ANNEX 5

Experimental outreach methods

Annex 5: Experimental outreach methods

The REELER project (Responsible Ethical Learning with Robotics) made use of novel methodologies to give both robot makers and affected stakeholders a space for mutual exchange about a robotic future, built around a number of REELER's ethnographic case studies of robots being developed in Europe. These novel methods include experiments with mini-publics, design games, and dramatic methods (including REELER's own social drama and explorations of the established approach with professional Sociodramatists).

1. *Mini-publics* A forum for knowledge transfer and debate, where the general public are invited to learn about and discuss targeted issues pertaining to a given topic presented by experts in that field.

2. *Action methods* Established and new experiments in dramatic methods, Sociodrama & social drama are used for perspective-taking and reflection on one's own practices.

3. *Design games* BuildBot and Brickster are games that allow players to reflect on responsible robotics by selecting design features that fulfill needs expressed by different stakeholders.

These development of these experimental methods provided input into REELER's ongoing economic and ethnographic research, but were also refined based on the findings of this research.

(Read more about REELER's outreach tools in the REELER Roadmap.)

Mini-publics

Mini-publics is a new method to give citizens a voice. Mini-public is a concept originally developed by political scientists. REELER, inspired by this work, has developed mini-public into a tool for citizen engagement on the topic of robots. It is in our version of a method to 'give voice' to groups not usually heard in the debates on robots (workers, students, retired people) as well as a debate space for engaging with scientists, companies, and politicians. In this respect, our mini-publics have become 'meeting' rooms where citizens affected by robots can speak directly to decision-makers and robot developers. It is our belief that this may improve opportunities for citizens to contribute to parliamentary deliberation on a given topic.

We have had three mini-publics: in 2017 in Cambridge, in 2018 in Copenhagen, and in 2019 in Hohenheim.

Mini-public I was held in Cambridge in 2017 and focused on robots in healthcare.

Mini-public II was held in Denmark in 2018 and focused on robots in workplaces (industry).

Mini-public III was held in Hohenheim in 2019 and focused on robots in agriculture.

(Read more about REELER's use of Mini-publics here: http://responsiblerobotics.eu/outreach/mini-publics/)

In general "[m]ini-publics are deliberative forums composed of lay citizens who communicate about questions of the political agenda" (Shablinskiy 2018, 104). Mini-public is a concept inspired by developments in the legal sciences. We found inspiration in the methodology and theories on mini-publics found in the social sciences (e.g. Gronlund, Bachtiger and Setälä, 2014; Fung 2003; Niemeyer 2011; Gastil 2000). Mini-publics have something in common with what philosopher Hannah Arendt named 'council systems', a bottom-up approach based on local councils that was expected to be open to all citizens, where they could let their voices be heard in order to deliberate political issues (Shablinskiy 2018). In the legal sciences, mini-publics has been developed over decades as an alternative to conventional public opinion polling techniques.

Instead of giving a normal pool of public opinion answers to pre-formulated questions, the deliberative mini-publics explore and simulate what this general public opinion could look like on a given issue like robotics if the public was well informed and had subjected their assumptions to deliberative scrutiny. Mini-publics can take many shapes and range from huge gatherings of several hundred people or small groups of citizens.

In REELER, our aim was to arrange outreach activities in which all involved are provided an opportunity for collaborative learning by facilitating debates based on research-based

knowledge and not least give people who are normally not heard in decision-making processes concerning robotics a chance to voice their views, wishes, and worries. In our three experiments on mini-publics (deliberating robots in 1. healthcare, 2. work, and 3. agriculture) we designed the event to enhance the local participants' knowledge so they could engage in collaborative learning with robot makers (in REELER's vocabulary robot developers, funding agencies, policymakers, and application experts are referred to as robot makers– see Policy Recommendations and Perspectives on Robots).

Each of our three mini-publics followed the same recipe: Get hold of a group of affected stakeholders (in REELER's vocabulary end-users, directly and distantly affected stakeholders), let them listen to experts in a given field (robots in for instance healthcare, work or agriculture) who give pro- et cons for having robots in a given field – and let them deliberate and come up with suggestions for improvement (see How to Make a mini-public).

Based on the participants' feedback on the three annual REELER mini-publics, we succeeded in creating attractive conditions for citizens to form, articulate and refine opinions about robotics based on research-informed, unbiased knowledge (through expert presentations) and through conversation with one another.

Across all three experiments with mini-publics we found that it is very difficult to engage citizens in the deliberations on robots. This is not a topic which has received much attention in the existing literature on mini-publics. It is interesting that it is difficult to engage citizens in public debates on a topic, which is likely to affect their future so much as robotics – and equally interesting that both robot makers and affected stakeholders learn so much from participating. The approach is both time consuming and costs some money (though REELER had very little funding for these experiments and could not offer participants compensation for participating). However, we conclude that the approach both hold potential for teaching robot makers about the lives of affected stakeholders and affected stakeholders about the reality of robots. Therefore, we recommend that mini-publics are further explored through the aid of the alignments experts, that can help identify themes and facilitate these events in the future (see Policy Recommendations).

In our first experiment with deliberations on robots in healthcare, we went out in public spaces inviting anyone with an interest in the subject. It was an attempt to engage "ordinary citizens chosen through near random or stratified selection from a relevant constituency" and tasked with "learning, deliberating, and issuing a judgment about a specific topic, issue, or proposal." (Warren and Gastil 2015, 562). Though much effort was put into getting citizens of all kinds to participate, only two dozen showed up (see Mini-public I on healthcare). Even so, we consider the event a success. Both the robot makers and the citizens who turned up changed their mind about robots and each other and found the day worth the while.

The next mini-public we arranged with a number of invited guests (including notable policymakers) – and just under hundred participated. The theme was meaningful work, but it was hard to get any ordinary working people to participate on their own accord, whereas it was fairly easy to get all kinds of experts to join. However, some shop-floor workers participated due to the special invited guests, as well as a number of union representatives and other people engaged in consultancy work or teaching. Again, we consider the event a huge success. Many participated, and later reported to have learned new things about both robots and the lives of the people supposed to work with them (see Mini-public II on meaningful work).

The last mini-public on robots in agriculture took place at a university for international students of agriculture – and around 30 participated. Here we directly targeted the students, however also here only a limited number of the potential participants showed up and listed to the two experts. Even also this event was considered a success by REELER as new voices from outside of Europe were able to questions some of

the taken-for-granted assumptions made by the robot makers (see Mini-public III on agriculture).

