs are provided free of charge by WHO to endemic countries with a kit containing all the material needed for its administration.

### **Public private partnership**

According to their website “In 2000 and 2001, WHO established public-private partnerships with Aventis Pharma (now Sanofi) and Bayer HealthCare which enabled the creation of a WHO-led control and surveillance programme, providing support to endemic countries in their control activities and the supply of medicines free of charge.

The partnership was renewed in 2006, 2011 and 2016. The success in curbing the number of sleeping sickness cases has encouraged other private partners to sustain the WHO’s initiative towards eliminating the disease as a public health problem.”

WHO provides the anti-trypanosome medicines free of charge to endemic countries through public-private partnerships with Sanofi (pentamidine, melarsoprol and eflornithine) and with Bayer HealthCare (suramin and nifurtimox). The conditioning and shipment of medicines is done in collaboration with MSF-Logistics.

In 2014 a coordination network for human African trypanosomiasis was established under WHO leadership to ensure strengthened and sustained efforts to eliminate the disease. The stakeholders include national sleeping sickness control programmes, groups developing new tools to fight the disease, international and non-governmental organizations, and donors.

**New approaches**

Even though the first choice of treatment is the combination of nifurtimox and eflornitina (NECT, Nifurtimox-eflornithine combination therapy) in the secong stage of the disease, its use is limited to the hospital setting. Nowadays, two new drugs are being studies at a clinical level:

Fexinidazole, a 5-nitroimidazole, which is also a pro-drug that is metabolized quickly in vivo, producing sulfoxide and sulphone, sulphone being the more active metabolite.

SCYX-7158, a benzoxaborole derivative, whose mechanism of action is still unclear.

Both these drugs have been proven effective in animal models with an African trypanosome infection; they can both be administered orally, are capable of crossing the blood-brain barrier and seem to be effective with short-term treatments.

**Which is the epidemiology of the sleeping sickness?**

According to the WHO, “human African trypanosomiasis takes 2 forms, depending on the parasite involved:

* *Trypanosoma brucei gambiense* is found in 24 countries in west and central Africa. This form currently accounts for 97% of reported cases of sleeping sickness and causes a chronic infection. A person can be infected for months or even years without major signs or symptoms of the disease. When more evident symptoms emerge, the patient is often already in an advanced disease stage where the central nervous system is affected.
* *Trypanosoma brucei rhodesiense* is found in 13 countries in eastern and southern Africa. Nowadays, this form represents fewer than 3% of reported cases and causes an acute infection. First signs and symptoms are observed a few months or weeks after infection. The disease develops rapidly and invades the central nervous system. Only Uganda presents both forms of the disease, but in separate zones.
* Another form of trypanosomiasis occurs mainly in Latin America. It is known as American trypanosomiasis or Chagas disease. The causal organism belongs to a different *Trypanosoma* subgenus and is transmitted by a different vector.”



They also state that, “ther parasite species and sub-species of the *Trypanosoma* genus are pathogenic to animals and cause animal trypanosomiasis in wild and domestic animals. In cattle, the disease is called *Nagana*. Trypanosomiasis in domestic animals, particularly in cattle, is a major obstacle to the economic development of affected rural areas.

Animals can host the human pathogen parasites, especially *T.b. rhodesiense*, of which domestic and wild animals are an important reservoir. Animals can also be infected with *T.b. gambiense* and act as a reservoir to a lesser extent. However, the precise epidemiological role of the animal reservoir in the gambiense form of the disease is not yet well known.”

**What have been the major human epidemics?**

The WHO states that there have been several epidemics in Africa over the last century: one between 1896 and 1906, mostly in Uganda and the Congo Basin; one in 1920 in a number of African countries, which was controlled thanks to the work of mobile teams that monitored the people at risk; and the most recent epidemic started in 1970, due to the relaxation of the measures taken in 1920 and lasted until the late 1990s. in 1970 the disease reappeared, reaching epidemic proportions, but the efforts deployed by the WHO, the national disease control programmes, the bilateral collaboration and the NGOs during the nineties and first years of the current century allowed for this tendency to be reversed. Since the number of new human African trypanosomiasis cases reported between 2000 and 2012 dropped by 73%, the WHO neglected tropical diseases roadmap targeted its elimination as a public health problem by 2020.

Sleeping sickness threatens millions of people in 36 countries in sub-Saharan Africa. Many of the affected populations live in remote rural areas with limited access to adequate health services, which complicates the surveillance and therefore the diagnosis and treatment of cases. In addition, displacement of populations, war and poverty are important factors that facilitate transmission.

According to the Who website, “The disease incidence differs from one country to another as well as in different parts of a single country.

* In the last 10 years, over 70% of reported cases occurred in the Democratic Republic of the Congo (DRC).
* The DRC is the only country that currently reports more than 1000 new cases annually and accounts for 84% of the cases reported in 2015.
* Central African Republic is the only country that declared between 100 and 200 new cases in 2015.
* Countries such as Angola, Burkina Faso, Cameroon, Chad, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Gjana, Guinea, Malawi, Nigeria, South Sudan, Uganda, United Republic of Tanzania, Zambia and Zimbabwe are reporting fewer than 100 new cases per year.
* Countries like Benin, Botswana, Burundi, Ethiopia, Gambia, Guinea Bissau, Kenya, Liberia, Mali, Mozambique, Namibia, Niger, Rwanda, Senegal, Sierra Leone, Swaziland and Togo have not reported any new cases for over a decade. Transmission of the disease seems to have stopped in some of these countries but there are still some areas where it is difficult to assess the exact situation because the unstable social circumstances and/or difficult accessibility hinder surveillance and diagnostic activities.”

**Which actors involved in the research, innovation and development process Discuss which criteria are used to decide on the research, innovation and development of pharmaceuticals**

Research and innovation into new drugs is carried out in different fields:

* Research in universities and research centres with public funding
* Research in private companies with public funding (subsidies, prizes, credits)
* Research and development with private funding, remunerated via the market instead of public funding, and incentivised via the intellectual property system, a mechanism to foment innovation which is part of the governmental policies.

Recent studies show that the resulting products from research financed by the public sector have a higher therapeutic effect than those that derive from research in the private sector.

One of the current systems to encourage innovation is the patent system, but whether or not this system can encourage inventions in fields where there is no real market can be questioned. One of the problems of this system which is driven by patents is that the profitability of the investment in innovation is generally integrated into the price of the resulting products. On the other hand, in the new initiatives and mechanisms of financing, the objective is not to finance the cost of research and development of the product with the final price of the product in mind, which means that they disassociate the cost of research from the price of the product.

The WHO has established a record in which the data from clinical research is generated and made public. The publication of the results in these trials is of interest to public health and science in general.

**Which is the ethical acceptability of scientific research in the development of new drugs?**

In a statement from 2009, the WHO declared that “WHO considers equitable access to safe and affordable medicines as vital to the attainment of the highest possible standard of health by all. WHO Member States reaffirmed their commitment to these principles in May 2008, with the adoption of a resolution on the "Global strategy and plan of action on public health, innovation and intellectual property" (WHA61.21). Among other important objectives, the resolution expressed Member States' commitment to improving the delivery of and access to all health products and medical devices by effectively overcoming barriers to access.

In this context, the recent events related to the handling of medicines in transit and the potential consequences for the supply of medicines in developing countries are of major concern to the organization. This issue has been raised in the meeting of the WHO Executive Board in January 2009 and was a subject of discussion in the recent WTO TRIPS Council.

In relation to this issue, WHO is continuing to follow developments and consulting with Member States and relevant international intergovernmental organizations. WHO also understands that there is ongoing dialogue among the parties concerned to resolve the matter. Given the public health impact of this issue, WHO remains ready to provide, upon request, technical and policy support to Member States.

Ensuring that the interests of trade and health are appropriately managed also means that the flow of legitimate medicines, including generic medicines, is not impeded.”

The ethical principles that have to be respected in the development and production of medications are:

**The principle of autonomy.** Autonomy refers to the capacity to give oneself rules or guidelines without the influence of outside pressures. The preferences and values of the patient are fundamental from the ethical point of view.

**The principle of beneficence.** The obligation to act for the benefit of others; by promoting their legitimate interests and doing away with prejudice.

**The principle of non-maleficence.** To intentionally abstain from carrying out actions that may cause damage or be harmful to others.

**The principle of justice.** To treat each person appropriately, with the aim to reduce situations of inequality (ideological, social, cultural, economic, etc.)

**What is RRI? Propose alternative governance models to assure RRI in health, such as the DNDi**

RRI is a transparent and interactive process through which social actors and innovators become responsible for each other, taking into account the ethical acceptability, sustainability and society in the process of innovation and its resulting products. The European Commission has identified six key issues of RRI: ethics, gender equality, science education, governance, open access and public engagement (commitment with society/population). In the frame of RRI, new organization models in the field of health have appeared, such as:

**DNDi:** is a collaborative non-profit organization, dedicated to the research and development of drugs, based on the patients’ needs, which is developing new treatments for forgotten illnesses. The international research community, the public sector, pharmaceutical companies and NGOs all collaborate in this organization to develop said treatments. The main goals of the organization are:

* To develop 16-18 treatments before 2023
* To expand and build Research and Development networks between different regions
* To create new entities to achieve the development of treatments for forgotten diseases.

**Discover other forgotten diseases**

Forgotten diseases are those which, even though they cause some of the highest morbidity and mortality rates in the world, they are ignored by the pharmaceutical development system. These diseases incapacitate or kill millions of people and they represent an important medical need that should be addressed. This type of diseases represents a global problem for public health, but the R&D of pharmaceutical companies is almost always oriented towards gain and is centred around the production of drugs to treat sickness that affects the population of more develop countries.

Some examples of forgotten diseases are:

* Malaria
* Sleeping sickness
* Chagas disease
* Visceral Leishmaniosis
* Lymphatic fibrosis
* Dengue fever
* Schistosomiasis

**Other reflecting questions:**

Which stakeholders take part in the patent system?

What is the importance of patents? How do they work?

What ethical dilemmas should be considered in the patent system?

Are there potentially harmful impacts involved in the patent system? How can they be prevented?

How can an open access system be implemented? What are the benefits and problems involved?

 What are the possibilities and limitations for ‘open-source’ approaches in life sciences?

**Recommended bibliography:**

* 2013. Promoting access to Medical technologies and innovation. Intersections between public health, intellectual property and trade. WHO
* Gold ER, Kaplan W, Orbinski J, Harland-Logan S, N-Marandi S (2009) Are Patents Impeding Medical Care and Innovation? PLoS Med 7(1): e1000208. doi:10.1371/journal.pmed.1000208

**PBL scenario 7: Deception**

**Adapted from the book: Research Methods in Psychology by**[**John J. Shaughnessy**](https://www.thriftbooks.com/a/john-j-shaughnessy/216307/)**,**[**Jeanne S. Zechmeister**](https://www.thriftbooks.com/a/jeanne-s-zechmeister/216306/)**,**[**Eugene B. Zechmeister**](https://www.thriftbooks.com/a/eugene-b-zechmeister/216308/)**, McGraw-Hill Education, 9th edition, 2012**

RESEARCH PROPOSAL:

The research project will involve 60 students, from the ages of 16 to 20. These students are volunteers who have signed up to participate in a research project that is investigating “attitudes of today’s teenagers”.

These students will be assigned to different discussion groups. There will be four people in each discussion group. They will be given a set of 20 questions to answer, and they will be instructed to discuss each question with their group before writing down the answer.

Among these questions, a section will be related to the consumption of alcohol in teenagers. Some of the questions will be about prevention methods and how to avoid teenage drinking and driving. In each group, there will be a debate moderator, appointed by the investigator, to guide the discussion.

Unknown to the students, some of the participants in the discussions are not volunteers. These participants are working for the investigators; they will be referred to as confederates. Thus, the students will be randomly assigned to different groups:

* groups with zero confederates
* groups with one confederate
* groups with two confederates

These confederates have previously received instructions on what to say and how to act during the debate on the questions related to alcohol consumption. They have been provided with a script to follow.

This script revolves around the argument that people who are of a legal driving age (16 or 18), and also people who are old enough to vote (18) should be considered old enough to make their own decisions when it comes to drinking. Also, they should say that it is up to each individual to decide if they want to drink or not, and therefore it is not fair to intervene if a person under the legal drinking age decides to consume alcohol. The confederates should also admit to drinking alcohol at least three times, one of them recently.

In this manner, depending on the number of confederates in the group, the experimental manipulation involves either zero, one or two people declaring that they don’t think students should be responsible for avoiding situations in which alcohol is available to minors or even to intervene when a fellow student makes the decision to drive after having consumed alcohol.

The evaluation of the experiment will be assessed by analysing the written answers given by the volunteers. At the same time, these group discussions will be recorded without the knowledge of the participants, and also analysed.

Once the experiment has been concluded the investigators will disclose the nature of the deception and the reasons for the tape recordings to all those involved in the research.

**Learning outcomes**

After this activity students should be able to:

* Understand the meaning of “deception” in psychological experiments
* Define the manner in which research is carried out using deception
* Analyse the possible applications of using deception in research
* Evaluate the possible risks involved in using this kind of techniques in psychological experiments
* Asses the ethical issues/impacts related to the use of deception
* Examine the possible security measures to be implemented in this type of research
* Determine if this type of research is transparent and of public interest
* Investigate if there are possible alternatives to the solution sought by this type of research

**Reflection questions**

What is deception in psychology?

Why is deception used in psychology?

What are the possible risks of using deception in a psychological experiment?

What ethical issues are involved in the use of deception?

Are the motivations for this research transparent and in the public interest?

Are there alternatives to the use of deception?

Under what conditions is it always unethical to deceive research participants?

How is debriefing beneficial to both participants and researchers?

How should researchers treat the information obtained from participants in order to protect them from social injury?

What is informed consent? Should researchers always obtain informed consent?