Our conclusion regarding mini-publics is that they are useful and powerful tools to let affected stakeholders engage directly with the people with expertise in robot-making, but that alignment experts are needed as mediators (*see Policy Recommendations*).

Selected statements from REELER's mini-publics:

"I guess when I looked at that, I wasn't thinking that that looked like a robot, to what I would think was a robot. It looked like a machine. Like I have to broaden my concept of what a robot is."
(Mini-public I, Robots in Healthcare, affected stakeholder Vanya)

"But one thing I did note down was reliability. If you're in the middle of this open heart surgery and suddenly the hospital has a power cut, or even if you have a back-up energy supply, but then something in the interface [of robots and AI] stops working, it malfunctions (…) are we going to kill someone because we can't finish that medical procedure?"
(Mini-public I, Robots in Healthcare, affected stakeholder Paul)

"Isn't the question though about, because we tend to compare robots and their performance with humans doing the same task, but we're faced with a situation increasingly with healthcare where it's robots or nothing, robots or nobody."
(Mini-public I, Robots in Healthcare, affected stakeholder Gregory)

"I feel like in lots of these arguments that potential human solutions are overlooked because techno solutions are so exciting. Like we can make a technological solution, then we won't be reliant on humans. And actually, a human solution is far more organic and like is more holistic so you won't have problems of unemployment as well as – it feels like you impose…"
(Mini-public I, Robots in Healthcare, affected stakeholder Flora)

"So I think underlying what's been said so far is the agenda for doing all of this. What's the agenda? So I think the first person said what's the problem that you're trying to solve, and I think that's absolutely key. And who's deciding what's the problem that we're trying to solve? Where is that coming from, and what is the problem? I mean there's obviously a number of problems; there's not a single problem. I think – yeah, go on."
(Mini-public I, Robots in Healthcare, affected stakeholder Charlotte)

Andy: "But we don't have that much control over these things."
Charlotte: "No. We're being asked today, but we have no idea what, you know. We're not the same as like the head of the European Commission for robotic development, sadly, are we? Not now."
Andy: "You've got economic growth going up and poverty increasing at the same time, which is – I mean somebody's described our society as more like the sort of structure of the pharaohs than – used to be. Accumulation up at the top."
Vanya: "Yeah, not much agency."
(Mini-public I, Robots in Healthcare, affected stakeholders Andy, Charlotte, & Vanya)

"I think that job can be replaced by robots. But I think empathy and talking to patients, that I think is more difficult to replace. But dressing patients, I feel like that can be done with robots. From my experience, and this is personal, it's just that sometimes I'm dressing older men, and I know they have dementia and stuff, but they sort of say things, inappropriate things, so yeah, I would say that."
(Mini-public I, Robots in Healthcare, affected stakeholder Anna)

"It was actually about the gap between….I was just thinking: Will the use of robots create a greater gap between the have and have-nots? I was thinking about the (healthcare exoskeleton) robot in particular, because what was so clever about, you know, these were all advertising and these were commercials for it, and, you know, I can just see the people who were confined to a wheelchair. If you can afford to have an exoskeleton, you know what I mean, so how is that going to be – again, it just makes it so much more visible. It's just that gap that's widening, you know, so that concerns me. And I guess I was thinking about the American system of insurance."
(Mini-public I, Robots in Healthcare, affected stakeholder Vanya)

"So I started off voting quite positively. And then – but not really for any reason, but just like a general mood, a positive attitude towards it. I've moved to neutral for the last couple because I think with the sort of practical medical tooly robots, it seems ultimately beneficial. But I'm much more wary of the social side of it. And in particular people who might not know that they're interacting with a robot, be aware of that. And something to do with the interdependence of different people on each other, just made me feel like I should be a bit more wary about some things."
(Mini-public I, Robots in Healthcare, robot maker Lisa)

"So it was the use of healthcare robots with vulnerable people. … I think if you differentiate between social robots and other robots then the risks are different. They're not necessarily any greater or worse, greater or less. But the risks you're thinking about are different. So although technically I circled the same thing at the beginning of the morning and just then, the reasons why are different."
(Mini-public I, Robots in Healthcare, robot maker John)

Action methods

REELER invited robot makers to take part in two types of role-based action methods to promote SSH-RRI collaboration. These are the established method Sociodrama & and the new experimental method social drama ©REELER.

Action methods are visual and role-based approaches to

individual and group work used for perspective-taking and reflection on one's own practices. The aim of testing these types of methods in REELER was to identify potentially useful tools to support interdisciplinary collaboration and to provide robot developers with a novel and collaborative tool for problem-solving techniques.

Both methods have rendered positive results by facilitating interdisciplinary collaboration that allows for new perspectives on robot design and robot uptake to be explored. In these processes, tacit assumptions and reflected viewpoints among robot engineers and social scientists were called forth and debated. Nonetheless, both methods also come with certain limitations, and for that reason, REELER cannot recommend them as easily accessible tools. See more about the beneficial outcome and challenges of Sociodrama and social drama, respectively, below.

Sociodrama

Sociodrama takes as its basic premise that people are not alone and live connected to others in society. Sociodrama is not a 'systems' (Wiener 1965) or 'hybrid' (Latour) theory because it values humans as significant actors that are capable of reflection, action, abstraction, speech and language and sociality. Sociodrama then is located in the sociality of human beings and recognizes that people are an ensemble of social relationships, some of these meaningful and important, and it is this what Sociodrama aims to discover. Who are the meaningful actors in a given social situation? What are their goals and motivations? What do we know about them and what do we need to find out? Who hold information about a process and how is it shared, or concealed from the group? Sociodrama does not preclude the fact that nonhuman entities can also be important, robots, AI, computer systems, tables and chairs. There are a whole range of physical objects that people interact with as part of their existence in the world with each-other. These physical objects have different properties to persons (though there is increasing dispute if robots and AI will become intelligent or reclassified as 'persons', as tested in the EU Parliament's 2017 Civil Law on Robotics).

The REELER project explored how robots are produced, often in discreet circumstances, for a particular purpose or to solve a problem, but the people these robots need to both design, produce and use them are different kinds of social spaces a sociodrama would be interested in exploring. Moreover, robots become aggregated into millions of robots that in turn impact on how human societies function and how they change. Robotics continue a long line of automation that began in the industrial revolution and continues to this day. Robots allow this form of automation to continue, deepen and extend its scope.

We proposed to explore if robot makers could use Sociodrama as a tool to help them gain insights into their work, perhaps in ways they had not thought. In our three-year long project we have mixed reactions to the use of Sociodrama.

Sociodrama on assumptions in robotics

The overall questions that initiated the collective exploration were: "Why develop robots?" "what is our point of reference when designing robots?"

In Milan we hosted a large Sociodrama group that included robot makers, and most of the REELER research team. The group was invited to participate in sociometry and mapping out relationships. Mapping out relationships in a team is vitally important and normally this is done with the production of a two-dimensional chart. In our case, the space in the room was used as the canvas in which to map out the significant actors in the actors working relationships.

The feedback from participants was mixed and participants felt the focus was not there:

"Start off more concrete, a little bit more guidance in focusing."

"I think it would be more effective we declare at the beginning the focus."

In Sociodrama, the group decides the question that will be explored, and the Sociodramatist facilitates the exploration of the question. Unfortunately, the Sociodramatist was not able to hold the group's focus, which led to poor outcomes for the group. This is not to say that all the feedback was negative, positive comments were included:

"Giving everybody voice is important."

"Very refreshing from other meeting formats."

Though most agreed the day was enjoyable, the Milan Sociodrama was not well received by most of our guests as it had not led to any significant insights about robotics. We took this as a learning experience but did not fully understand why this had not worked. Contrary to our experience with Mini-publics and REELER's own social drama, where the involvement the REELER team was critical to the success of the method, we determined that Sociodrama might be more effective if the group included fewer academics and REELER members, and if the group had the right Sociodramatist to work with.

Sociodrama on ethics and economic sustainability

For the next Sociodrama, we recruited a new Sociodramatist. The majority of our invited guests were CEOs and company employees from robotic businesses. Here we shifted the focus away from academics to business. Themes that emerged from the Sociodrama explored how business ethics was sometimes at odds with academic ethics. The companies believed that robots were an inevitable part of the business sector, and that while jobs might be lost, other jobs would be created. There was also an issue around profit. For businesses, profit is ethical. It is not unethical to make a profit, to develop a business or to build a good life. This can sometimes seems at odds with academics who are paid by the public purse and their livelihoods are not threatened in the same way that a business owner's might be threatened.

Sociodrama, Loughborough

Throughout REELER we had used Sociodrama with at least seven robot makers, plus the project team. Often, our team outnumbered our invited participants. At Loughborough University, we were in contact with a team of a researchers in robotics and artificial intelligence, and we hoped to explore the use of Sociodrama just among the robotics & AI researchers (two REELER project members acted as assistants to the professional Sociodramatist). Participants were given the options of deciding questions to explore. As the day had been put together by engineers to explore ethics in robotics and AI, the group decided to focus on questions about ethics and collaboration with other partners. The Sociodramatist introduced the methodology to the group and explained how it would be used. Sociodrama is not about 'acting'. It is about trying to uncover the different actors involved in a social process (sociometry), and discovering through action what the actors can and cannot do. As the Sociodrama developed, engineers took on roles of funding organizations, the public, and even aging members of the public. This is an example of what happened.

Scenario

A robot maker is explaining the benefits of robots to a grandmother. This was a scene played out in the Sociodrama. In the spontaneous performance the robot makers continually told of the benefits of robots while ignoring the concerns of the grandmother.

Robot maker: *We have a really great robot that can help you and will change your life. You will be able to be more independent and have more freedom. The robots are a really great thing.*

Grandmother: *I don't know what you're talking about and to be honest I feel terrified by the whole process. I feel I'm just going to end up alone.*

Robot maker: *But the robot is great and will really help you. Robots will bring all these wonderful benefits to your life. You will be able to do more and have more free time.*

Grandmother: *I still don't like what you are saying. It makes me feel alone.*

The role of Grandmother was taken by an engineer who was speaking on behalf of her own grandmother. She was a targeted end-user of some of the robots the robot makers would produce in the lab and yet a richer understanding of the difference in experience is not well understood.

This is one example of how Sociodrama can be used. Contrary to social drama (which should be facilitated by alignment experts – see section on social drama below), no roles were assigned to any robot makers. The robot makers created the roles, and acted them out, taking on different ones and experimenting with different roles. This is what Moreno means when he called Sociodrama a "theatre of spontaneity". Moreover, the robot makers started to include family members, such as the ageing or very young, when they were taking on different roles. This is because robot makers are not outside of their own social relationships, particularly meaningful intimate relationships, and because of this can also bring insight into their own processes.

In this scenario, the participants gained an understanding of what it might mean to develop technology for a section of the community that has not grown up with technology. The Sociodrama also explored the concerns that increased technology can lead to social isolation, yet the robot maker initially failed to understand this. A robot maker produces robots in a lab surrounded by people, but the intended recipients of these technologies might have fewer social relationships. These often overlooked experiences need to be addressed when developing robots for the aging population.

This was the most successful use of Sociodrama in the project. It was led by robot makers using a trained Sociodramatist.

Feedback from the session was generally positive:

"It was great to meet people interested in robot ethics. I again a few new insights of other people's perspectives"

"It really helped me to think outside of the box and understand more of what people think who are the stakeholders in this systems. It was really interesting to see other researchers' perspectives when they play different roles. I really like the 'hidden voice' as that represents more of the honest opinions. It would be really interesting to see the comparison to what the real stakeholders would say is what we covered in this workshop.

PS. The role play with different toys really lightened up my mood."

Evaluation

REELER found it difficult to find the right Sociodramatist and the right group of participants. It may be that this task could be taken up by alignment experts (see Policy Recommendations). As Sociodrama is little known, more work has to be done by its practitioners to bring its value to the attention of different stakeholders. While many contemporary theories play down the role of human agents (consider the importance of actor network theory on the European school of thought), Sociodrama centers on the person in their relationships with others. Sociodrama has the potential to allow participants to draw connections between the personal, professional, and societal in constructive ways that are meaningful. To give an example of this, in our Leicester Sociodrama group, one engineer wrote:

"For me, I'm terrified so the big question for me is how do we get it right? For such a generalized and huge ward, how do we strive for balance for all?"

This is the core of what REELER's use of Sociodrama has attempted to explore. We conclude that arts-based practices, such as Sociodrama, should be further explored as research methods in future robotics projects.