**Recommended bibliography**

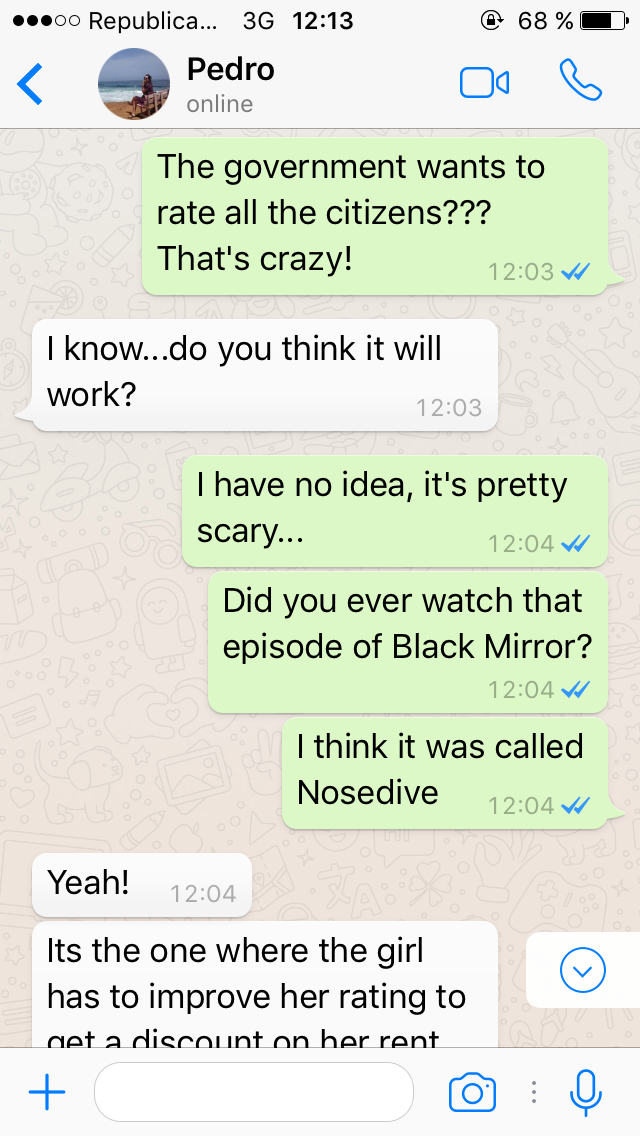
* Won Oak Kim, Institutional review board (IRB) and ethical issues in clinical Research, Korean J Anesthesiol 2012 January 62(1): 3-12<http://dx.doi.org/10.4097/kjae.2012.62.1.3>
* Chapter 3. Ethical Issues in the Conduct of Psychological Research, Research Methods in Psychology by [John J. Shaughnessy](https://www.thriftbooks.com/a/john-j-shaughnessy/216307/), [Jeanne S. Zechmeister](https://www.thriftbooks.com/a/jeanne-s-zechmeister/216306/), [Eugene B. Zechmeister](https://www.thriftbooks.com/a/eugene-b-zechmeister/216308/), McGraw-Hill Education, 9th edition, 2012
* Ethical Principles of Psychologists and Code of Conduct, American Psychology Association: <http://www.apa.org/ethics/code/index.aspx>
* Boynton MH, Portnoy DB, Johnson BT, Exploring the Ethics and Psychological Impact of Deception in Psychological Research, IRB. 2013 Mar-Apr; 35(2): 7–13.
* Ortmann A, Hertwig R, Deception in Social Psychological Experiments: Two Misconceptions and a Research Agenda, *Social Psychology Quarterly* 2008, Vol. 71, No. 3, 222–227

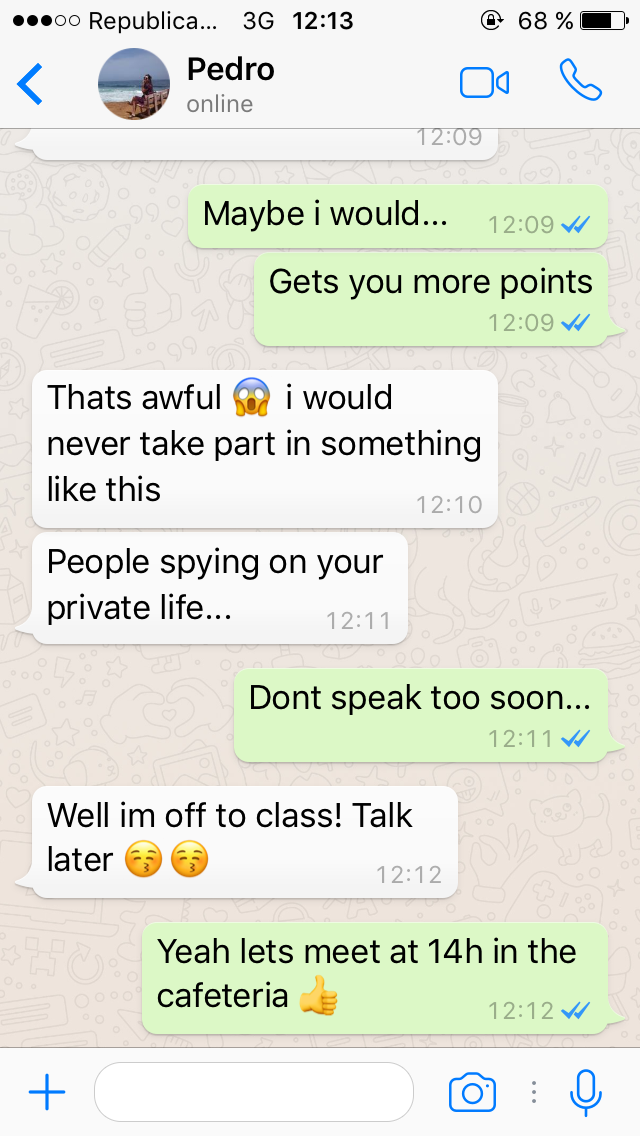
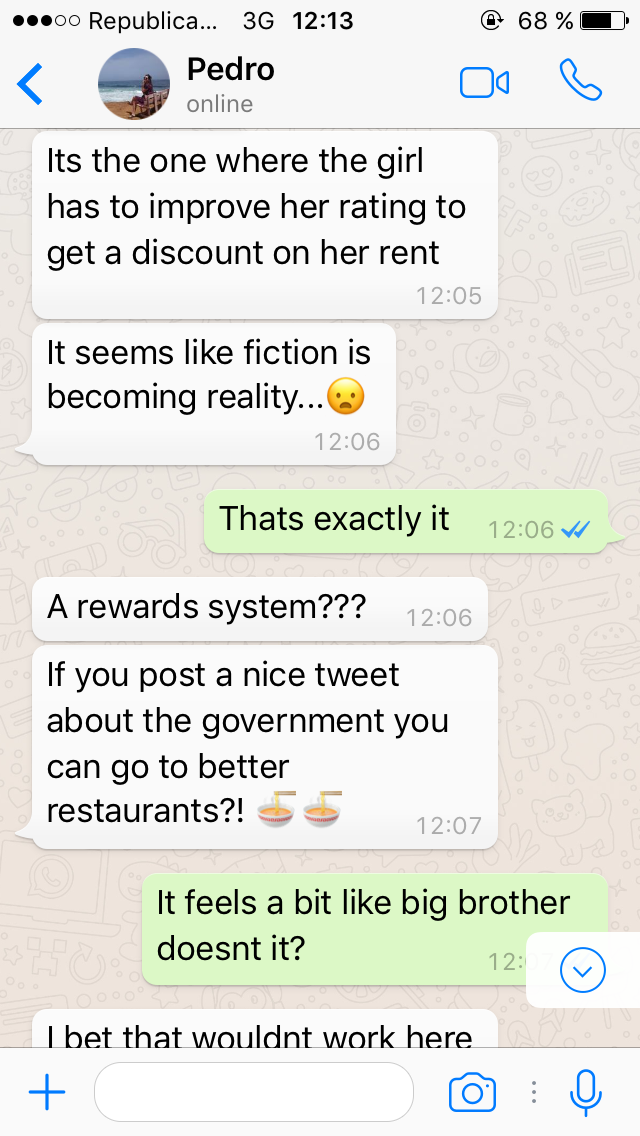
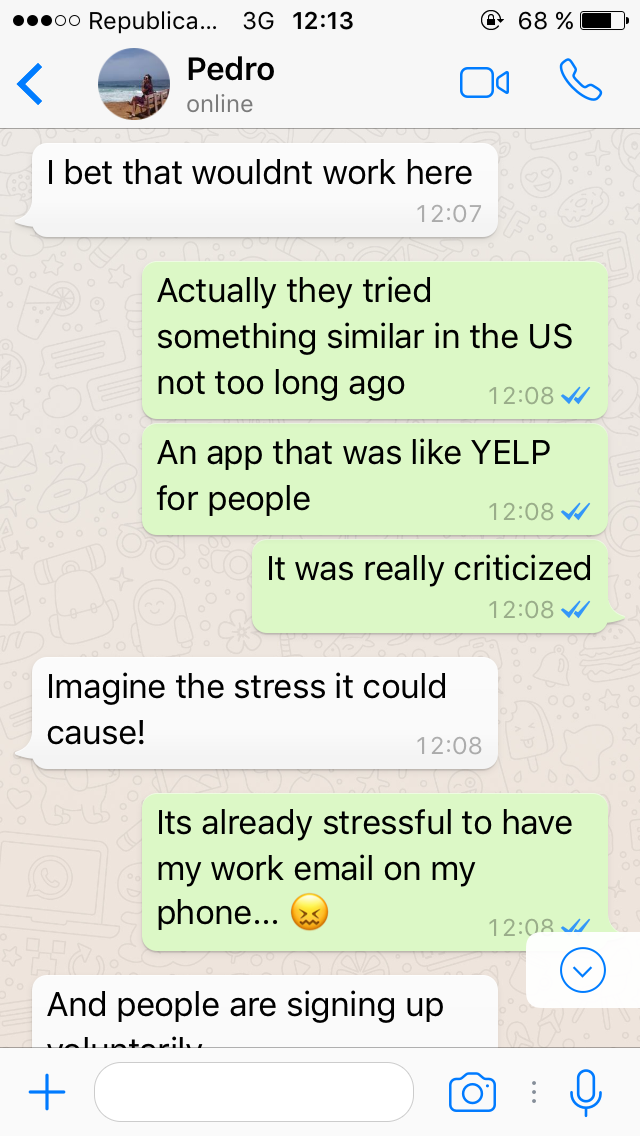
**PBL scenario 8: What’s your score?**

*Conversation on instant messaging app between two friends:*

* Good morning! How was last night?
* Hey! Great! We stayed up until 2 am talking. I’m a bit worried. Did you see the article I posted?
* No…send me the link
* Read the whole thing! <http://www.wired.co.uk/article/chinese-government-social-credit-score-privacy-invasion>
* The government wants to rate all the citizens? That’s crazy!
* I know…do you think it will work?
* I have no idea…it’s really scary though. Did you ever watch that episode of Black Mirror? I think it was called Nosedive.
* Yeah! It’s the one where the girl has to improve her social rating to get a discount on her rent! It seems like fiction is becoming reality.
* That’s exactly it.
* A rewards system??? If you post a nice tweet about the government you can eat at a better restaurant???
* It feels a bit like Big Brother doesn’t it?
* I bet that this wouldn’t work here…
* Actually, they tried something similar in the US not too long ago, an app that was like YELP for people. It was really criticized.
* Imagine the stress it could cause!
* It’s already stressful to have my work email on my phone…
* And people are signing up voluntarily before it becomes mandatory!
* Maybe I would…gets you more points
* That’s terrible! I would never take part in something like this!
* Don’t speak too soon…
* Well, I’m off to class! We can talk about this later…xxx
* Yeah! Let’s meet at 14h at the cafeteria! Xx





**Learning outcomes**

After this activity students should be able to:

* Discuss the purpose of creating a social credit system
* Analyse the possible applications such a system in society
* Discuss the actors taking part in the research process and implementation
* Evaluate the possible benefits and risks involved in creating a social credit system
* Asses the possible impacts related to a “people-rating” technology on society
* Argue if this technology is socially acceptable

**Reflection questions**

What are possible risks involved in creating a system to rate people and their interactions?

Who will benefit from this research?

What aspects are taken into consideration when creating such a system? What aspects should be taken into consideration?

What ethical issues are involved in the creation of such a system?

Should security measures be implemented? How could this be done?

What impacts of this technology can be anticipated?

Are the motivations for this research transparent and in the public interest? Who is taking part in the decisions process?

Who would own and have access to the data collected? Could this data be sold?

Has the general public been consulted on this topic? What is their opinion?

**References in the scenario:**

<http://www.wired.co.uk/article/chinese-government-social-credit-score-privacy-invasion>

<https://www.theatlantic.com/entertainment/archive/2016/10/black-mirror-nosedive-review-season-three-netflix/504668/>

<https://www.theguardian.com/media/2016/mar/07/peeple-the-yelp-for-people-review-app-launches-in-north-america-on-monday>

**Recommended Bibliography**

* Hal Hodson,  Inside China’s plan to give every citizen a character score, 9 October 2015, New Scientist <https://www.newscientist.com/article/dn28314-inside-chinas-plan-to-give-every-citizen-a-character-score/>
* Tanya M. Machin, Carla H. Jeffries, Threat and opportunity: The impact of social inclusion and likeability on anonymous feedback, self-esteem, and belonging, Personality and Individual Differences 115 (2017) 1–6
* Rebecca L. Kauten, Joyce H.L. Lui, Amanda K. Stary, Christopher T. Barry, ‘‘Purging my friends list. Good luck making the cut’’: Perceptions of narcissism on Facebook, Computers in Human Behavior 51 (2015) 244–254
* Dirk Helbing, Evangelos Pournaras. Build digital democracy Nature 2015

**ANNEX 4. HEIRRI ROLE PLAY SCENARIOS**

**TABLE OF CONTENTS:**

* ROLEPLAY TUTOR GUIDE
* GOF EXPERIMENTS
* SUSTAINABLE FASHION
* BIOMASS
* NANOTECHNOLOGY IN AGRICULTURE
* DECEPTION

**ROLE-PLAY TUTOR GUIDE**

**Goal:**

*The aim of this activity is to promote discussion regarding different points of view and arguments related to a controversial issue in which the research process involves certain risks for society.*

**Learning outcomes:**

After this activity, the students should be able to:

* Analyse the current situation related to the role-play scenario.
* Construct arguments and an opinion on the role-play scenario.
* Discuss different perspectives related to this issue.
* Apply the RRI perspective to this issue.

**Materials:**

* Articles to read
* Role-Play Scenarios
* Characters
* Moderator questions

**Description of the activity:**

This activity is designed for 30 students, more or less. The students should be divided up into the number of roles in the chosen scenario in groups of 4-5 participants. Before the activity, each group of students will be assigned a character. Then, each group should study a role, by reading the selected articles before the role-play session. Also, the students have to read which kind of character they have. Each group will choose an spokesman to play the character.

Another option to carry out this activity is for the students to read the selected articles, without specific roles having been assigned. In this manner, the students themselves should decide on which roles are involved in the role-play session once they have analysed the scenario in depth.

During the role-play session:

1. Presentation of the scenario (10 minutes)
2. Preparation of the characters’ arguments (20 minutes)
3. Role-play (1 hour).

* Each role play character has to be introduced by each group spokesman and has to explain their position in relation to role-play debate (15 minutes).
* After that, there will be 30 minutes of questions directed by the moderator to generate debate.
* Finally there will be 15 minutes of final conclusions.

It is important that the groups of students defend their role during the debate, despite their personal opinion. After that, in the final conclusions, the students can free themselves of their role and give their personal opinion/arguments about this issue, if they want.

**Total duration of the activity:**1 hour 30 minutes/ 2 hours

**Teacher’s role: how can the teacher facilitate the activity?**

To direct the activity it is interesting for the instructor/teacher to play the role of the moderator. To perform a more interactive debate the instructor can use the “theatre of the oppressed” dynamic, formulated by Augusto Boal, concretely the forum theatre technique. In this technique Boal looked to provide different structures which could be adapted according to the groups he was working with, developing a method by which the theatre process could be transferred from actors to the audience, also called spec-actors, through enabling discussion and debate without hierarchy and respecting everybody’s knowledge. This technique has been applied in the educational community, and basically it is based on engaging the participants through creating opportunities to engage in active discussion around a specific issue with the aim of considering different perspectives. In this case, the dynamic to guide the activity is the following:112

**Facilitator:** the instructor has to play the role of the facilitator, there has to be a neutral party at the centre of the proceedings and to guide the debate.

**Actors:** some of the participants have to play the different characters of the role-play and defend their arguments related to the debate’s issue.

**Spec-actor:** during the debate, the public or the other participants are engaged in the forum theatre. The spec-actors can participate and discuss their own ideas, they are not passive public anymore.

The dynamic starts with the moderator at the centre of the stage and the different characters’ representatives. Each character/spokesman exposes their arguments and then the moderator starts with the questions to generate debate. The public (the other members of the groups that are not acting as spokesman) or spec-actors can intervene with the debate, so, when a public participant doesn’t agree with something that one of the actors has exposed, the participant has to clap and they switch roles: the actor becomes part of the public and the public participant gets on the stage and becomes an actor.