Social drama

Social drama as a tool in robot development was developed by the REELER team with inspiration from Victor Turner's work with ritual and theatre, persona and individual, role-playing and performing for a greater understanding of culture and its symbols (From Ritual to Theatre: The Human Seriousness of Play). We also drew on MacAloon's work with social drama as a form of plural reflexivity in human social action (Drama, Festival, Spectacle: Rehearsals toward a Theory of Cultural Performance).

REELER's adaptation of social drama served as a method to explore role-play action within an interdisciplinary group. Through social drama we can learn to speak as the other in a dialogical encounter with them, whether they be a person, a moral, a robot or ethical question. Thus we used the potential of social drama to explore an issue from multiple perspectives without the constraint of reality to enable a deepening of understanding each other and the questions being examined in action.

Ambition and aim

With the ambition to increase collaborative learning between robot engineering and the social sciences and humanities (SSH), REELER introduced social drama as a m ethodological tool for interdisciplinary exploration in robotics.

The specific aim of this event, social drama in robotics, was to explore:

1) How REELER can help robot makers reflect on responsible ethics in relation to their robots

2) How social scientists may contribute with their expertise to the practices and expertise of robot developers.

Social drama in action

The participants broke out into small interdisciplinary groups, each of which devised a social drama scenario centered around their particular robot in relation to the day's topic: distributed ethical responsibility.

Select robot makers enacted the parts of their own robots, which included both service and industrial robots with functions relating to sanitation, care, health, and manufacturing. Grouped with each robot were social scientists and other robot makers representing their areas of expertise, such as field research, ethics, learning, engineering, and innovation systems.

Each group first enacted their social drama, then sat for a panel Q&A. The scenarios brought forth such issues as worker displacement, technological enskillment, design challenges, user constraints, and regulations. The panel discussed certain ethical themes that emerged from the social dramas.

Themes elicited from the social drama scenarios

In the panel discussions following each social drama, a number of themes emerged. We present a selection of these themes below, along with some questions for further exploration.

- **The robot** What is a robot? Is it unique from other machines? Or is it just a tool? What is its role in relation to the human and to society? Do we need a uniform robot definition? And if so, what might it be?

- **Economy & work** What role does funding play in robot design? What are the economic impacts of implementing robots?

- **Design** What is involved in the design process? How is the user considered? When does the user participate? Can ethical responsibility be placed in design? Who do we consider to be users? Who else might we consider as users / affected stakeholders?

- **Ethics** What is ethical responsibility? How do we think about ethics in robotics? How can we translate ethical thinking from the individual to the work processes? When robots effect change in our physical social worlds, what are the ethical implications and how do these relate to responsibility?

- **Distributed responsibility** Where is ethical responsibility in a distributed technology? What is the implication of distributed ethical responsibility from a robot maker perspective?

- **Collaborative learning** What is learning? How does it tie in to design and implementation? How did we learn in this REP and how can we learn from each other in future? How do we establish common ground between the disciplines of robotics and SSH, but also bring robot developments closer to societal needs and concerns?

Reproduction and evaluation of social drama as a method

Following the social drama session with the REELER project, one robot maker felt so inspired by the method that she conducted two similar sessions at KUKA's Corporate Research Department. Here is an excerpt from a working paper she wrote for the REELER project:

"The idea behind social drama is to explore an issue from multiple perspectives without the constraint of reality to enable a new level of understanding of each other and the questions being examined. To this end, REELER invited a selection of robot makers and social scientists from different backgrounds. Each robot maker chose a robot they work with and the social scientists were asked to select a theme or concept that lies within their expertise. I for example chose our mobile human-robot collaboration robot called KMR iiwa and paired up with two social scientists who were 'Learning' and 'Innovative Systems'. Next, we were given 40 minutes to get acquainted by presenting more details about the robot and the concepts and come up with a short sketch (five minutes maximum), integrating the two concepts and the robot, so that a fruitful discussion would evolve afterwards. Once we had presented our sketch, we stayed on stage and discussed our scenario with the other participants. Here the remarkable point was, that for this dialogue we stayed in our chosen roles as robot or concepts and argued from their perspective. But not only the actors stayed in their roles, but also all other participants asked their questions most of the time from their chosen concept's perspective. In the end, each role of the sketch was asked who in their opinion was carrying the ethical responsibility in a highly distributed technology like a robot.

Social dramas brought up a new differentiation between internalized ethics of a person and the (external) ethical responsibility. In the first case, the question is if the person in the respective scenario acts ethically correct, whereas the question of ethical responsibility was aimed at for example the producer of the robot. Here it was admonished that physical safety and

current norms and standards don't include societal aspects and issues. Therefore it was discussed whether the current "top-down" method is the right one or if ethical responsibility should be embedded differently.

Summarizing my experience with both social dramas with the REELER and the CR groups, I find it noticeable that the method worked similarly with both a group of social scientists as well as a group of engineers. Yes, they focused on different concepts and emphasized different (ethical) values, and some of them were likely connected to their different educational upbringing and professions. But on a higher level, the similarities overweigh. Both groups were in the beginning mildly skeptical (maybe the engineers a tad more), but soon fully understood the task at hand. In both groups the method social drama led to experiences and debates that would otherwise never have happened. Therefore I find this method especially valuable when it is used to approach a new field or topic which might be controversial but needs to be evaluated from different perspectives. Especially the discussions after each short play proved to show even further insights. I could also imagine that this method proves valuable for the evaluation of new stakeholder groups and their issues with a new technology."

Despite the success of the REELER-hosted event, and the successful replication of the event at KUKA, REELER finds that more research and testing is required for recommending the experimental social drama as a method.

Design games

In order to study how humans do and should design robots, REELER made several experiments with agent-based modelling. During several attempts to develop an agent-based model of robot design, we were not able to model robot makers' behavior and heuristics to our satisfaction. Not only could we not deal with the conceptual richness of the ethnographic data, also much of the information required could not be provided by the interviewees themselves. See the Section entitled 'Agent-based modelling and policy laboratory for 'what-if' analysis' as well as the deliverable 'Integration of ethnographic data and ABM-inspired methods' for more details. As a backup strategy and seeking to comply with our commitment to develop a computer simulation model to shed light on the design roadmap to be followed by robot makers, we developed an agent-based model in which agents 'compete' against each other using stylized, codified design policies ('roadmaps'). However, also these simulation results fell short. Firstly, in studying the design roadmaps emerging from the simulation run (which would be the primary simulation outcome), we noticed particularly weak convergence and substantial noise in the results. So, for instance, the 'design policies' followed by agents had quite different performance for similar design challenges. We concluded that these design policies used just too little contextual information. However, in subsequent attempts to improve/ extend the operationalization of the behavior of the robot designer agents, we noticed that literature did not provide concrete specifications of human design activities subject to market uncertainty, ethical dilemmas, technical complexity, etc. In fact, for instance, while there are models in which 'design' under technical complexity & uncertainty is operationalized as search on a high-dimensional binary landscape, these models do not feature advanced, context-sensitive heuristics either (such as conflicting market requirements, dealing with trade-offs, etc.). So, conclusively, we would not be able to claim that our agent-based model produces externally valid roadmaps if the individual decisions over the course of the timeline are not properly understood and modelled. Moreover, we conclude that, at the core of our issue lies the fact that, while innovation economists do acknowledge the role of uncertainty, complexity, segmentation of the users, etc., little is known on how humans really cope with it in an operational sense. As such, we realized that it would be valuable to, at first, simply measure how humans actually go about designing complex products. As the ethnographic case write-ups are also doing so, in a way, we chose to study robot design practices in a controlled laboratory setting to allow us to experimentally vary certain conditions, study learning effects over the course of repeated challenges, analyze particular differences across subjects, etc. An enhanced understanding, once obtained, could subsequently be used to formulate heuristics for agent-based model studies. This led to the 'design game' experiments described in more detail below.

On top of this – in itself already – challenging research agenda, there are additional argument as to why agent-based modeling will fall short. First of all, the human design activities in practice as described in our ethnographic research and also acknowledged during our extensive multidisciplinary discussions during the common ground meetings revealed substantial complexity. Moreover, the richness and vastness of the REELER ethnographic data had us conclude that there are substantial challenges in construing human designer's behavior in robot design. For instance, we realized that design activities are driven by 'shoulds' and 'oughts' (and thus bound by imperative logic, which is arguably hard to program), and are also highly dependent on particularities and situatedness of both the designer, intermediaries, and users as well as their contexts. That said, though, we realized that the 'design game' could very well be used to also to, firstly, have humans experience the conceptual complexity of robot makers' dilemmas, how ethics enters design decisions, etc., and, secondly, subsequently study human decisions in such a contextualized design setting (by simply providing the stakeholder quotes, for instance). This 'serious game' is also described in more detail below.

Design game to measure human design activities in laboratory settings

As we have provided an extensive description of the design game and first experimental results in Deliverable 8.1, we will not go into details here. In a nutshell, though, we devised a design game from the perspective of the product development methodology in which humans play through various stylized 'design challenges', while doing so, their actions are recorded

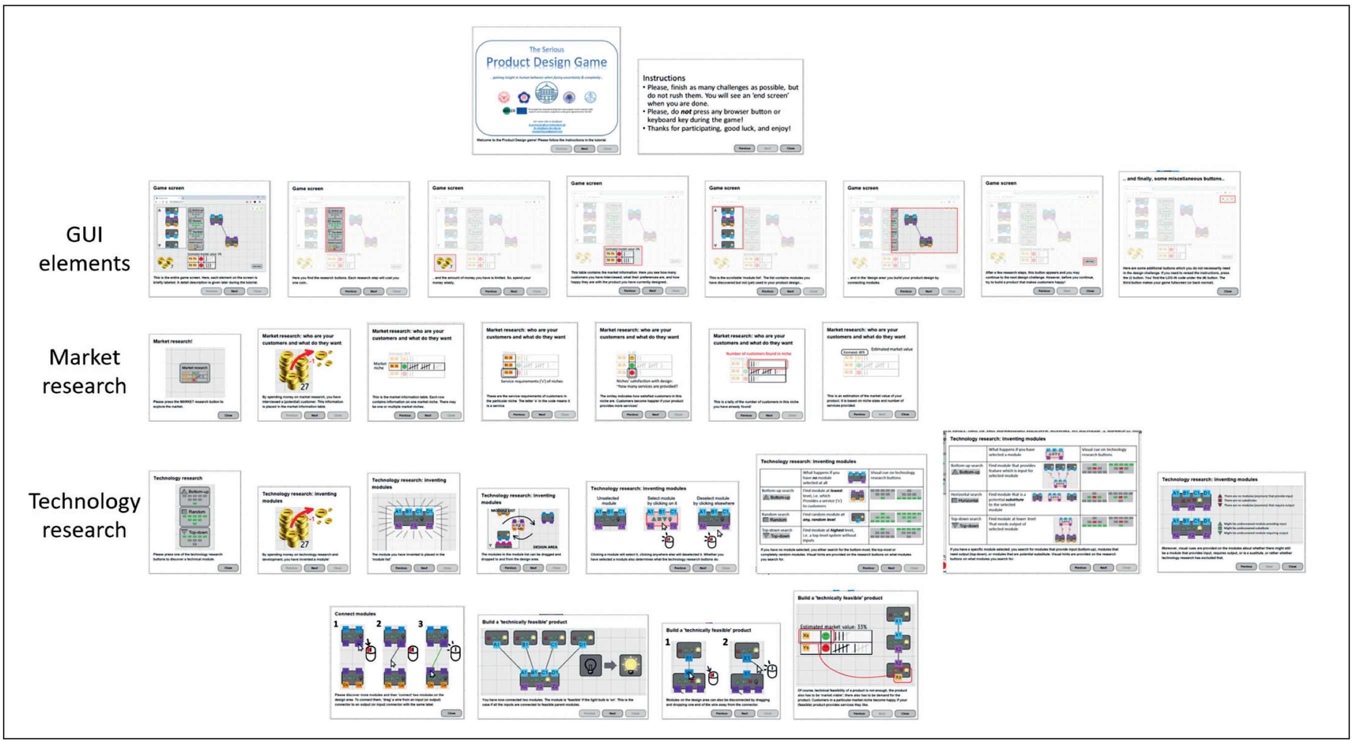


Figure 3. The tutorial screens for Experiment 4, part of which is shown after the instructions in previous dialogs is followed. The 'success rate' of subjects actually constructing technically feasible products went up after moving from the instruction video and/or instruction screens to the tutorial setup.

for further statistical analysis. More specifically, the human subjects have a limited amount of resources to conduct either market or technological research. Market research provides information on the existence and size of market segment and what customers in that segment want in terms of 'services'. By conducting technological research, subjects discover 'modules' of various sorts, which can subsequently be connected (or not) to, and thus ultimately 'activate' modules that provide particular services (in demand or not). Statistical analysis of the recorded activities for a variety of parameter settings would (i) provide insights of how humans cope with market uncertainty, trade-offs & conflicts between users, technical complexity and uncertainty, resource constraints, etc., (ii) allow us to isolate 'behavioral rules' or heuristics followed during those activities, and notably elucidating the concept of the design roadmap, (iii) instruct us on 'actual' and 'normatively superior' design activities that can (potentially) be used in agent-based models. Either way, each of these results would be valuable research findings in their own right, but given the repetition of the number of challenges, we would also be able get insight on the dynamics and notably learning of human subjects over time.