Furthermore, to guide this activity, the instructor can choose the characters he or she thinks are convenient. Here there are eight characters to be chosen, however, it is recommended to choose at least six of them.[[53]](#footnote-53)

**GAIN OF FUNCTION EXPERIMENTS**

**Scenario:**

Gain-of-function (GOF) experiments are an experimental tool that is routinely used in biomedical research. What GOF means is that an entity has gained a new property, for example, GOF in the influenza virus has been associated with the acquisition of a new function, such as mammalian transmissibility, increased virulence for humans or evasion of existing host immunity[[54]](#footnote-54). In recent years, some members of the scientific community have been involved in a vigorous debate over GOF experiments involving pathogens with pandemic potential (PPP), such as the influenza virus. This controversy has become a State issue; in fact, in October 2014 the U.S. government announced a pause in research involving GOF experiments with three respiratory viruses: influenza virus, MERS and SARS. Furthermore, the National Science Advisory Board for Biosecurity (NSABB) met to discuss another added controversy, GOF papers publications.[[55]](#footnote-55)

GOF experiments have become a current debate issue which worries the scientific community. After several months of discussion, a meeting has been proposed, involving all the actors of this debate, to discuss the many issues involved in the risks-benefits analysis of GOF experiments future work and this developing situation.[[56]](#footnote-56)

**Characters:**

**Yoshi Kinamata**

Yoshi Kinamata is a recognised virologist, researcher and professor at the University of Wisconsin, Madison. He works in the department of biopathological sciences. His research focuses on the molecular mechanism of interspecies transmission of the influenza virus that triggers human influenza pandemics, as well as the molecular pathogenesis of the influenza virus in birds and mammals. He has published the main articles involving the topic of GOF experiments.

“Our research could bring lots of benefits to biomedical research: we could identify mutationts that could influence the viruses’ effects on the immune system and their resistance to antiviral drugs. We have been transparent with our work and we are trying to upfront what needs to be done, how it could be done and how we could do it safely.”

**Bob Smith**

Bob Smith, a biotechnologist, is the vice president of the pharmaceutical company BioCryst Pharmaceutics. He has participated in the development and launching of different pharmaceutical treatments. He is currently focusing on the direction of the research on new antiviral drugs and vaccines carried out in this pharmaceutical company.

“If Gain of Function research is not allowed to proceed, our company research on antiviral drugs and vaccines will grind to a halt because drug development is financially risky, but we don’t want to.”

**Tina Truman**

Tina Truman is a biosafety and biosecurity consultant from Maryland, USA. She works on the promotion of good biosecurity practices to safeguard the population from potential risks. She worked for many years with the UK government in the disarmament of biological weapons.

“Nobody will support an experiment that attempted to make HIV or Ebola transmissible by air, there are lines we wouldn’t cross. If the virus escape, nobody could predict the trajectory. And even worse, what will happen if GOF are used for bioterrorism.”

**Francesca Colleman**

Francesca Colleman, a biochemist, is the director of the National Institutes of Health (NIH) of the United States. Her institution works with the government to finance, via public money, part of the biomedical and biotechnological research projects. For a few years, Francesca authorized the funding of GOF experiments.

“Researchers on contract with the NIH might be affected, some of our several scientists have received orders to stop work this week. Between 20 to 24 NIH-funded projects are directly affected. The pause comes a cost, but will provide robust deliberation.”

**Samuel Webbe**

Samuel Webbe is a virologist, professor and researcher at the Pasteur Institute. He works in the Molecular Retrovirology department. For years he has worked with AIDS and HIV and has published more than 200 papers. He is currently a member of the European Molecular Biology Organization and Chairman of the Board of Directors of the Foundation for Vaccine Research. He has been involved in the debate of the GOF and has been very critical with Kinamata’s work.

“The only impact of this work is the creation, in a lab, of a new, non-natural risk. What's more, the research of Dr. Kinamata could be done in other kind of experiments without the need of putting them in an infectious virus.”

**Julia Stills**

Julia Stills, a biologist, has worked for several years in a Molecular Virology research group. Some time ago, she left her professional career in basic research to pursue biohacking. She currently works in a DIY biology laboratory as a biohacker. She has participated in the writing of the ethical code for the network of DIY laboratories in Europe and the United States.

“The community has not to worry about biohackers, we are working to include GOF experiments in our ethical code. However, this issue must be debated to reach an agreement.”

**Rita Donald**

Rita, who did a bachelor in Life Science, is the current Editorial Director of Nature. Her tasks at the science journal include overseeing the editorial content and management of biological science. She has been involved in the publication of Dr. Kinamata’s studies in 2013.

“Journal Editors have a difficult role in this debate. We want to be transparent and publish all the data, but our concern is that publishing it will allow labs around the world, which won’t adhere to the same safety requirements or the same purpose, to do the same.”

**Richard Green**

Richard, an activist and expert in ecology, works in the Third World Network (TWN), an alternative policy group that produces and disseminates analyses, proposals and information tools related to ecological sustainability. He has participated in the movement of collecting signatures, promoted by scientists in the field, who have stridently opposed to GOF experiments.

“The risks are too high. We are talking about a possible epidemic. I don’t know why there is still debate here. ”[[57]](#footnote-57),[[58]](#footnote-58),[[59]](#footnote-59)

**Reflection questions**

**Moderator questions during the debate:**

* Which are the benefits and risks of using Gain of function experiments?
* To what extent is there agreement about the general balance between risk avoidance and innovation/research support?
* Which powers are traditionally used to prohibit the research?
* How should regulation or prohibition be managed in cases of research collaborations that cross borders?
* One of the main concerns are biosafety and biosecurity. Even so, research with pathogens has been carried out for many years and it seems quite safe. Do we have enough reasons to believe that the current requirements of biocontainment are insufficient for GOF experiments?
* The USA government has paused the funding of GOF experiments and studies. What do you think about it?
* How and when should the results of these experiments be reported? How should scientific journals deal with this topic? How should this information be published? Do all the details of the experiment have to be given, or just the surface information or does anything have to be published at all?
* The press has published this information on the debate of the GOF. Is it beneficial that the debate has reached the general public and the entire population? Or is it just a provocation of alarmism?
* Are there any alternatives to GOF experiments?[[60]](#footnote-60)

**Moderator questions for the conclusions and closing of the activity:**

Goal: To search a theoretical position about GOF experiments and agree on a regulation.

 -Do these experiments have to be allowed?

- To what extent should they be regulated?

- Which is the current situation in EEUU and Europe? Is there an International agreement of regulation?

**Selected Articles to read:**

* Wain-Hobson, S. (2013). Pandemic influenza viruses: time to recognize our inability to predict the unpredictable and stop dangerous gain-of-function experiments. *EMBO Molecular Medicine,* 5, 1637-1641.
* Reardon, S. (2014). Viral-research moratorium called too broad. *Nature News*.
* Casadevall, A., Imperiale, M.J. (2014). Risks and Benefits of Gain-of-function experiments with Pathogens of Pandemic Potential, such as Influenza Virus: a call for a Science-Based Discussion. *mBio Editorial,* 5 (4), 1-5.

**SUSTAINABLE FASHION**

**Inspired by a case study from the UPC ERASMUS intensive programme in sustainable technology development:**

**Clara Mallart*:* A local booming sustainable clothing market**

**Scenario**

After China, the EU is the world’s second largest exporter of textile products. Europe dominates the global markets for high quality textiles and clothing. According to the European Commission, the textile and clothing sector plays a crucial role on the economy and social well-being in numerous regions of the EU and based on the latest structural data available, in 2013, there were 185 000 companies in the industry employing 1.7 million people and generating a turnover of €166 billion. The textile and clothing sector accounts for 3% of total manufacturing value added in Europe.[[61]](#footnote-61)

The EU created the European Fashion Council in 2007, a representative, nongovernmental organization whose aim is to bring fashion into the EU agenda. The global economy and the globalization of so many fashion brands is viewed as a challenge for investigating new ways of trade and the development of different kinds of sustainable processes. The EU is offering financing to European research projects related to sustainability, and there are many proposals related to the fashion industry. All proposals related to the clothing industry are to be presented to the Fashion Council, who will then decide which ones should receive funding.

The proposals are related to:

* Water consumption
* Industrial water pollution
* Textile waste
* Use of pesticides and fertilizers
* Upcycling/recycling clothes
* Gender equality in the industry

**Characters**

**Sandra Noel, Vice President of the European Fashion Council**

The European Fashion Council is a non-governmental organization authorized to represent the European Union in fashion and fashion design worldwide. It is a union of 20 countries that are primarily located in Europe.

“New initiatives are needed to deal with the problems related to the ever growing global fashion industry. In the last decades, we have seen the appearance of fast fashion, more consumerism and throwaway lifestyles, more prevalent in richer countries. The clothing industry puts a big strain on natural resources and has a huge carbon footprint even before reaching the end user. This is because of the large amount of water, chemicals and energy used up in the manufacturing and transportation phases.”

**Laia Santiago, Saffo Spokesperson**

Saffo is a German multinational corporation, headquartered in Munich, that designs and manufactures shoes, clothing and accessories. It is the largest sportswear manufacturer in Europe, and the second biggest in the world. They are a good example of a company that dedicates a lot of resources to sustainability purposes, and are at the meeting to give advice.

“Sustainability forms the basis of all our decisions. You can see its presence in all our processes, inspired by our commitment to selling ethical, safe and community- and environmentally-friendly products.”

**Carol Drake – Water consumption project**

Carol Drake works for The Environmental Justice Foundation (EJF). The Environmental Justice Foundation is a UK-based non-profit organization working internationally to protect the environment and defend human rights. Carol Drake specializes in fresh water research, and the effect of agriculture on water resources.

“Over 53% of cotton fields in the world require water irrigation, and the majority of these are in regions where water is scarce. During the decades of 1960-2000, the Aral Sea lost approximately 70% of its water volume due to the process of diverting water so as to be able to grow cotton in the desert. We need to find a way to reduce water consumption. “

**Leonard Kanye - Dye technology project**

Leonard Kanyeis a chemist specialised in waterless dyeing techniques. He works for ColouredZen, a company that has created a treatment for cotton that makes the dyeing process more environmentally friendly.

“Approximately 17 to 20% of industrial water pollution comes from textile dyeing and treatment and an estimated 8,000 types of synthetic chemicals are used around the world (with the purpose of turning raw materials into textiles). A lot of these chemicals are then released into fresh water sources. The wet processing of clothing, such as wash­ing and dyeing, is also very water-intensive. It is essential to come up with new techniques for dyeing clothes that are more environmentally friendly. “

**Rick Blanco - Textile waste Project**

Rick Blanco is a professor in Textile Technology and an expert on sustainable processes for Textile Recycling at the Paris Sorbonne University. He is currently researching different methods for recycling textile waste.

“In the European Union it’s estimated that each person generates between 7 and 16 kilos of textile waste in a year. The average use of one garment is only 6 times. There is an obvious mismatch between the consumerism speeds, the usability rhythm, the production rhythm, the production of fabrics rhythm and above all, the natural growing rhythm of the resources. Much of the discarded clothing is made from plastic (such as polyester, nylon, spandex...). These plastic fibres can take up to 200 years to degrade and have an invisible, but deadly, effect on our oceans. We are trying to figure out ways of avoiding and/or dealing with all this waste. “

**Melody Miller – Organic Production project**

Melody Miller researches the use of pesticides and their effect on the environment and human health. She has done work for the WWF on the unsafe use of agricultural chemicals.

“22.5% of the world’s insecticides and 10% of all pesticides are used for the production of cotton, on 2.5% of agricultural land. A specific pesticide, which is used in West African cotton, causes brain and fetal damage, impotence and sterility. Something has to be done to improve this situation, as it is having a serious affect on the environment and the people who work in this part of the production chain. “

**Alejandro Cenzano - Awareness campaign**

Alejandro Cenzano has created the small scale campaign Love your Wardrobe, to make people more aware of the effect the textile industry has on the environment. The campaign centres on changing the way consumers buy and dispose of their clothing.

“Our campaign aims to improve the sustainability of clothing across its lifecycle, and we believe that the attitudes of end users are a major part of that. The most significant opportunity for reducing the environmental impact of clothing lies in increasing the active life of the clothes we wear.”

**Emilie Harrison, Fashion revolution project**

Emilie Harrison is an MS graduate in Development Studies, and she is working on a project called Fashion Strike which aims to help improve worker’s rights and conditions in the clothing industry, the work is especially centred on women.

“More than 70% of garment workers in China are women, in Bangladesh the number is 85%, and in Cambodia it is as high as 90%. For these women, development is closely linked to their conditions at work. The working conditions need to be improved.”

**Reflecting questions**

**Moderator questions during the debate:**

* + What are the possible risks posed by the fashion industry for the environment?
  + How is the fashion industry socially unsustainable?
  + Are these impacts taken into account?
  + How can this industry improve the environmental impact?
  + How can the industry improve its social impact?

**Moderator questions for the conclusions and closing of the activity**

* Should the need for a more sustainable fashion industry be considered a priority? Which are the main problems to be addressed?
* To what extent can this industry be regulated, and by whom?
* What is the current situation, in the EU and globally?

**Selected Articles to read:**

* Goworek, H*. Social and environmental sustainability in the clothing industry: a case study of a fair trade retailer*, SOCIAL RESPONSIBILITY JOURNAL VOL. 7 NO. 1 2011
* Niinimäki, K . *Ethical foundations in sustainable fashion* Textiles and Clothing Sustainability (2015) 1:3

**BIOMASS**

**Inspired by a case study from the UPC ERASMUS intensive programme in sustainable technology development:**

**The development of the Association of forestry owners (APF) of el Massís del Garraf for the energetic exploitation of forest biomass.**

**Scenario**

Biomass refers to the wood and other organic matter that is burned to obtain energy. Burning biomass releases carbon emissions, which are around a quarter higher than when burning coal. Even so, biomass has been classed as a "renewable" energy source in the EU and UN legal frameworks, because the plants that are used can be re-grown.

Due to scarce forest management in the last few decades in the Garraf region, and in a large part of Catalonia (Spain), a significant amount of biomass has accumulated in forests, increasing the forest surface area. This is a direct consequence of the poor economic profitability of forestry exploitation and of the reduced commercial interest in wood. The result is that the forests are under exploited.

This situation causes an increased risk of fires, more so for large forest fires, which have already strongly affected the Garraf region.

Biomass can be used directly via combustion to produce heat as an energy source, or indirectly after converting it to different forms of bio-fuel. Progress in the general thermal use of biomass is being halted by the lack of consumers in the area given that currently there is little demand. Using biomass as a fuel produces air pollution in the form of carbon monoxide, carbon dioxide, particulates and other pollutants at significant levels. These have been measured to be above those from coal or natural gas in some cases, traditional fuel sources.

On combustion, the carbon from biomass is released into the atmosphere as carbon dioxide (CO2).[[62]](#footnote-62) The amount of carbon stored in dry wood is approximately 50% by weight.[[63]](#footnote-63) However, according to the Food and Agriculture Organization of the United Nations, plant matter used as a fuel can be replaced by planting for new growth. If trees harvested as biomass are replanted as fast as the wood is burned, new trees take up the carbon produced by the combustion, the carbon cycle theoretically remains in balance, and no extra carbon is added to the atmospheric balance sheet—so biomass is considered “carbon neutral.”[[64]](#footnote-64) When the biomass is from forests, the time to recapture the carbon stored is generally longer, and the carbon storage capacity of the forest may be reduced overall if destructive forestry techniques are employed.

A group of land owners from the Garraf region is interested in creating an association, so as to promote collective biomass extraction. Before proceeding with the plan, they have organized a meeting with international experts on subjects related to the use of biomass as a fuel, due to controversial points of view on the subject.

**Characters:**

**Josep Pelach, Forest land owner/manager**

Josep Pelach owns a large piece of land with a large expanse of forest.

“Forests have been harvested for bioenergy long before it became a controversy, they benefit from thinning, and they are healthier because there is less competition for water and nutrients.”

**Don McKenna, Research ecologist –expert on Forest Fires**

Don McKenzie is a Research ecologist, specialized in Forest Fires and Forest Ecology. He works at the U.S. Forest Service, Pacific Northwest Research Station; and is a professor of environmental and forest sciences. His topics of expertise are: Forest ecology, fire ecology, landscape ecology and climate change.

“The combination of a warming climate, overcrowding and accumulation of dry forest residue contribute to the recent increase in forest fires. These fires release large amounts of carbon with no energy benefit whatsoever, at great costs and loss of property and lives. Carbon emissions from forest fires are estimated to range from 1-2 percent to roughly 25 percent of total emissions.”

**Evan DeLuca, Research ecologist – expert on Forest Ecology**

Evan DeLuca is a Professor of Biology at the University of Iowa; he served as the Head of the Department of Plant Biology. He was named Director for the new Institute for Sustainability, Energy and Environment in 2011.

“Forest biomass has enormous potential, if sources such as forests are managed properly, we don’t have the right technology yet – but we’re close.”

**Kevin Bind, Environmentalist - Centre for Biological Diversity**

**Kevin Bind is the Climate Legal Director and Senior Attorney of the Center for Biological Diversity and** works with the Climate Law Institute. He spent several years advocating for ancient forests and endangered species on California’s North Coast.

“We have some serious concerns about the use of this energy source. We’re putting excessive demands on the forest, with damage to wildlife habitat; with damage to water quality … we might also be making the climate problem worse in the name of making it better.”

**Antonio Farchione, FAO representative**

Antonio Farchione has a degree in Biological Sciences and a PhD in Plant Sciences. He has a background in Plant Ecophysiology, Forestry, and Carbon Cycle, particularly with regard to terrestrial ecosystems response to stress, including climate change.

“Biomass creates a carbon debt, it is far from being carbon neutral, both by removing trees that recycle CO2, and then burning (which releases CO2 stored in the biomass). When the biomass is from forests, the time to recapture the carbon stored is generally longer, and the carbon storage capacity of the forest may be reduced overall if destructive forestry techniques are employed.”

**Heather Young, Energy Bioscientist**

Heather Young is a scientist with the Energy Biosciences Institute at NYU. She is the Editor of the publication Bioenergy Connect and a former professor of plant and fungal biochemistry.

“It’s true that old biomass boilers are much less efficient than the current coal plants. The difference is that the carbon from fossil fuels adds to the atmospheric load. Biomass gives us a chance to recover energy from the natural carbon cycle, if we manage things well and keep the long-term life cycle in mind.”

### **David Grohl, WoodChem representative**

### David Grohl is the Vice President of TreeChem, a company that transforms biomass into ethanol, to be used as fuel. TreeChem’s technology is a sugar conversion via bacteria.

### “TreeChem uses a combination of enzymes and heat to break down the cellulose from trees grown on a nearby plantation as well as other plant waste. These sugars are then fermented in a process that releases no carbon dioxide. The company is currently building a new plant that will process 10 tons of biomass every day and produce 25 million gallons of ethanol every year.”

**Rose Water, Researcher on carbon footprint**

Rose Water is a Researcher specialized in the carbon footprint. She received the Executive Education Certificate in Conservation and Sustainability from the Earth Institute Center for Environmental Sustainability.

“Biomass can reduce carbon dioxide if fast growing crops are grown on unproductive land that is not being used; in this case, the re-growth of the plants offsets the carbon produced by the combustion of the crops. But cutting or clearing forests for energy, either to burn trees or to plant energy crops, releases carbon into the atmosphere that would have been sequestered had the trees remained untouched, and the re-growing and recapture of carbon can take decades or even a century. Moreover, carbon is emitted in the combustion process, resulting in a net increase of CO2.”

**Reflection questions**

**Moderator questions during the debate:**

* What are the benefits and risks of using Forestry Biomass as an energy source?
* What are the benefits and risks of using Forestry Biomass for the environment?
* What is the balance between these benefits and risks?
* Who should govern and regulate the use of Forestry Biomass as an energy source?
* To what extent is the use of Forestry Biomass a renewable energy? What are the arguments used for and against this statement?
* What are the possible alternatives to the use of Forestry Biomass as an energy source?
* Are the possible social and environmental impacts of the use of this energy source taken into account?

**Moderator questions for the conclusions and closing of the activity**

* Should Forestry Biomass be used as a renewable energy source?
* To what extent, and who by, should the use of this energy source be regulated?
* What is the current situation in the USA and Europe?

**Selected articles to read:**

* Horstman, J.*Turning to forests for energy*, Bioenergy Connection v 2.3
* de Jong J., Akselsson C., Egnell G, Löfgren S., Olsson B.A., *Realizing the energy potential of forest biomass in Sweden – How muchis environmentally sustainable?* Forest Ecology and Management 383 (2017) 3–16

**NANOTECHNOLOGY IN AGRICULTURE**

**Adapted from original author: Andrew Moore, Manager, EMBO Science & Society Programme: Trouble in Mawatubiki – Nanotech to the rescue of tropical island state?**

**Scenario**

As a result of climate change, in 2010 the tropical island state of Mawatubiki suffered a greater number and greater intensity of tropical storms than ever before in its recorded history. The agricultural economy depends on at least two annual harvests of the fast-growing bio-diesel producing variety of Tappi-tappi plant. Mawatubiki farmers have to deal with mountainous terrain, much of which is laid out as fragile terraces. Traditionally these are planted with a variety of crops, some of which are harvested only once a year. Twice-yearly harvesting of the shallow-rooted Tappi-tappi plants makes the soil especially vulnerable to erosion by heavy rain-fall. Much agricultural land was destroyed – literally washed down the hillside in tropical storms.

The Mawatubiki government called on international advisory agencies including the FAO (Food and Agriculture Organisation), but while the FAO was preparing a study of the situation, a US company "Agrosol" came forward with a possible solution. This involves a new, as yet untested, nanotechnology product that claims to be able to bind the surface of fragile soil into a semi-solid crust. SurfaceSave is a nanoparticulate combination of an organic moiety that binds to humus (decaying organic matter) and silicate particles in the soil. It thus forms an amorphous structure that is relatively water insoluble but easily broken up by physical means (such as ploughing or tilling the earth). Sprayed onto the surface of the soil as a mildly alkaline emulsion, SurfaceSave penetrates to a depth of only 1 cm, and upon moistening with rainwater catalytically binds the surface into a crust, hence reducing erosion. It has since emerged also that the Mawatubiki application of SurfaceSave might act as a pilot project for a larger scale use in California, USA, where hillsides are regularly made vulnerable to erosion as a result of deforestation by fires. Environmental protection agencies, notably NGOs Greenpeace and Friends of the Earth, have reacted with horror at the news of the experimental use of a nanotechnology product in Mawatubiki. Residents of California are also "concerned" to say the least, after hearing of the "secret" plan to use their neighbourhood as a beta-testing ground for the product. Mawatubiki farmers are desperate to save their land, and are keen to try any solution, but as the NGOs point out, a short-term gain could be accompanied by a long-term environmental disaster. The Mawatubiki government says it is prepared to discuss the "aid" from Agrosol, which would be provided free of charge according to a company spokesman.

Whatever the situation in Mawatubiki, a public challenge (mainly in the developed world) to the use of SurfaceSave, and even to nanotechnology itself, is growing. Basic researchers and technologists alike are becoming concerned at what this could mean for the public image and hence funding of their work at a time when it already arouses fear and mistrust. Indeed, Agrosol funds certain research projects that are ongoing at the University of California San Francisco – academic laboratories that rely on such funding to keep their heads above water.

**Characters:**

**Taika Waikiti, Minister for agriculture of the Mawatubiki government**

Taika Waikiti is a politician and minister for agriculture in Mawatubiki. He has studied agricultural engineering and has been minister for two legislatures.

“Agriculture is our economy on Mawatubiki's. If we do not act soon, we may not be able to grow anything, let alone Tappi-tappi. That said, we do not want to become slaves to western technology, and must try to find long-term solutions to the problem ourselves."

**Nicola Alvares, Friends of Earth representative**

Nicola Alvares is one of the Friends of Earth NGO representative. She is ecologist and has worked in the academia during 10 years, but after an exhausting career at university she has decided to affiliate to this NGO.

"If this is some kind of catalyst, that means that it can carry on reacting with the soil for as long as it survives, and we don't know how long that is, or where it might end up over that time span. We don't even know much about its toxicity to humans and other organisms, especially in the Mawatubiki ecosystem. This is yet another example of unnatural interference with the environment – we have to stop the cycle somewhere and say 'enough is enough'.”

**Dr. Franz Knausider, Chief Scientific Officer of Agrosol**

Dr. Franz Knausider is a chemist and the current Chief Scientific officer of Agrosol. He has worked as a group leader at University of California, Berkeley for twenty years. He started his current job five years ago. He is the responsible of devising Agrosol research proposals and programmes.

“We have done trials in our lab installations and Surfacesave has passed all the controls and safety requirements. Of course, this collaboration is beneficial for our enterprise, but we think that our product will help Mawatubiki’s farmers. This project is not just for making money, there is solid and rigorous science behind it.”

**Shivendu Ranjan, Eminent independent scientist**

Shivendu Ranjan is an academic professor working in the Biomedical Sciences Department at Harvard University. She has been doing research in nanoscience for eight years and has given more than fifty conferences about nanoscience controversies.

“In my opinion, and taking into account my expertise in the nanoscience field, I can assure that Surfacesave is an incredible product with a great potential. I cannot regret anything from the inside-lab process. However, this product has never been tried at large scale and ecologic effects are unknown and could be, in the worst case, devastating for the Mawatubiki inhabitants.”

**Miranda Velasco, FAO representative**

Miranda Velasco is the FAO representative and she is working with agricultural aid. She has been involved in the Mawatubiki situation since the beginning and she has organised the debate to reach a solution to Mawatubikis’ farmers.

“I’m not sure if this product is the safer solution to Mawatubiki’s inhabitants. It seems a revolutionary product that could solve their situation, but I’m afraid of the potential risks of this technology. Maybe we should look for an alternative”

**Other characters that can be included in this Role-play: critical journalists from different newspapers, like e.g. The Mawatubiki Evening Standard, The Economist, Christian Science Monitor, The Sun, Der Spiegel, Farmers International Herald, The Proletarian, Voice of the Third World, etc.**

**Reflection questions**

**Moderator questions during the debate:**

* Which are the benefits and risks of using Surfacesave?
* To what extent is there agreement on the general balance between risk avoidance and innovation/research support?
* Which impacts can be anticipated of using Surfacesave?
* Surfacesave implementation will be provided for free. What do you think about this kind of agreement? Is it transparent?
* The press has published Mawatubiki’s case. Is it beneficial that the debate has reached the general public and the entire population?
* Are there any alternatives to Surfacesave technology?

**Moderator questions for the conclusions and closing of the activity**

* -Does the implementation of Surfacesave have to be allowed?
* Do the technology alternatives to Surfacesave reach a better situation?
* Have all the relevant stakeholders been involved in the decision-making process? Why?

**Selected articles to read:**

* Fraceto L.F., Grillo R., deMedeiro G.A., Scognamiglio V., Rea G. and Bartolucci C. *Nanotechnology in Agriculture: Which Innovation Potential Does It Have?**Front. Environ. Sci. 4:20. doi: 10.3389/fenvs.2016.00020*
* Parisi C., Vigani M., Rodríguez-Cerezo E., Agricultural *Nanotechnologies: What are the current possibilities?,* Nano Today(2015) 10, 124—127

**DECEPTION**

**Adapted from the book: Essentials of Research Methods in Psychology by**[**John J. Shaughnessy**](https://www.thriftbooks.com/a/john-j-shaughnessy/216307/)**,**[**Jeanne S. Zechmeister**](https://www.thriftbooks.com/a/jeanne-s-zechmeister/216306/)**,**[**Eugene B. Zechmeister**](https://www.thriftbooks.com/a/eugene-b-zechmeister/216308/)**, McGraw-Hill Education, 9th edition, 2012**

**Scenario**

A meeting of the Institutional review board has been called, to discuss a research proposal that has been submitted to review. Once the summary of this proposal has been analysed, the members of the committee respond to each of the five steps for ethical decision making:

**1.** Find out all the facts of the situation.

**2.** Identify ethical issues that are relevant.

**3.** Decide what is at stake for all parties involved (participants, researchers, institutions, society).

**4.** Identify alternative methods or procedures, discussing the consequences of each alternative, including their ethical implications.

**5.** Decide on the action to be taken (approve the proposal, request modifications, or fail to approve the proposal).

Research proposal: The research is on the topic of psychological conformity. Psychological conformity is the tendency to modify your attitude, beliefs or behaviour according to the people that surround you. People accept the opinions of others without there being significant reasons to do so, or even in the face of evidence to the contrary. Research has shown that the conformity is more likely to occur when it the situation involves anticipation of unpleasant events. Also, there are more chances of there being conformity when the pressure comes from individuals with whom the subject can easily identify.

**Method**

The research project will involve 60 students, from the ages of 16 to 20. These students are volunteers who have signed up to participate in a research project that is investigating “attitudes of today’s teenagers”.

These students will be assigned to different discussion groups. There will be four people in each discussion group. They will be given a set of 20 questions to answer, and they will be instructed to discuss each question with their group before writing down the answer.

Among these questions, a section will be related to the consumption of alcohol in teenagers. Some of the questions will be about prevention methods and how to avoid teenage drinking and driving. In each group, there will be a debate moderator, appointed by the investigator, to guide the discussion.

Unknown to the students, some of the participants in the discussions are not volunteers. These participants are working for the investigators; they will be referred to as confederates. Thus, the students will be randomly assigned to different groups:

* groups with zero confederates
* groups with one confederate
* groups with two confederates

These confederates have previously received instructions on what to say and how to act during the debate on the questions related to alcohol consumption. They have been provided with a script to follow.

This script revolves around the argument that people who are of a legal driving age (16 or 18), and also people who are old enough to vote (18) should be considered old enough to make their own decisions when it comes to drinking. Also, they should say that it is up to each individual to decide if they want to drink or not, and therefore it is not fair to intervene if a person under the legal drinking age decides to consume alcohol. The confederates should also admit to drinking alcohol at least three times, one of them recently.

In this manner, depending on the number of confederates in the group, the experimental manipulation involves either zero, one or two people declaring that they don’t think students should be responsible for avoiding situations in which alcohol is available to minors or even to intervene when a fellow student makes the decision to drive after having consumed alcohol.

The evaluation of the experiment will be assessed by analysing the written answers given by the volunteers. At the same time, these group discussions will be recorded without the knowledge of the participants, and also analysed.

Once the experiment has been concluded the investigators will disclose the nature of the deception and the reasons for the tape recordings to all those involved in the research.

**Characters**

The characters in this role-play exercise are all members of an Institutional Review Board. The committee includes:

**Ralph Dorne, a clinical psychologist**

Ralph is a senior clinical psychologist who works for the NHS in London

“Deception is a necessary evil, often required to provide the necessary ‘technical illusions’ and increase the impact of a laboratory or field setting, such that the experimental situation becomes more realistic and reduces the effects of participants’ motives and role-playing behavior.”

**Alexandra Boss, a social psychologist**

Alexandra is a researcher at the University of New South Wales in the social psychology of deception.

“Deception is not a problem in itself as long as it is not malicious, as long as people have a reasonable expectation that it might occur, and the opportunity to avoid it if they choose.”

**Paula Hall, social worker**

Paula is a social worker who works with struggling teenagers

“The issue critical to the deception research concerns informed consent because, by definition, participants cannot consent to something that they do not know.”

**Maria Sanchez, philosopher**

Maria is a professor at Oxford University, specialized on the topic of Lying and Deception

“Any deception in research is inappropriate and takes advantage of the implicit trust and obedience given by the participants to the researcher. When the participant volunteers to participate, their dignity must be preserved and should not be taken for granted. Deception can strongly affect the reputation of the individual laboratories and the scientific profession, thus contaminating the pool of participants.”

**Martin Hammer, protestant minister**

Martin works for the Christian Research Institute, and is especially interested in the topic of Psychology and the Church.

“The use of deception includes actual threat to the dignity, privacy, and self-determination of participants, but may also include potential bodily or economic harm.”

**Dominic De Bois, history professor**

Dominic also works at Oxford University, and is a professor in the history of psychology

“There is something deeply problematic about employing deception in the search for truth. Yet deception has played a prominent -- and many would say integral -- role is psychological research for well over a century. Over the first two-thirds of the 20th century, deception became a staple of psychological research.”