Deliverable 8.1 contains results from the first experiments. Since then, we have made changes to the graphical interface of the design game and tried different experiment setups. The biggest changes were made to (1) the instructions for human subjects both on the purpose of the game as well as the elements in the GUI and (2) the presentation of the 'challenging' task of picking particular technical research directions (to cope with uncertainty and complexity). Firstly, in the first experiment conducted in 2018, we showed subjects an instruction video explaining all the design elements. In the second and third experiment, also conducted in 2018, we showed an instruction screen (with randomization of the order in which we introduced market or technological activities so as to prevent framing). In the last experiment, conducted in June 2019, we had subjects follow a tutorial (again randomizing the order of market and technology-related instructions), telling them step-by-step what to click and do in the GUI, gradually phasing in the buttons and elements in the GUI, only showing the next instruction once they did follow instructions, etc. See Figure 3. Interestingly, while there were subjects in the earlier experiments not able to construct even a single product, in the last experiment, all subjects with admissible results managed.

In Experiments 2 and 3, we showed 8 dense pages with the instructions (See Figure 4).

Secondly, in terms of research results, after the first experiments, we realized that human subjects struggled with particular design challenge variables and, notably, the technological complexity in the product design space. The concept of exploring a universe of technological modules, acquiring a subset thereof (under resource scarcity), and subsequently building a 'tree' of modules may have been not only conceptually hard to grasp, also the visual cues we provided was (purposefully) limited. However, it may have been too limited, because, as said, some subjects did not construct even one single feasible product over the 12–16 challenges. So, in addition, we sought to isolate the effect of technological complexity on design activities and filter away the potentially compounding effect of design flaws in the design game. We did so by, firstly, providing the extensive tutorial described

Figure 4. Instruction pages used in Experiment 2 and 3. These pages were also used during the Instruction video in Experiment 1. For Experiment 4, we used to stepwise, interactive tutorial.

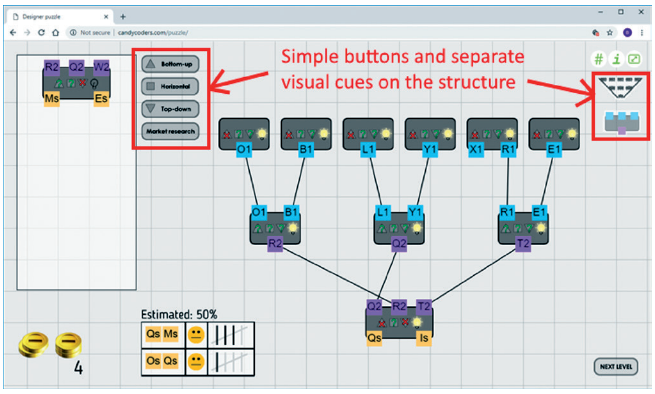
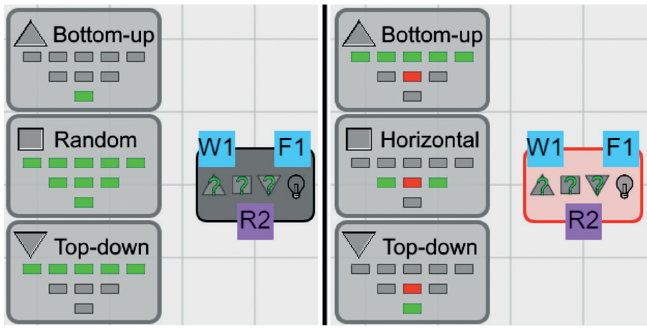


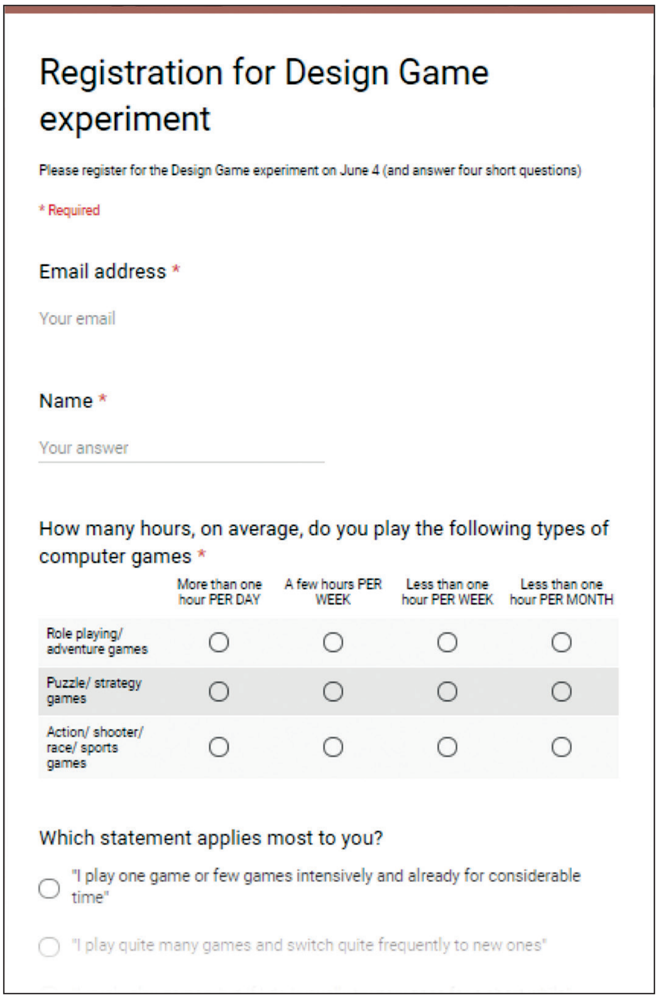
Figure 5. 'Old' style with simple uninformative buttons and inconspicuous visual cues provided to subjects in Experiment 1- 3



.Figure 6.'New' style of dynamic visual cues on the research buttons highlighting the direction and the 'tier' in the technology universe (right with and left without module selected) in which modules would be discovered would the human subject actually press the particular button.

above. Secondly, and possibly importantly, we supplanted the crude visual cues in the design pictured in Figure 5 that was used in Experiments 1-3 with dynamic visual cues on the research buttons which indicate what where to happen if the subject would press a particular button, see Figure 6. As said, in Experiment 4, the rate of technical feasible design went up considerably.

Thirdly, we changed the setup to incorporate the personal background of the subjects to study how that may impact their performance. To associate experiment outcome with personality traits, background, etc., we required subjects to register to obtain a log-in code. An e-mail was sent out two weeks prior to the experiment to ~300 potential subjects and asked them to register. Reminder were sent on the Friday and on the Monday before the experiment on Tuesday. The registration page (See Figure 7) was a Google Forms page at which we also asked several questions about familiarity with



Registration for Design Game experiment

Please register for the Design Game experiment on June 4 (and answer four short questions)

* Required

Email address *

Your email

Name *

Your answer

How many hours, on average, do you play the following types of computer games *

	More than one hour PER DAY	A few hours PER WEEK	Less than one hour PER WEEK	Less than one hour PER MONTH
Role playing/ adventure games	○	○	○	○
Puzzle/ strategy games	○	○	○	○
Action/ shooter/ race/ sports games	○	○	○	○

Which statement applies most to you?

○ "I play one game or few games intensively and already for considerable time"

○ "I play quite many games and switch quite frequently to new ones"

Figure 7. Screenshot of the Google Forms registration form at which we also asked questions on which we could infer the acquaintance with game interfaces, the general performance of the subjects on certain types of tasks/ courses, the familiarity of the subjects with particular concepts we sought to measure, etc.

certain concepts (like innovation, uncertainty, complexity, etc.), performance on particular tasks relative to other subjects (e.g. science, economics, etc.), and frequency at which the subject plays computer games.

A last big change in our setup was to follow experimental economic principles in the last run (Experiment 4). We provided a small compensation to each subject for the time (A €5 lunch voucher) and a book voucher lottery (€50) with a win-chance proportional to the number of successfully finished challenges (i.e. number of feasible products with a non-zero market performance), see Figure 8

Output of the experiments 1-3 is contained in the follow publication:

- Vermeulen, B., Chie, B.-T., Pyka, A., Chen, S.-H. (2019). Coping with bounded rationality, uncertainty, and scarcity in product development decisions: experimental research. In: Buccarelli, E., Chen, S.-H., Corchado, J.M. (eds.), Decision economics: Complexity of decisions and decisions for complexity. Advances in Intelligent Systems and Computing. Springer Verlag.

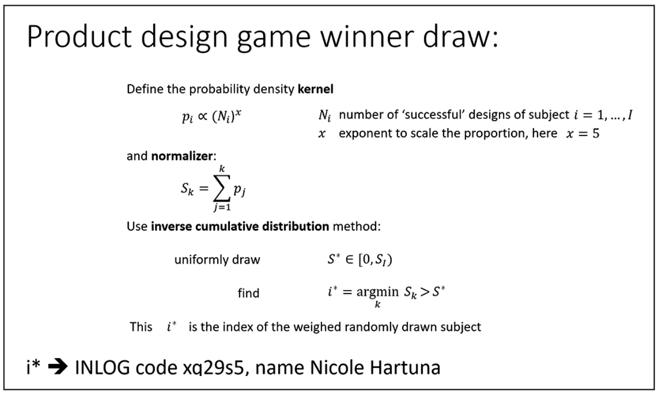


Figure 8. Slide shown to subjects in which the 'winner' of the €50 voucher was announced.

Moreover, we are currently evaluating the outcomes and consider adjustments for a large-scale experiment.

At present, the game in the form of Experiment 4 is still available through http://www.candycoders.com/puzzle. Log-in codes for the game can be obtained from Ben Vermeulen (b.vermeulen@uni-hohenheim.de).

As a final observation: in many regards, also the 'product development roadmap' we have been and are still traversing in programming and testing the design game is itself also reminiscent of the process we describe in the handbook chapter on robot development and study using the game. After all, during the first few experiments, we observed unexpected difficulties of the 'users' (our human subjects) in playing the game, how particular GUI design & experimental setup decisions made by use had unforeseen consequences, etc.. This led to improvements, additional tests, etc. So, indeed, we too are involved in multiple iterations of the 'develop-test-plan' cycle described in the handbook chapter 'Innovation economics'.

Serious design game to raise awareness of and study contextualized design decisions

As described before, we realized that we could not provide a fully-fledged agent-based model for repeated simulation runs doing justice to the richness of real-world robot design cases. Essentially there are three reasons. Firstly, because this would require operationalization of particularities of robot makers and context specificities, many of which are not known. That said, even if we would, the flipside of specificity of the operationalization is a lack of generality in the simulation outcomes. Secondly, humans struggle with recollecting and articulating considerations and factors that determined their decisions, especially in the past. Clearly, this will have considerable impact on any specific description of the 'roadmap' of the design of a particular robot. Lastly, decisions affecting the robot design are taken over time and by different actors, so supposedly difficult to trace in great detail.

That said, we had the idea to use the 'design game' to have 'players' experience the richness of the decision context and the dilemmas that robot makers face in design. We thus adorned the design game with dialogs that provide conceptual background information, stakeholder-quotes from interviews, and thus 'set up' particular decision contexts. In fact, doing so would allow us to have the player of the game for instance experience how development of a technically perfectly feasible robot may ultimately not have enough market demand to warrant the investments done. Or, how particular (preliminary) 'needs' of potential customers of the robots may trigger extensive technological developments without eventually finding suitable technical solutions. As such, the player experiences having to balance investment decisions under uncertainty. Moreover, the narratives distilled from the ethnographic case descriptions did reveal numerous other interesting ethical challenges. On the one hand there might be rather banal cases in which one stakeholder requires a particular feature that is prohibited by or may potential harm another stakeholder (e.g. with matters like safety, security, privacy, etc.). On other hand, the ethnographic material revealed cases in which robot developers faced trade-offs (Consumer X does like A and B, but the design can technically not offer both at the same time), conflicts (Consumer X likes A, Consumer Y dislikes A), and in-/exclusion decisions (Consumer X likes A, Consumer Y likes B, but the design cannot offer both at the same time).