**Bella Neill, respected business executive**

Bella is an expert in the field of marketing and business psychology

“In order to acquire reliable and unbiased research results, especially in psychological experiments, the less that the subject knows, the better.”

**Reflecting questions**

**Moderator questions during the debate:**

* Why is deception used in psychology?
* What are the possible risks of using deception in a psychological experiment?
* Are there alternatives to the use of deception?

**Articles to read:**

* Won Oak Kim, Institutional review board (IRB) and ethical issues in clinical Research, Korean J Anesthesiol 2012 January 62(1): 3-12<http://dx.doi.org/10.4097/kjae.2012.62.1.3>
* Chapter 3. Ethical Issues in the Conduct of Psychological Research, Research Methods in Psychology by [John J. Shaughnessy](https://www.thriftbooks.com/a/john-j-shaughnessy/216307/), [Jeanne S. Zechmeister](https://www.thriftbooks.com/a/jeanne-s-zechmeister/216306/), [Eugene B. Zechmeister](https://www.thriftbooks.com/a/eugene-b-zechmeister/216308/), McGraw-Hill Education, 9th edition, 2012
* Ethical Principles of Psychologists and Code of Conduct, American Psychology Association: <http://www.apa.org/ethics/code/index.aspx>
* Boynton MH, Portnoy DB, Johnson BT, Exploring the Ethics and Psychological Impact of Deception in Psychological Research, IRB. 2013 Mar-Apr; 35(2): 7–13.
* Ortmann A, Hertwig R, Deception in Social Psychological Experiments: Two Misconceptions and a Research Agenda,*Social Psychology Quarterly* 2008, Vol. 71, No. 3, 222–227

**ANNEX 5. HEIRRI CASES**

**TABLE OF CONTENT**

* INTRODUTION TO RRI CASES
* GENDER EQUALITY
  + HOUSING AND NEIGHBOURHOOD DESIGNS
  + HIV MICROBICIDES
  + MALVECBLOK
  + *CASAS MATERNAS*
* SUSTAINABILITY
  + IMRR
  + KLIMA ALLTAG
  + PIER
  + MOSQUITO ALERT
  + MARLISCO
* ETHICS
  + TRREE PROJECT: ADOLESCENTS IN HIV RESEARCH
  + PPI PARKINSON’S
  + THE BUCHU PLANT
  + UCL CHANGEMAKERS
* INCLUSIVE SCIENCE
  + AMBIACT
  + DNA LABS
  + IMRR
  + KLIMA ALLTAG
  + PIER
  + MOSQUITO ALERT
  + MARLISCO
  + PPI PARKINSON’S
  + SUSTAINABILITY IN PRISONS
  + CROSSCULT

**INTRODUCTION TO RRI CASES**

The cases proposed below are used in different Higher Education programmes. These case examples can be useful to promote a reflection on responsibility in R&I issues related to: Gender, Sustainability, Ethics and Inclusive Science. Some of these cases can be used for different aspects (see the previous list). The HEIRRI project has identified and defined these different aspects (Gender, Sustainability, Ethics, Inclusive Science) from the 6 key issues proposed by European Commission just for methodological and pedagogical purposes.

The cases consist of:

-A brief description of the case

-The bibliography of the case

-The learning objectives of the case

-The reflection questions of the case

**How can these cases be used in class?**

To start the activity, the teacher will give the students/participants the brief description of the case. If the teacher considers that the students need more information to generate a good debate/discussion, each case is provided with useful links and bibliography to add more information.

The instructor will have also the learning objectives, what the students/participants are expected to learn during the activity, and some reflection questions. After the students/participants have read the description of the case, the teacher can use the reflection questions that we propose here to generate a robust discussion. These reflection questions are specific for each case and for each issue (Gender, Sustainability, Ethics and Inclusive Science). Furthermore, with the reflecting questions posed by the teacher, the students can analyse the controversies of each aspect to construct a deeper discussion and consolidate knowledge on each one. The instructor can also add more reflection questions if needed or to enrich the debate.

After the discussion, the teacher can end the activity with the conclusions formulated by all the students’ contributions.

**GENDER EQUALITY**

**“Housing and Neighbourhood design: analysing gender”**

*RRI Key issues: gender*

The website Gendered Innovations presents a case study called “Housing and Neighbourhood design: analysing gender”[[65]](#footnote-65) with the aim of providing an example of how urban design may incorporate a gender perspective.

In the website, it is said that “gender roles and divisions of labour result in different needs with respect to built environments”, which sometimes reinforce gender roles or can’t provide equal services to women and men[[66]](#footnote-66). These differences can be visible at many levels, from single buildings to whole neighbourhoods, cities or even regions, and can also be seen within cities through its means of transport, public facilities, housing, open spaces, and so on. This case in Gendered Innovations states that “urban design typically lacked a gender perspective, and was ‘blind’ to differences between groups”. It should be taken into account that the entity UN Women[[67]](#footnote-67) states that, around the world, women carry out at least two and a half times more unpaid household and care work than men[[68]](#footnote-68).

In Vienna, Gendered Innovation writes, the gender analysis integrated in its urban planning has contributed to the city’s quality of life, and as an example of this planning, the project “Frauen-Werk-Stadt I” is described. This initiative designed a whole area of the city[[69]](#footnote-69) that didn’t separate housing from commercial spaces, nor from childcare facilities, medical centres or police stations. This way, according to Gendered Innovations, overall car use was reduced, as well as the stress experienced by those people combining career and house/family care, since “Frauen-Werk-Stadt I” was designed in a way where daily needs could be met within the vicinity of the apartments.

**Learning objectives**

* To identify the gender issues involved in this project
* To describe which gender policies should be implemented: equal opportunities for women and men in this research
* To discuss which gender issues should be taken into account in the research content
* To analyse how the gender issues have been addressed and which stakeholders have been involved in the process

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* Does the case presented reflect on gender roles and tasks typically attributed to men/women?
* Do you think this case presents gender equality in a simplistic way? How could it be improved?
* Can you think of arguments against gender equality in urban planning? Could it reinforce gender stereotypes? Could it neglect other collectives?
* Do you think the urban planners did a public consultation, or rather they based their designs on stereotypes and preconceptions?
* Does this case include enough different perspectives? How could they be complemented or improved?

**“HIV MICROBICIDES: Rethinking Research Priorities and Outcomes”**

*RRI Key issues: gender*

As stated in the Gendered Innovations site of the case on “*HIV microbicides: Rethinking Research Priorities and Outcomes*”[[70]](#footnote-70), in the last years, both the European Union and the U.S. have invested to increase the number of women scientists and engineers[[71]](#footnote-71),[[72]](#footnote-72). However, from Gendered Innovations it is considered that women's participation is low in the STEM fields (i.e., science, technology, engineering, and mathematics), and they conclude that “increasing the number of women requires more than programmes focused on removing subtle gender bias from hiring and promotion practices, stopping tenure clocks, leadership training, and the like; such interventions are necessary but not sufficient”. They also state that, in order to increase the numbers of women in STEM fields, research should be re-conceptualised so that it includes “methods of sex and gender analysis in creative and forward-looking ways”. They say that since the image of engineers and the offering of engineering education “focus narrowly on mathematics and science”, many girls and young women “are dissuades from pursuing engineering careers“[[73]](#footnote-73), and argue that engineering would be more appealing to women “if engineering images and education fore-grounded the social aspects of engineering alongside the technical.[[74]](#footnote-74),[[75]](#footnote-75) "

To prove this point, Gendered Innovations mentions the case of a mechanical engineering lab at the University of California that shifted its research focus from applied physics to biomedical engineering and changed its research goals from “understanding the physics of a problem to developing models that could be used to evaluate devices or treatments for medical conditions”. Over the period of a decade, the lab researchers were a majority of women.

**Context** **information**

More than 36 million people worldwide live with HIV[[76]](#footnote-76). Gendered Innovations writes that most of the infections and related deaths happen in sub-Saharan Africa, where the prevalence of HIV infection among women aged 15-24 is about 8 times higher than that of men of the same age-group.[[77]](#footnote-77) The only woman-controlled HIV prevention option, the site states, is the female condom; however, it is detectable, requires partner consent, and is less available and more expensive than the male version.[[78]](#footnote-78)

According to Gendered Innovations, the lab from the University of California was able to develop a woman-controlled HIV protection because they understood in this context why HIV has a higher incidence in them. The result of the research is a vaginal gel that provides an HIV microbicide.

As a conclusion, the site writes that research priorities “have a profound effect on who will perform research”, as exemplified with the case of HIV microbicides at the mechanical engineering lab from the University of California: in that instance, “research priorities related to improving women's and men's health increased the representation of women in the lab”. The Gendered Innovations site concludes that “it is possible that changing research priorities in engineering could increase the representation of women in the field overall”.

**Learning objectives**

* To identify the gender issues involved in this project
* To describe which gender policies should be implemented: equal opportunities for women and men in this research
* To discuss which gender issues should be taken into account in the research content
* To analyse why the gender balance changed and what effect it had on the project

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* Does this case reflect on gender roles and stereotypes?
* Does this case present gender equality in a biased way?
* Can you think of arguments against gender equality in research? Could there be problems related to imposed quotas or to positive discrimination (aka affirmative action)?
* What ethical problems could arise from the research presented?
* Are there other ways of increasing the number of women in engineering? Are these ways based on gender stereotypes?
* Does this case include enough different perspectives? How could they be complemented or improved?

**“MALVECBLOK Project”**

*RRI Key issues: gender*

As the World Health Organisation (WHO) reports, there were 212 million malaria cases worldwide in 2015, most of which occurred in the WHO African Region (90%)[[79]](#footnote-79),[[80]](#footnote-80). Malaria is caused by the parasite Plasmodium and is transmitted to humans by the mosquito *Anopheles gambiae* s.s. The strategies currently used to control mosquito populations are insecticides and mosquito nets, but the appearance of resistance and the lack of new insecticides hold up its control[[81]](#footnote-81).

The European project MALVECBLOK[[82]](#footnote-82), composed of three European countries and two African teams, wanted to get an integrated view of mosquito immunity and reproduction and to establish the mosquito interaction with the parasite in order to provide a new vision for malaria control.

The project aimed to consider, when studying the reproduction of the malaria mosquitos, the different gender roles in society (for example, that men and women interact differently with water, where the mosquito reproduces). These differences can be relevant because vulnerability to the disease and access to treatment tend to vary between men and women. According to the “Gender and Health” report (Module 2, Field 1) of the “Gender in EU funded research” website[[83]](#footnote-83), “a careful gendered analysis of how the outcomes can be used to actually improve disease control will be necessary. The success of any disease control programme depends on a gender-sensitive approach”.

**Learning objectives**

* To identify the gender issues involved in this project.
* To describe which gender policies should be implemented: equal opportunities for women and men in this research.
* To discuss which gender issues should be taken into account in the research content.

**Reflection questions**

* Do you think the case presented is a good example of responsible research? Why?
* Does this case reflect on gender stereotypes and roles?
* Can you think of arguments against including a gender perspective in research? Is it necessary for all sorts of research projects?
* Could including a gender perspective in research favour bias in its findings?
* How is gender portrayed in the research project presented? Which cultural and social issues are involved in it?

***Casas Maternas* in the Rural Highlands of Guatemala: A Mixed-Methods Case Study of the Introduction and Utilization of Birthing Facilities by an Indigenous Population**

*RRI Key issues: sustainability, inclusive science and gender*

In Guatemala, the NGO “Curamericas” established birthing facilities (or “*casas maternas*”) in an isolated region of the country with the aim to help reduce the high maternal mortality rate of indigenous women living there, who traditionally gave birth at home. This was achieved by providing “local access to community-based, culturally appropriate maternal services for routine deliveries”, according to the website of the [Communication Initiative Network](http://www.comminit.com/global/content/casas-maternas-rural-highlands-guatemala-mixed-methods-case-study-introduction-and-utili).

This website explains that the maternal mortality rate in Guatemala for indigenous women is twice as high as non-indigenous women. These days, after the construction of birthing facilities, “birth attendants are encouraged to bring patients for delivery at *Casas Maternas*, where trained staff are present and access to referral care is facilitated”. A study was conducted with 275 women surveyed and, together with *casas maternas*, volunteers visited homes to encourage the use of the facilities. The website says that various actors were identified as stakeholders, including the women delivering, midwifes and partners.

The [article](http://www.ghspjournal.org/content/ghsp/4/1/114.full.pdf) published in “Global Health: Science and Practice” states that Curamerica’s initiative strengthens maternity care and “has potential to increase health facility utilization in isolated mountainous areas inhabited by an indigenous population where access to government services is limited and where maternal mortality is high”.

According to the [World Health Organisation](http://www.who.int/mediacentre/factsheets/fs348/en/), “maternal mortality is higher in women living in rural areas and among poorer communities”. “Skilled care before, during and after childbirth can save the lives of women and new-born babies”.

**Bibliography:**

* <http://www.ghspjournal.org/content/4/1/114.full>
* <http://www.comminit.com/global/content/casas-maternas-rural-highlands-guatemala-mixed-methods-case-study-introduction-and-utili>
* <http://curamericasguatemala.blogspot.com.au/>
* <http://www.who.int/mediacentre/factsheets/fs348/en/>

**Learning objectives**

* To identify the stakeholders involved and assess the benefits of their inclusion.
* To reflect on the role of inclusion of marginalized communities and its possible impacts.
* To discuss the methods used to involve society in this kind of projects.

**Reflection questions**

* How do you think community engagement impacts a society?
* What are the possible social impacts of this project? And in the demography?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* Do you think this project is “responsible”? In what way?
* What is the role of stakeholder engagement? How does it contribute to this project?

**SUSTAINABILITY**

**IMRR – “Integrated and sustainable water management of Red-Thai Binh Rivers System in changing climate”**

*RRI Key issues: sustainability and inclusive science*

The Red-Thai Binh Rivers basin is the largest in Vietnam, supplying for a total population of 26 million people[[84]](#footnote-84). This region is growing economically and in population numbers very fast. In this context, and with the aim to develop “strategies for the sustainable management of the Red-Thai Binh rivers system”, the IMRR project[[85]](#footnote-85),[[86]](#footnote-86) has been launched. This project intends to meet “Vietnamese society's long-term needs for water resources while maintaining essential ecological services and improving the economic benefits from hydropower production and agriculture”, so the initiative claims to “combine coordinated decision-making and stakeholder participation, supported by advanced modelling and optimization tools, and capacity building in local institutions”85.

Previously, according to the project’s information, there had been water shortages (and many problems derived from it) due to the “lack of coordination and inefficient operation of the reservoirs” 85. That is why the IMRR states that it wants to promote a participatory approach to include relevant stakeholders from different fields and ensure that Vietnamese institutions are given the tools and capacities to manage the Red River basin.

The IMRR project is funded by the Italian Ministry of Foreign Affairs (cooperation program).

**Learning objectives**

* To identify the stakeholders involved in the project
* To discuss the outcomes and possible use of the project for stakeholders
* To analyse the methodology used to obtain the results
* To understand the importance of public engagement in science and innovation practices
* To assess the sustainability of the project and possible environmental impacts

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* Do you think that the data presented by the IMRR project could be biased?
* What is the role and possible importance of public engagement? How did public engagement contribute to this project? Can you think of negative environmental impacts of this project? And political impacts?
* Why do you think the Italian government funds such a project applied in Vietnam? Could this have negative impacts for the Vietnamese authority?

**The “KlimaAlltag” project**

*RRI Key issues: sustainability and inclusive science*

According to the “KlimaAlltag” project[[87]](#footnote-87), organised by the Institute for Social-Ecological Research (ISOE) in Frankfurt am Main, CO2 emissions come substantially from daily requirements of private households, these being the third source of CO2 (15%) only after the energy industry (25%) and transports (23%), and followed closely by the food industry (14%)[[88]](#footnote-88).

On this line, researchers from the “KlimaAlltag” project studied from 2010 to 2013 how daily behaviours varied in different social strata and tried to promote lifestyles and choices more environmentally sensitive. “KlimaAlltag” main focuses were on “mobility, nutrition, home living and household energy consumption”[[89]](#footnote-89).

The “KlimaAlltag” research did field tests and empirical surveys to households’ members, who also received climate-consultant advice for the following half year. According to the project leader, Immanuel Stieß, “more than half of those surveyed were basically ready to make changes in their behaviour”, and he adds that actions like “choosing green energy, buying seasonal and regional food, and using buses and trains more often” could decrease CO2 emissions by 10-15%.

“KlimaAlltag” explains in its leaflet[[90]](#footnote-90) that “the course and results of the field study were carried out and evaluated under scientific supervision”, and that they checked whether municipal climate protection measure would be possible and effective through a survey of 1000 people.

**Learning objectives**

* To identify the stakeholders involved in the project at all levels
* To understand the importance of public engagement in science and innovation practices
* To discuss the reason and methods used to involve society in this kind of projects
* To discuss the initial objectives and effectiveness of this program
* To assess the sustainability of the project and possible environmental impacts

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* Do you think that the data presented by the “KlimaAlltag” organisers could be biased?
* Is the data presented applicable only in Europe or is a trend around the world?
* What is the role and possible importance of public engagement? How did public engagement contribute to this project?
* What stakeholders were involved in the research? Why have they been selected?
* Can you think of possible negative environmental impacts of this project? Have they been taken into consideration?
* How could the inclusion of more perspectives improve the overall project?

**The PIER project: “Public Involvement with Exhibition on Responsible Research and Innovation”**

*RRI Key issues: sustainability and inclusive science*

The PIER project[[91]](#footnote-91) was a European project of the 7th Framework Programme, which, according to the CORDIS website[[92]](#footnote-92), aimed to engage the public in Responsible Research and Innovation in society. As it is said in their report, the project developed an exhibition on the topic of Marine Research in the Mediterranean Sea. The exhibition was designed through several participatory activities to involve stakeholders, researchers, politicians, and the wider public. The PIER project wanted to enhance the importance of responsibility in research and to highlight the implications research can have on local development and on the quality of life of the citizens.91

As is described in their report, the involvement of the public and the experts started in the early stages of the project, with the realisation of workshops and focus groups. Citizen participation helped researchers decide the main topics of the exhibition, which were: fishery and aquaculture, biodiversity, energy from the sea, preventing disasters, new materials from the sea and safe maritime transportations.

The report mentions that the public was involved in questions related to responsible aspects of the Marine research: “how much personal behaviours can affect marine ecosystems, in terms of food selection, of waste disposal, on tourism activities, but also what people can do to improve the health of the Ocean, how people can have their say on research and policies related to the seas, how personal engagement can be strengthened, and how to get access to reliable scientific information and facts.”92

The project developed an exhibition with a participatory programme to engage the larger public in their achievements, for which it included different communication and participation channels like hands-on exhibits, prototypes, videos and multimedia products.

**Learning objectives**

* To understand the role of public engagement in science and innovation practices.
* To reflect on the role of science education in society and its possible impacts.
* To discuss the methods used to involve society in this kind of projects.
* To assess the possible environmental impacts of the project.

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* What is the role and possible importance of public engagement? How does public engagement contribute to this project?
* What is the role and possible importance of science education in this project?
* How can you promote reflection on R&I and its impacts in science education projects?
* Can you think of arguments against public engagement in science? What about science education?
* How can you promote reflection on R&I in the exhibition?
* What are the possible environmental impacts of this project?

**“MOSQUITO ALERT”**

*RRI Key issues: sustainability and inclusive science*

According to the European Centre for Disease Prevention and Control[[93]](#footnote-93), the tiger mosquito (Aedes albopictus) is an **invasive species and a** vector of diseases originating in Southeast Asia. Its habitat is mainly in urban areas where it breeds in small vessels or containers of stagnant water. According to the Mosquito Alert website[[94]](#footnote-94), this mosquito was detected in Spain for the first time in 2004, near Barcelona, and now it is present all around the Mediterranean coast.

The **Yellow fever mosquito** (Aedes aegypti) is a species of African origin found in Africa and tropical and subtropical countries, and it is also a vector of diseases. This mosquito has also adapted to urban areas, but currently there are no populations of Aedes aegyptiin Spain. However, as it is stated in the Mosquito Alert website, the increase of the global mean temperature could favour the eventual appearance of this mosquito in Spain.

The diseases transmitted by these mosquitoes are caused by viruses (like the Dengue virus, the Chikungunya virus or the Zika virus) and can result in fever and joint and muscle pain, among other symptoms, and can lead to hospitalization[[95]](#footnote-95).

The Mosquito Alert project wants to fight the invasive species of the tiger mosquito and the yellow fever mosquito. The project claims that: “To prevent transmission of these diseases it is crucial to control the presence of these species, minimize them in areas where they reside and control its expansion. To do this, the cooperation of citizens, along with the work of scientists, governments and managers of vectors and vector-borne diseases is essential.”93

Mosquito Alert describes itself as a **citizen science platform** that aims to unite citizens, **scientists**and**managers** in the fight against mosquito-borne diseases. “With the Mosquito Alert app anyone can report a possible finding of a tiger mosquito and its breeding sites by sending a photo. A team of experts is in charge of reviewing and classifying the photos before making them public on a map. With this information, scientists are studying the distribution of these mosquitoes.”

**Learning objectives**

* The students should be able to:
* Understand the role of public engagement in science and innovation practices
* Analyse the methodology used to involve society and obtain the results
* Discuss the outcomes and possible use for stakeholders
* Identify the potential future impacts, social and environmental, of the project

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* What is the role and possible importance of public engagement? How does public engagement contribute to this project?
* What is the role and possible importance of citizen science?
* Can you think of arguments against public engagement in science? Could there be problems related to the development of the project and results?
* Is there a wide range of stakeholders involved? How does this affect the project?
* What are the possible social and environmental impacts of the Mosquito Alert project?
* Do you think it’s positive to involve citizens in mosquito detection? What are the possible outcomes of these involvement?

**“The MARLISCO project”**

*RRI Key issues: sustainability and inclusive science*

**The MARLISCO project (from “MARine LItter in European Seas: Social AwarenesS and CO-Responsibility”)**[[96]](#footnote-96)**, is a European initiative of the Seventh Framework Programme that went from June 2012 to the end of May 2015. In its website**[[97]](#footnote-97) **it is said that the project’s objective was to “raise public awareness, facilitate dialogue and promote co-responsibility among the different actors towards a joint vision for the sustainable management of marine litter across all European seas”.**

**The project’s context was, according to their website, that marine litter was an emerging thread to the environment and human health, a problem that has arisen from our** production systems, consumption patterns, and waste management.

MARLISCO’s website97,[[98]](#footnote-98) states that it wanted to raise awareness about social behaviours and their consequences, to promote co-responsibility among relevant stakeholders, and to achieve collective solutions for the litter impact, among other goals. MARLISCO’s activities took place in the four European seas (North-East Atlantic, Baltic, Mediterranean and Black Sea), and included **a “study**of the sources and trends regarding marine litter in each regional sea”, a best-practices collection from consortium countries, an attitude survey of different actors about marine litter, a European video contest, national debates and tailor-made activities in each partner country.

**Learning objectives**

* To identify the stakeholders involved in the project at all levels
* To understand the importance of public engagement in science and innovation practices
* To discuss the methods used to involve society in this kind of projects
* To analyse the initial objectives and effectiveness of this program
* To assess the sustainability of the project and possible environmental impacts

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* Do you think that the data presented at the MARLISCO website could be biased?
* Do you think this project could be applied to the rest of the world, or is it only relatable to the production, consumption and waste-management patterns of Europe?
* What is the role and possible importance of public engagement? How did public engagement contribute to this project?
* What is the role and possible importance of science education? Is this project a good example?
* What are the stakeholders involved in MARLISCO? Why have they been selected?
* What are the possible environmental impacts? Can you think of possible negative impacts?
* Can you think of ways of improving the project by including more perspectives? Which ones?
* Can you think of ways the MARLISCO project promotes reflection on the impacts (ethical, legal, environmental, social) of marine litter?

**ETHICS**

**“Adolescents in HIV research”**

*RRI Key issues: ethics*

According to the TRREE project[[99]](#footnote-99), HIV is still a huge burden of disease in many settings. Optimal HIV prevention will possibly require a combination of interventions which should be tailored to specific sub-groups.[[100]](#footnote-100) At the moment, there is considerable prevention research agenda and HIV prevention trials are being conducted worldwide.[[101]](#footnote-101)

Up until now, the majority of HIV prevention trials have involved adult participants. Adolescents around the world are considered to be the epicentre of the epidemic, or close to.101 They demonstrate a range of behaviours that increase their risk of acquiring an HIV infection, for example an early sexual debut, overlapping sexual partnerships and inconsistent condom use.4  Because of this high risk, adolescents are one the principal populations for intervening to reduce risk of HIV acquisition.[[102]](#footnote-102) This means that they are important targets for up and coming biomedical approaches for HIV prevention.103 The TRREE project states that “It is imperative that adolescents are able to access safe and effective interventions to address their pressing health problems, including risk of HIV acquisition.”

According to Rudy et al100, changes that occur during adolescence can make it difficult to extrapolate data obtained in adult trials. In this manner, adolescents should be involved in trials to collect specific data about this group and to improve understanding of adolescent responses to biomedical prevention technologies. Some characteristics of adolescence, such as poorer impulse control, can make their participation in trials complicated, especially when it comes to issues such as retention and reporting all of which can impact on the scientific validity of trial results. 100,[[103]](#footnote-103)

The challenge of adolescent populations is to ensure they are adequately represented and protected. Adolescent involvement in research trials for HIV prevention therefore requires attention to ethical challenges so adolescent trials meet high-level legal and ethical standards.

**Learning objectives**

* To discuss the ethical guidelines that should govern such trials
* To assess who should be involved in the design and outcomes of these trials
* To reflect on the ethics of involving adolescents in clinical trials and the possible risks involved, and how they should be prevented

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* Which cultural and social issues are involved in the execution of this project involving adolescents in HIV research?
* What ethical impacts should be anticipated in involving adolescents in clinical trials?
* What is the role of ethics in this project?
* Are there potentially harmful impacts of the project? How can they be prevented?

**“PPI PARKINSON’S”**

*RRI Key issues: ethics and inclusive science*

Parkinson's disease (PD) is a chronic and progressive movement disorder, meaning that symptoms continue and worsen over time. The cause is unknown, and although there is presently no cure, there are treatment options such as medication and surgery to manage its symptoms. As the World Health Organisation (WHO) states, about 1 in 500 people suffer from Parkinson's disease[[104]](#footnote-104), which means there are an estimated 127,000 people in the UK with the condition. Most people with Parkinson's start to develop symptoms when they're over 50, although around 1 in 20 people with the condition first experience symptoms when they're under 40.104

Parkinson’s UK is a charity that aims to contribute to better care, treatments and quality of life for people with Parkinson’s disease. They want to fund research that is relevant and beneficial to people affected by the condition. Therefore, they encourage researchers to work with patients and carers in designing, delivering and sharing their research. In this exercise, we will discuss some of the activity of this charity as a possible example of a good RRI practice. Specifically, we are interested in a pilot project run by Parkinson’s UK to facilitate involvement.[[105]](#footnote-105)

The main idea of the pilot project was the following: They sent an email to current grant-holders and co-applicants with an invitation to take part in the pilot, as well as advertising it in the Parkinson’s UK researcher e-newsletter. Eight research teams came forward, including a wide range of research projects and researchers. Fifty-two people affected by Parkinson’s were involved at five locations across the UK. These volunteers met with one or two researchers from one of the pilot projects. This allowed the researchers and volunteers to ask each other questions. The researchers were then encouraged to follow-up with the volunteers to seek further input.

According to Parkinson’s UK, there were three main ways in which the volunteers’ contributions made a difference to the research:

* Improving the written information about the research project.
* Improving the practical arrangements to make the research more feasible and acceptable for participants.
* Commenting on the ethical issues raised by the research.[[106]](#footnote-106)

**Learning objectives**

* To analyse the methodology used to obtain the results and involve society in the project
* To discuss the outcomes and possible use for stakeholders
* To identify the potential future impacts of the project
* To understand the role of public engagement in science and innovation practices
* To assess the ethical principles involved in this pilot project

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* What is the role and possible importance of public engagement? How does public engagement contribute to this project?
* (Which stakeholders are taking part in the public engagement activities and why have they been selected?)
* Can you think of arguments against public engagement in science? Could there be problems related to the involvement of patients in the setting of research agendas?
* Could different methods and techniques for engaging specific stakeholder groups in dialogue have been taken into consideration? Why?
* Are sufficient perspectives and participants included? How could one enrich the perspectives?
* What ethical impacts should be anticipated in this project?
* What is the role of ethics in this project?

**Responsible, Inclusive Innovation: a documentary on the Buchu Plant**

*RRI Key issues: sustainability, inclusive science and ethics*

The [ProGReSS project](http://www.progressproject.eu/) (PROmoting Global REsponsible research and Social and Scientific innovation) wanted to establish a global network on RRI “involving academia, SMEs, international organisations, policy advisors, research funders, NGOs and industry”. The project sought to connect “existing international networks of RRI with relevant societal actors”, to “compare science funding strategies and innovation policies in Europe, the US, China, Japan, India, Australia and South Africa”, to “advocate a European normative model for RRI globally”, and to foster “the convergence of regional innovation systems at the global level”.

The project developed the [documentary “Responsible, Inclusive Innovation - The Buchu Plant](https://www.youtube.com/watch?v=Nk_Tl7dK5O0)”. The film talks about the San people of Southern Africa, a marginalised community with deep knowledge on medicinal plants. The narrative focuses on the Buchu plant and its many uses. The film includes interviews with San people talking about the plant, its history, spirituality, and role in the San community. Other interviews include a pharmaceutical representative, a researcher, a professor from Cape Town University, and a San Legal representative. According to ProGReSS, the film was made to “show how traditional knowledge holders can collaborate with responsible entrepreneurs and scientists to drive inclusive innovation”.

The United Nation’s General Assembly “Report of the Special Rapporteur on the situation of human rights and fundamental freedoms of indigenous people[[107]](#footnote-107)”, focused on the indigenous peoples in Botswana (including the San), states that initiatives to address “marginalisation in political spheres and a history of underdevelopment” are important but “still suffer from a variety of shortcomings and need to be designed and implemented in a manner that recognizes and respects cultural diversity and (…) identities”.

**Bibliography:**

* <http://www.progressproject.eu/news/2044-responsible-inclusive-innovation-a-documentary-on-the-buchu-plant/>
* <http://www.progressproject.eu/>
* <http://unsr.jamesanaya.org/docs/countries/2010_report_botswana_en.pdf>

**Learning objectives**

* To reflect on the role of inclusion of marginalized communities and its possible impacts.
* To discuss the methods used to involve society in this kind of projects.
* To identify the stakeholders involved and assess the benefits of their inclusion.

**Reflection questions**

* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* Do you think this project is “responsible”? In what way?
* What is the role of stakeholder engagement? How does it contribute to this project?
* Do you think this film is a good vehicle to promote reflection on R&I?
* Do you think this film helps the marginalised community? In what way?
* What are the possible environmental impacts of this project? And social impacts?

**UCL CHANGEMAKERS: Fostering Multiple Abilities through Sensory Object Engagements**

*RRI Key issues: inclusive science*

[UCL ChangeMakers](http://www.ucl.ac.uk/changemakers) promotes collaboration and innovation to improve the learning experience at UCL (University College London). This programme encourages students to work together with university staff, undertaking projects to benefit the UCL community, by providing funding and support. This method benefits both the students, by allowing them to become more engaged, responsible and pro-active; and the university, which gains the expertise and enthusiasm of the students to contribute to making UCL better.