As such, the serious game is a conceptually enriched design game with the purpose to have players become aware of ethical issues in design (in conjunction to other 'common' factors issues). Moreover, it would allow us to study their decisions in a contextualized setting.

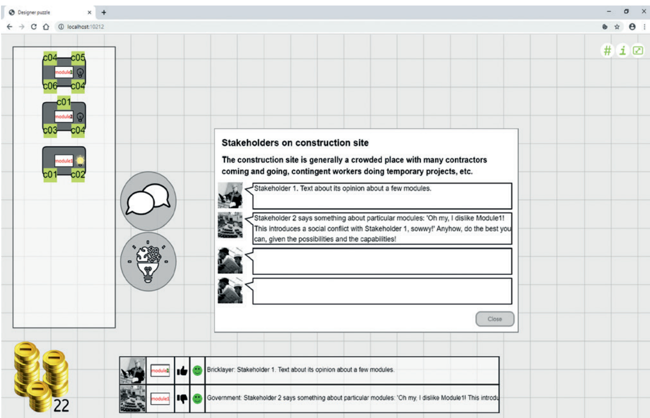


Figure 9. Serious design game with the dialog in which stakeholder feedback can be obtained. This feedback shows up in the (revised) market table at the bottom.

While the serious design game has yet to reach a state of development suitable for dissemination, we have hopes that this experiment can be used for engineers and outsiders interested in exploring the connection between stakeholder feedback and design choices.

BuildBot

BuildBot is a board game developed out of interdisciplinary collaboration between REELER's robot developers and anthropologists, using data from ethnographic interviews to simulate a reflective robot design process. In this game, players take on the role of robot developers designing a healthcare robot. The players must manage their resources in interviewing different stakeholder types (patients, care providers, unions, policymakers, e.g.) and spending money on developing robot features. The game involves a dialogue between players where they can explain their interpretation and consideration of stakeholder statements in the selection of robot features. Players are rewarded for selecting features that best match stakeholder needs. This game raises awareness about the complexity of a robot's context and expands development considerations beyond the inner circle to take in perspectives across the human proximity model.

Nowadays, games, as creative teaching mechanisms, have become a common tool for learning and training. Games are considered to be engaging learning resources, in which skills such as cognitive understanding, communication, problem solving, and participation are developed. In the context of the REELER project, we used this approach to develop BuildBot, a board game aiming at promoting the collaboration between the different stakeholders involved in robot design and development from a robot maker's perspective. BuildBot was developed through an iterative process, considering the feedback received by different stakeholders and experts in the field of robotics, and education.

Version 1.0

The first version of BuildBot comprised five sets of cards, containing statements extracted from the field interviews for each of the diverse stakeholders, and a table of 27 features to be implemented in the robot. Players were asked to select 9 initial features, and then to interview the desired stakeholders (i.e. reading a statement). After each interview, players could change the selected features, and choose new ones. After three rounds of interviews the final features were discussed.

This version was tested with engineering students from Politecnico di Milano, and during the European Robotics Forum (2018). The game was considered repetitive, not interesting, and lacking motivation as there wasn't a clear winner, nor the possibility to win. Moreover, this version was not really promoting collaboration nor communication, as the final features were exactly the same as the initial ones in most cases, which implies an overall lack of consideration of the stakeholder motives, and an unclear relation between the interviews and the features.

Version 2.0

The second version of BuildBot was developed aiming at making it fun, with a predefined goal and therefore a possibility to win, and a causation effect between the robot features and the stakeholders' opinions, targeted at promoting discussion and communication.

This version comprised a game board, six sets of cards, five containing statements from the field interviews and one containing robot features, and a score matrix. Players were asked to navigate around the board to meet and interview the stakeholders and then choose a robot feature that relates to the information given by the stakeholder. At the end of the game players were asked to use the score matrix to quantify the relation between the chosen features and the stakeholders' cards: the stronger the relation, the higher the score. Extra points were given to each player if able to interview all fourth different stakeholders. The player with the higher score would become the winner.

This version was tested with engineers and social scientists. The game was considered more dynamic, interesting, but a bit confusing, in particular when calculating the final score with the score matrix. Moreover, the construction of the score matrix resulted problematic since it implied an objective judgement, on a subjective matter.

Version 3.0

The third, and final, version of BuildBot was developed as an upgrade of the previous version. Here, the score matrix was removed and replaced with a voting system, promoting debate, discussion, and subjective judgements.

This version was tested with engineers and social scientists with positive results. Players considered BuildBot to be a fun, interactive, and intuitive space for promoting collaboration and discussion about ethical aspects in robotic design, stakeholder participation and collaboration.

Moreover, engineers argued that BuildBot is a great tool to explore what different people can bring to the design and development of robots, which is not conventionally considered during the traditional design process.

Evaluation

REELER participated at the European Robotics Forum in 2017, 2018, and 2019, with the aim of raising awareness about the aims of the projects and collecting valuable inputs from the robotics community to make our outreach tools more complaint with the needs of the main stakeholders.

The ERF is organized by euRobotics under the SPARC initiative. euRobotics is a non-profit organization aimed at making robotics beneficial for Europe's economy and society, while SPARC is the public-private partnership (PPP) between the European Commission and euRobotics, to foster Europe's leadership in robotics. At ERF, all the major European players in robotics meet, including researchers, manufacturers, students but also expert in ethics with background in social sciences.

REELER used our participation at ERF to develop and evaluate our outreach tools, through devoted workshops, detailed in the following paragraphs, and face to face meetings with robot makers as well as experts from other disciplines. (Indeed, it is important to point out that the audience of the ERF is typically multidisciplinary joining professionals with different background mainly in the regulations domain.) At the ERF in Tampere (2018), a devoted workshop was organized to test the first version of the BuildBot game. The game was introduced to the audience and several tables were arranged to play the game. 5-6 persons attended the game at each table together with a facilitator from REELER team. At the end of the workshop, the players were asked to comment about the game and its potential use in robotics design. The workshop allowed us to better understand expectations form the robotics community, even if, because of the clear focus of the workshop on ethical issues, most of the audience was already used to the concepts introduced through the BuildBot game itself.

At ERF 2019, which took place the last Spring in Bucharest, the REELER consortium introduced the outreach tools developed up to last Spring, i.e. the BuildBot game, the mini-public and the socio-drama. The discussion with the audience was very constructive. The BuildBot game was well evaluated as an education tool, the mini-public was appreciated as a raising awareness tool, while the socio-drama raised some concerns about its potential application in industry settings without facilitators.

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