**Fostering Multiple Abilities through Sensory Object Engagements** was a student-initiated project that took place during 2015-2016. The project parted from the question “What are the potential learning benefits of museum objects for students with specific learning disabilities?” with the aim of improving teaching techniques, especially those oriented towards students with learning disabilities. The idea was that education is very often text heavy, and this can sometimes be an obstacle for those who are visual learners or have more specific learning needs.

The hypothesis was discussed in various group sessions, and the students then held an open workshop, held at an Art Museum at UCL. The workshop was called “making teaching more accessible and learning more engaging”. According to the report, the workshop showed that “Using objects encourages students to think more laterally and actually apply the knowledge they have, forming stronger memories of the material. Using museum objects in seminars also engages student’s natural curiosity – encouraging students to speak up in class and share their ideas.” The participants were asked to offer feedback on the objects provided so the students could “proceed further with integrating tactile and kinaesthetic learning and if, where and how it would be viable to adopt this as a regular practice in teaching.”

The project showed that using museum objects in teaching could significantly improve learning experiences, making them much more enjoyable and accessible to all students, not just those with learning disabilities. The participants expressed that the objects might be especially useful in science and history classes, for example to show how science and technology have evolved over time. The props were seen to help conversation flow and intellectual discussion.

**Bibliography**

* 2015/16 UCL ChangeMakers Report: <https://www.ucl.ac.uk/changemakers/docs/UCL_ChangeMakers_Report_2015-16.pdf>
* <http://www.ucl.ac.uk/changemakers>

**Learning objectives**

* To identify the stakeholders involved and assess the benefits of their inclusion.
* To discuss the outcomes and possible use of the project for stakeholders.
* To assess the possible social and educational impacts.
* To discuss the methods used to involve society in this kind of projects.

**Reflection questions**

* What are the possible social impacts of this project?
* Do you think this project helps the student community? In what way?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* Do you think this project is “responsible”? In what way?
* What is the role of stakeholder engagement? How does it contribute to this project?

**INCLUSIVE SCIENCE**

**“AMBIACT”**

*RRI Key issues: inclusive science*

According to the case study on Responsible Research and Innovation about Information and Communications Technology for Ageing People, the Ambiact is a smart meter designed to be placed in any power outlet, with an appliance to be plugged in to the Ambiact itself[[108]](#footnote-108). If the appliance is not used for a certain amount of time (generally, for more than 24 hours), the Ambiact will automatically generate an emergency call. This devise would provide elderly people who live alone with improved home safety and quality of life.[[109]](#footnote-109)

The Ambiact project claims that interviews were conducted during the whole product development in order to design the device according the people’s needs. The interviewees included social alarm customers and alarm operators. At the same time, the project also conducted two 13-months field trials involving approximately 100 people, where men and women were equally represented and where people with disabilities were also included. Results from these interactions were made publicly available and were used by the project in lectures, scientific talks and public presentations.[[110]](#footnote-110),[[111]](#footnote-111)

With its results, Ambiact concluded in its report that “the impact achieved by the project was the development of an innovative and patented product which is accepted by both the customer (e.g. care providers) and the end-user. It is currently sold by a start-up company, the Oldntec GmbH, to social alarm operators in Germany”.

**Learning objectives**

* Analyse the methodology used to obtain the results and to involve society in the project
* Discuss the outcomes and possible use for stakeholders
* Identify the potential future impacts of the product development
* Understand the importance of public engagement in science and innovation practices

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* Can you think of possible negative impacts of this product? If so, which ones?
* Do you think people could feel that Ambiact violates their privacy?
* What is the role and possible importance of public engagement? How does public engagement contribute to this project?
* Which stakeholders are taking part in the public engagement activities and why have they been selected?
* Can you think of arguments against public engagement in science?
* Could different methods and techniques for engaging specific stakeholder groups in dialogue have been taken into consideration? Why?
* Are sufficient perspectives and participants included? How could one enrich the perspectives?

**“Mobile Education DNA Labs”**

*RRI Key issues: inclusive science*

The Article titled “Genomics Education in Practice: Evaluation of a Mobile Lab Design The DNA-Labs” explains that the gap between scientific research and school science is ever wider, and due to the rapid progresses in many fields, school education finds it difficult to keep up with all the new advances.[[112]](#footnote-112)

The initiative “DNA labs on the road” started in 2006 in the Netherlands as an extracurricular development activity to fill this gap between school science and scientific research, and to empower the students, the future citizens, to deal with these personal and societal science decisions. According to the DNA labs project[[113]](#footnote-113), the workshops organised offer students the opportunity to experience scientific research through experiments with equipment that usually is not available in schools, while at the same time, they place scientific research in a relevant societal context.111

In these DNA labs, teacher and student manuals were developed for each activity and given in advance of the introductory lessons, which were taught by teachers at the schools before the “lab” itself. The practical part of the lab was taught by visiting university students, who were previously trained by the institutions involved. The labs were offered free of charge to all secondary schools in the Netherlands. From the start of the project, the article reveals, the five mobile labs reached 54.000 students in 342 different schools.111

The DNA Labs were evaluated on their quality, learning outcomes and effect on the attitude of the students towards genomics applications through questionnaires and some personal interviews (also with teachers).111

**Learning objectives**

* The students should be able to:
* Understand the role of public engagement in science and innovation practices
* Evaluate the role of science education in schools, in science and innovation practices
* Identify the future impacts of this project
* Discuss the methods used to involve society in this project.

**Reflection questions**

* Do you think the case presented is a good example of research done responsibly? Why?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* What is the role and possible importance of public engagement? How does public engagement contribute to this project?
* Do you think this project could be applicable around Europe? And around the world? If so, how?
* Do you think this project is a good tool to promote scientific careers among youngsters? Why?
* What is the role and possible importance of science education in this project?
* Which stakeholders are taking part in the education activities and why have they been selected?
* How can you promote reflection on R&I and its impacts in science education projects?
* Can you think of arguments against public engagement in science? What about science education?

**Sustainability in Prisons Project (SPP)**

*RRI Key issues: sustainability and inclusive science*

The [Sustainability in Prison Project](http://sustainabilityinprisons.org/) (SPP) is an initiative from the Evergreen State College (Washington) and Washington State Department of Corrections. Their mission is, according to their website, “to bring science, environmental education, and nature into prisons”. They “conduct ecological research and conserve biodiversity by forging collaborations with scientists, inmates, prison staff, students, and community partners”, while at the same time, “help reduce the environmental, economic, and human costs of prisons by inspiring and informing sustainable practices”. Ultimately, the SPP wants to help incarcerated people rebuild their lives.

Currently, the SPP has several programmes involving different actors, such as the “Beekeeping & Pollinator Landscapes” programme, the “Environmental Engagement Workshop Series”, the “Taylor’s Checkerspot Butterfly Rearing” and the “Western Pond Turtle Rehabilitation” programmes. They claim that all their programmes have five components: 1) Partnerships and collaborations with multiple benefits, 2) Bringing nature “inside”, 3) Engagement and education, 4) Safe and sustainable operations, and 5) Evaluation, dissemination and tracking.

As stated in their website, the SPP is funded by different conservation organizations and state and federal agencies, such as the Washington State Department of Corrections, the Centre for Natural Lands Management, or the Institute for Applied Ecology. The SPP publishes a biannual newsletter and has a Facebook page.

**Bibliography:**

* <http://sustainabilityinprisons.org/>
* <http://www.evergreen.edu/>
* <http://www.doc.wa.gov/>
* <https://www.facebook.com/sustainabilityinprisons/>

**Learning objectives**

* To identify the stakeholders involved and assess the benefits of their inclusion
* To discuss the outcomes and possible use of the project for stakeholders
* To assess the sustainability of the project and possible environmental impacts

**Reflection questions**

* In what ways do you think the SPP is “Responsible”? Do you think it is also “Irresponsible” in other ways?
* Do you think the SPP is a good example of research done responsibly? Why?
* What is the role of public engagement in this project? Who is it involving and why?
* Can you think of negative environmental impacts of this project? And political impacts?
* Who is this initiative addressed to?

**CROSSCULT: Where History meets IT**

*RRI Key issues: inclusive science*

**“Nothing in History occurs just because one person causes one event. Everything has to be understood in a wider context. “**

[CrossCult](http://www.crosscult.eu/) is a project that has received funding from the European Union's [Horizon 2020](https://ec.europa.eu/programmes/horizon2020/) research and innovation programme. The aim of CrossCult is to “better understand and reinterpret history and culture”, as they describe in their website. The project describes itself as “empowering reuse of digital cultural heritage in context-aware crosscuts of European history”, to provoke a change in the way citizens of Europe view history.

The idea is that history is a complex web of interrelated events and facts, not a collection of unconnected happenings, which is how it is often taught. The project plans to change people’s views on what they have learnt by providing them with “pieces of cultural heritage, other citizens' viewpoints and physical venues”. In this manner, CrossCult aims to promote reflection amongst citizens, helping them to reinterpret history in a wider and more global way.

CrossCult considers that the way history is taught in school and universities is lacking in certain aspects such as “cross-border cultural aspects and global views”. According to their website, the experiences they have designed aim to: raise consciousness, give an overview of historical events from multiple perspectives, approach history via alternative sources (archaeological remains, iconography, epigraphy, numismatics, architecture, art, etc.) and transmit the fact that there can be many contrasting viewpoints in history.

The project uses technology and mobile apps as a tool to reach citizens across Europe. The project states in their website that the idea is to “connect people to digital and physical historical artefacts and in different places across Europe”. The end products will be a semantic knowledge base that “interrelates an unrestricted set of (existing and future) digital cultural heritage resources and venues across different repositories, on the grounds of common properties or crosscutting, transversal concepts”, and also to “design business models and plans for the exploitation of the project results in collaboration with a new network of researchers, scholars, ICT professionals and specialists of digital heritage.”

**Bibliography:**

* [**http://www.crosscult.eu**](http://www.crosscult.eu)

**Learning objectives**

* To identify the stakeholders involved and assess the benefits of their inclusion
* To assess the possible social and political impacts
* To analyse the methods used to involve society in this kind of projects
* To discuss the outcomes and possible use of the project for stakeholders

**Reflection questions**

* What are the possible social impacts of this project?
* What aspects of RRI can you see in this case? How are these aspects achieved and worked on?
* Do you think this project is “responsible”? In what way?
* What is the role of stakeholder engagement? How does it contribute to this project?

1. Cobern W. and Loving C. 1998. The card exchange: introducing the philosophy of science. In McComas W. The nature of science in science education, rationales and strategies. Kluwer academic publishers. [↑](#footnote-ref-1)
2. <http://grasia.fdi.ucm.es/hackwithpeople/> [↑](#footnote-ref-2)
3. Savery, J. R. (2006). Overview of Problem-based Learning: Definitions and Distinctions. *The Interdisciplinary Journal of Problem-based Learning, 1(1)*. [↑](#footnote-ref-3)
4. Zhang M, Lundeberg M, McConnell T, Koelher J, Eberhardt J. Using questioning to facilitate discussion of science teaching problems in teacher professional development. 2010. *The interdisciplinary Journal of Problem-based Learning, 4 (1): 57-82.* [↑](#footnote-ref-4)
5. Hmelo-Silver, C. And Barrows, B. Goals and strategies of a Problem-based-learning facilitator. 2006. *The interdisciplinary Journal of Problem-based Learning, 1 (1): 21-39* [↑](#footnote-ref-5)
6. Torp, L., & Sage, S. (2002). Problems as possibilities: Problem-based learning for K-16 education (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development. [↑](#footnote-ref-6)
7. Bourret et al, *Human–animal chimeras: ethical issues about farming chimeric animals bearing human organs*, Stem Cell Research & Therapy (2016) 7:87 [↑](#footnote-ref-7)
8. Palacios-Gonzalez C., *Human dignity and the creation of human–nonhuman chimeras*, Med Health Care and Philos (2015) 18:487–499 [↑](#footnote-ref-8)
9. Hermeren G., *Ethical considerations in chimera research*, Spotlight, Development (2015) 142, 3-5 doi:10.1242/dev.119024 [↑](#footnote-ref-9)
10. Lensch, M. W., Schlaeger, T. M., Zon, L. I. and Daley, G. Q. *Teratoma formation assays with human embryonic stem cells: a rationale for one type of human-animal chimera.* Cell Stem Cell 1, 253-258 (2007) [↑](#footnote-ref-10)
11. Behringer, R. *Human-animal chimeras in biomedical research.* Cell Stem Cell 1, 259-262. (2007). [↑](#footnote-ref-11)
12. Commission E, editor. *Journalist workshop on organ donation and transplantation: recent facts & figures.* European Commission; 2014. p. 1–9. http://ec.europa.eu/health/blood\_tissues\_organs/docs/ev\_20141126\_factsfigures\_en.pdf. [↑](#footnote-ref-12)
13. International Society for Stem Cell research guidelines, 2016 <http://www.isscr.org/docs/default-source/guidelines/isscr-guidelines-for-stem-cell-research-and-clinical-translation.pdf?sfvrsn>=2 [↑](#footnote-ref-13)
14. Reardon S., *Hybrid zoo: Introducing pig–human embryos and a rat–mouse* , 26 January 2017, Nature News [↑](#footnote-ref-14)
15. Hyun I., *From naïve pluripotency to chimeras: a new ethical challenge?* Spotlight, Development (2015) 142, 6-8 doi:10.1242/dev.119206 [↑](#footnote-ref-15)
16. Vogel G., *NIH debates human-animal chimeras-* Grant to add human cells to animal embryos is delayed (October 15, 2015) *Science* **350** (6258), 261-262. [↑](#footnote-ref-16)
17. Holden C.,  Vogel G., *Panel Would Entrust Stem Cell Research to Local Oversight*, Science  29 Apr 2005:Vol. 308, Issue 5722, pp. 611 [↑](#footnote-ref-17)
18. Webbersten, R., Sun, Q., Li, H. (2014). The future potential for Carbon Capture and Storage in climate change mitigation-an overview from perspectives of technology, economy and risk. *Journal of Cleaner Production, 103* (2015), 724-736. [↑](#footnote-ref-18)
19. IPCC (2014). Summary for policymakers. Climate change 2014: impacts, adaptation, and vulnerability, in: part A: global and sectoral aspects. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. [↑](#footnote-ref-19)
20. Hardin, G. (1968). The Tragedy of Commons. *Science 168* (3859), 1243-1248. [↑](#footnote-ref-20)
21. Gough, C., Boucher, P. (2013). Ethical attitudes to underground CO2 storage: Points of convergence and potential faultlines. *International Journal of Greenhouse Gas Control*, *13* (2013), 156-167. [↑](#footnote-ref-21)
22. Whitmarsh, L., Upham, P., Poortinga, W., McLachlan, C., Darnton, A., Devine-Wright,P., Demski, C., Sherry-Brennan, F. (2011). Public Attitudes to and Engagement with Low-Carbon Energy: a Selective Review of Academic and Non-academic*. Literatures. Report for RCUK Energy Programme*. EPSRC, Swindon. [↑](#footnote-ref-22)
23. Lofstedt, R. (2015). Effective risk communication and CCS: the road to success in Europe. *Journal of Risk Research*, 18(6), 675-691. [↑](#footnote-ref-23)
24. Breukers, S, Upham, P. (2015). Organisational aspects of Public Engagement in European energy infrastructure planning: the case of early stage CCS project. *Journal of Environmental Planning and Management*, 58(2), 252-269. [↑](#footnote-ref-24)
25. EEA (2011). Air pollution impacts from carbon capture and storage (CCS), EEA Technical report No 14/2011, European Environment Agency. [↑](#footnote-ref-25)
26. IPCC, 2005. IPCC special report on carbon dioxide capture and storage. In: Metz, B.,Davidson, O., Coninck, H.C.d., Loos, M., Meyer, L.A. (Eds.), Prepared by Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, US. [↑](#footnote-ref-26)
27. Global CCS Institute 2015, The Global Status of CCS: 2015, Summary Report, Melbourne, Australia. [↑](#footnote-ref-27)
28. Boucher, P., Gough, C. (2012). Mapping the Ethical landscape of Carbon Capture and Storage. *Poiesis and Praxis*, 9, 249-270. [↑](#footnote-ref-28)
29. Wang c., Festin M., Swerdloff R., *Male Hormonal Contraception: Where Are We Now?*, Curr Obstet Gynecol Rep (2016) 5:38–47 [↑](#footnote-ref-29)
30. M. Y. Roth, S. T. Page and W. J. Bremner, *Male hormonal contraception: looking back and moving forward*, Andrology, 2016, 4, 4–12 [↑](#footnote-ref-30)
31. C. Wang, R. Sitruk-Ware and D. Serfaty*, It is time for new male contraceptives!,* Andrology, 2016, 4, 773–775 [↑](#footnote-ref-31)
32. The Paris Manifesto: It’s Time for New Male Contraceptives Declaration of the International Consortium for Male Contraception (ICMC) on May 4, 2016 at the First ICMC Congress in Paris, at the French National Academy of Medicine [↑](#footnote-ref-32)
33. Waller D., *Reversibility of Vasalgel™ male contraceptive in a rabbit model*, Basic and Clinical Andrology, Journal officiel de la Société d'andrologie de langue française2017**27**:8 [↑](#footnote-ref-33)
34. Jing H. Chao, Stephanie T. Page *The current state of male hormonal contraception*, Pharmacology & Therapeutics 163 (2016) 109–117 [↑](#footnote-ref-34)
35. Dismore L., Van Wersch A., Swainston K., *Social constructions of the male contraception pill: When are we going to break the vicious circle?,* Journal of Health Psychology 2016, Vol. 21(5) 788–797 [↑](#footnote-ref-35)
36. Martin C.W et al. *Potential impact of hormonal male contraception: cross-cultural implications for development of novel preparations* , Hum Reprod (2000) 15 (3): 637-645. [↑](#footnote-ref-36)
37. Jasanoff, S., Benjamin Hurlbut, J., Saha, K. (2015). CRISPR Democracy: Gene Editing and the Need for Inclusive Deliberation. *Issues in Science and Technology,* 32 (1). [↑](#footnote-ref-37)
38. Reardon, S. (2016). The CRISPR Zoo: Birds and bees are just the beginning for a burgeoning technology. *Nature,* 531, 160-163. [↑](#footnote-ref-38)
39. Ledford, H. (2015). The landscape for Human Genome Editing. *Nature,* 526, 310-311. [↑](#footnote-ref-39)
40. Nerlich, B., McLeod, C. (2016). The dilemma of rising awareness “responsibly”. *EMBO reports,* 17 (4), 481-485 [↑](#footnote-ref-40)
41. Kick, L., Kirchner, M., Schneider, S. (2017). CRISPR-Cas9: From a bacterial immune system to genome-edited human cells in clinical trials. *Bioengineered,* 1-7.  [↑](#footnote-ref-41)
42. Alta Charo, R., Greely, H.T. (2015).CRISPR critters and CRISPR cracks. *The American Journal of Bioethics,* 15 (12), 11-17. [↑](#footnote-ref-42)
43. Hogan, A. (2016). From Precaution to Peril: Public Relation across Forty Years of Genetic Engineering. *Endeavour,* 40 (4), 218-222. [↑](#footnote-ref-43)
44. Grunwald, A. (2011). Responsible Innovation: Bringing together Technology Assessment, Applied Ethics and STS research. *Enterprise and Work Innovation Studies,* 7, 9-31. [↑](#footnote-ref-44)
45. Finger M., Razaghi M., *Conceptualizing “Smart Cities”,*2017*,* Informatik\_Spektrum40\_1 [↑](#footnote-ref-45)
46. Komninos, N. (2006). *The architecture of intelligent cities; integrating human, collective, and artificial intelligence to enhance knowledge and innovation*. 2nd international conference on intelligent environments. Athens: Institution of Engineering and Technology. [↑](#footnote-ref-46)
47. Kitchin R., (2014) *The real-time city? Big data and smart urbanism* GeoJournal 79:1–14 [↑](#footnote-ref-47)
48. Hollands, R. G. (2008). *Will the real smart city please stand up*? City, 12(3), 303–320. [↑](#footnote-ref-48)
49. Kitchin R., *Reframing, reimagining and remaking smart cities*, 2016, The Programmable City Working Paper 20 [↑](#footnote-ref-49)
50. Hancke, G. P., de Carvalho e Silva, B., & Hancke, G. P, Jr. (2013). *The role of advanced sensing in smart cities. Sensors*, 13(1), 393–425. [↑](#footnote-ref-50)
51. Farber, D. (2013). *Counting the internet of things in real time*. C|Net, July 30th. http://news.cnet.com/8301-11386\_3-57596162-76/counting-the-internet-of-things-in-real-time/. [↑](#footnote-ref-51)
52. Kloeckl, K., Senn, O., & Ratti, C. (2012). *Enabling the real-time city: LIVE Singapore!* Journal of Urban Technology, 19(2), 89–112 [↑](#footnote-ref-52)
53. [Rae](http://www.emeraldinsight.com/author/Rae%2C+Jan), J. (2013). Facilitating learning spaces in forum theatre. *European Journal of Training and Development*, 37 (2), 220-236 [↑](#footnote-ref-53)
54. Casadevall, A., Imperiale, M.J. (2014). Risks and Benefits of Gain-of-function experiments with Pathogens of Pandemic Potential, such as Influenza Virus: a call for a Science-Based Discussion. *mBio Editorial,* 5 (4), 1-5. [↑](#footnote-ref-54)
55. Duprex, P., Fouchier, R.A., Imperiale, M., Lipsitch, M., Relman, D. (2015). Gain of function experiments: time for a real debate. *Nature Reviews: Microbiology*, 13, 58-64. [↑](#footnote-ref-55)
56. Reardon, S. (2014). Viral-research moratorium called too broad. *Nature News*. [↑](#footnote-ref-56)
57. Reardon, S. (2015). US plan to assess risky disease research takes shape. *Nature News*. [↑](#footnote-ref-57)
58. Butler, D. (2015). Engineered bat virus stirs debate over risky research. *Nature News*. [↑](#footnote-ref-58)
59. Trevan, T. (2015). Rethink biosafety. *Nature,* 527, 155-158. [↑](#footnote-ref-59)
60. Wain-Hobson, S. (2013). Pandemic influenza viruses: time to recognize our inability to predict the unpredictable and stop dangerous gain-of-function experiments. *EMBO Molecular Medicine,* 5, 1637-1641. [↑](#footnote-ref-60)
61. European Commission: Textiles and clothing in the EU https://ec.europa.eu/growth/sectors/fashion/textiles-clothing/eu\_en [↑](#footnote-ref-61)
62. Partnership for Policy Integrity, Biomass energy overview <http://www.pfpi.net/biomass-basics-2> [↑](#footnote-ref-62)
63. Forest and Wood Products, Andrea Jane Leys PhD for Forest Learning [↑](#footnote-ref-63)
64. Biomass, Food and Agriculture Organization of the United Nations (FAO) [↑](#footnote-ref-64)
65. <http://genderedinnovations.stanford.edu/case-studies/urban.html#tabs-2> [↑](#footnote-ref-65)
66. Hayden, D. (2005). What Would A Non-Sexist City Be Like? Speculations on Housing, Urban Design, and Human Work. In Fainstein, S., & Servon, L. (Eds.), Gender and Planning: A Reader, pp. 47-64. New Brunswick: Rutgers University Press. [↑](#footnote-ref-66)
67. <http://www.unwomen.org/en> [↑](#footnote-ref-67)
68. <http://interactive.unwomen.org/multimedia/infographic/changingworldofwork/img/data/unpaidwork.png> [↑](#footnote-ref-68)
69. map: <https://goo.gl/maps/s95YuPMoLzN2> [↑](#footnote-ref-69)
70. <https://genderedinnovations.stanford.edu/case-studies/hiv.html#tabs-2> [↑](#footnote-ref-70)
71. Marchetti, M. & Raudma, T. (Eds). (2010). Stocktaking: 10 Years of “Women in Science” Policy by the European Commission, 1999-2009. Luxembourg: Publications Office of the European Union. [↑](#footnote-ref-71)
72. Rosser, S. (2008) Building Two-Way Streets to Implement Policies that Work for Gender and Science. In Schiebinger, L. (Ed.), Gendered Innovations in Science and Engineering, pp. 182-197. Stanford: Stanford University Press. [↑](#footnote-ref-72)
73. Faulkner, W. (2000). The Power and the Pleasure? A Research Agenda for Making Gender Stick to Engineers. *Science, Technology, and Human Values*, *25 (1),* 87-119 [↑](#footnote-ref-73)
74. Faulkner, W. (2007). Nuts and Bolts and People: Gender-Troubled Engineering Identities. *Social Studies of Science*, *37 (3)*, 331-356. [↑](#footnote-ref-74)
75. Sagebiel, F., Dahmen, J., Davidsson, B., Godfroy-Jenin, A., Rommes, E., Thaler, A., & Urbancikova, N. (2008). *Motivations of Young People for Studying Science, Engineering, and Technology (SET): The Gender Perspective*. Wuppertal: University of Wuppertal Press. [↑](#footnote-ref-75)
76. <http://www.who.int/hiv/en/> [↑](#footnote-ref-76)
77. http://files.unaids.org/en/media/unaids/contentassets/documents/factsheet/2014/20140716\_FactSheet\_en.pdf [↑](#footnote-ref-77)
78. http://www.unaids.org/sites/default/files/media\_asset/global-AIDS-update-2016\_en.pdf [↑](#footnote-ref-78)
79. World Health Organisation (WHO), Malaria site (http://www.who.int/malaria/en/) [↑](#footnote-ref-79)
80. World Health Organisation (WHO), Malaria site: <http://www.who.int/malaria/en/> and <http://www.who.int/malaria/publications/world-malaria-report-2016/WMR-2016-key-points.pdf?ua=1> [↑](#footnote-ref-80)
81. Gender in EU funded research – Toolkit and Training – Module 2, Field 1: Gender and Health (https://yellowwindow.com/genderinresearch/downloads/YW2009\_GenderToolKit\_field1\_Health\_001.pdf) [↑](#footnote-ref-81)
82. Cordis – MALVEBLOK project: http://cordis.europa.eu/project/rcn/90124\_en.html [↑](#footnote-ref-82)
83. Gender in EU funded research – Toolkit and Training – Module 2, Field 1: Gender and Health: <https://yellowwindow.com/genderinresearch/downloads/YW2009_GenderToolKit_field1_Health_001.pdf> [↑](#footnote-ref-83)
84. http://baobab.elet.polimi.it/twoleweb/projects/imrr/ [↑](#footnote-ref-84)
85. http://xake.elet.polimi.it/imrr/ [↑](#footnote-ref-85)
86. European Foundations Award for Responsible Research & Innovation - Youtube video: <https://www.youtube.com/watch?time_continue=59&v=L1ibR7oylQU> [↑](#footnote-ref-86)
87. “KlimaAlltag” website: <http://www.klima-alltag.de/Forschungsansatz.3.0.html> [↑](#footnote-ref-87)
88. EuroStat: “Greenhouse gas emissions by economic activity and by pollutant, EU-28, 2014 (thousand tonnes of CO2 equivalents)”: <http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Greenhouse_gas_emissions_by_economic_activity_and_by_pollutant,_EU-28,_2014_(thousand_tonnes_of_CO2_equivalents)_YB17.png> [↑](#footnote-ref-88)
89. “KlimaAlltag section at the ”Institute for Social-Ecological Research“ (ISOE) website: <http://www.isoe.de/en/projects/completed-projects/energie-und-klimaschutz-im-alltag/klimaalltag/> [↑](#footnote-ref-89)
90. “KlimaAlltag” leaflet: <http://www.klima-alltag.de/uploads/media/Reducing-Carbon-Emissions_Schuldt-Baumgart_Stiess-2014.pdf> [↑](#footnote-ref-90)
91. <http://cordis.europa.eu/result/rcn/165387_en.pdf>

    <http://cordis.europa.eu/result/rcn/165387_en.html> [↑](#footnote-ref-91)
92. <http://cordis.europa.eu/project/rcn/111478_en.html> [↑](#footnote-ref-92)
93. European Centre for Disease Prevention and Control: <http://ecdc.europa.eu/en/healthtopics/vectors/surveillance-invasive-mosquitoes/pages/disease-risk.aspx> [↑](#footnote-ref-93)
94. Mosquito Alert website: <http://www.mosquitoalert.com/en/> [↑](#footnote-ref-94)
95. <http://www.mosquitoalert.com/en/about-mosquitos/biology/> [↑](#footnote-ref-95)
96. CORDIS page on MARLISCO: http://cordis.europa.eu/project/rcn/103611\_en.html [↑](#footnote-ref-96)
97. http://www.marlisco.eu/about-project.en.html [↑](#footnote-ref-97)
98. MARLISCO Twitter: <https://twitter.com/MarliscoProject> [↑](#footnote-ref-98)
99. <http://elearning.trree.org/> [↑](#footnote-ref-99)
100. Rudy, B.J. Kapogiannis, B.G., Lally, M.A., Gray, G.E., Bekker, L., Krogstad, P., & McGowan, I. (2010). Youth-specific considerations in the development of Pre-Exposure Prophylaxis, Microbicide, and Vaccine research trials. Journal of Acquired Immune Deficiency Syndromes, 54(1), S31–S42. [↑](#footnote-ref-100)
101. Nelson, R.M., Lewis, L.L., Struble, K., & Wood, S.F. (2010). Ethical and regulatory considerations for the inclusion of adolescents in HIV biomedical prevention research. Journal of Acquired Immune Deficiency Syndromes, 54(1), S18–S24. [↑](#footnote-ref-101)
102. Wilson, C.M., Wright, P.F., Safrit, J.T., & Rudy, B. (2010). Epidemiology of HIV infection and risk in adolescents and youth. Journal of Acquired Immune Deficiency Syndromes, 54(1), S5–S6. [↑](#footnote-ref-102)
103. Hosek, S.G., & Zimet, G.D. (2010). Behavioural considerations for engaging youth in HIV clinical research. Journal of Acquired Immune Deficiency Syndromes, 54(1), S25–S30. [↑](#footnote-ref-103)
104. World Health Organisation (WHO), Neurological Disorders: Public Health Challenges <http://www.who.int/mental_health/publications/neurological_disorders_ph_challenges/en/> [↑](#footnote-ref-104)
105. <https://www.parkinsons.org.uk/content/patient-and-public-involvement-ppi-your-study> [↑](#footnote-ref-105)
106. <https://www.parkinsons.org.uk/sites/default/files/cs2442_ppi_evaluation_pilot.pdf> [↑](#footnote-ref-106)
107. <http://unsr.jamesanaya.org/docs/countries/2010_report_botswana_en.pdf> [↑](#footnote-ref-107)
108. Ambiact – product description: <http://www.oldntec.eu/wp-content/downloads/ambiact_Hausnotruf.pdf> [↑](#footnote-ref-108)
109. Ambiact website: <http://www.oldntec.eu/en/> [↑](#footnote-ref-109)
110. <http://www.responsible-industry.eu/activities/bu-casestudies-results> [↑](#footnote-ref-110)
111. Project Report: <http://bit.ly/2qD5fb6> [↑](#footnote-ref-111)
112. Marc H.W. Van Mil, Dirk Jan Boerwinkel, Jacobine E. Buizer-Voskamp, Annelies Speksnijder,and Arend Jan Waarlo *Genomics Education in Practice: Evaluation of a Mobile Lab Design,* BIOCHEMISTRY AND MOLECULAR BIOLOGY EDUCATION, Vol. 38, No. 4, pp. 224–229, 2010  
     http://onlinelibrary.wiley.com/doi/10.1002/bmb.20397/epdf [↑](#footnote-ref-112)
113. <http://www.dnalabs.nl/english/> [↑](#footnote-ref-113)