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Responsible Ethical
Learning with Robotics

BRICKSTER

An interdisciplinary experiment between ethnography and programming

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FOREWORD

Responsible Ethical Learning with Robotics – REELER – is an interdisciplinary H2020 project funded by the European Commission with 1,998,265 EUR from the 1st of January, 2017 – 31st of December, 2019. Its main objective is to develop the REELER Roadmap for responsible and ethical learning in robotics. The project involves four European partners from the fields of anthropology, learning, robotics, philosophy, and economics, who work closely together in a research-driven collaboration between SSH-RRI and Robotic-ICT communities. Together, they aim to raise awareness of the human potential in robotics development, with special attention to distributed responsibility, ethical and societal issues, collaborative learning, as well as economic and societal impacts. The REELER Roadmap aims at aligning roboticists' visions of a future with robots with empirically-based knowledge of human needs and societal concerns, through a new proximity-based human-machine ethics that takes into account how individuals and communities connect with robot technologies. REELER's comprehensive research methodology includes a design-anthropological approach to onsite studies of roboticists' laboratories and daily work, as well as onsite ethnographic studies and impact studies of present and potential affected stakeholders. The project also includes quantitative research in geographical distribution of patents and an AMB (agent-based model) research approach. Furthermore, the project makes use of novel methodologies to give both robot-designers 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, role play, social drama, and also explorations of the established sociodrama approach with professional sociodramatists. REELER aims to include all relevant aspects of this research in the roadmap, which will present ethical guidelines for Human Proximity Levels (HPL) in design work, as well as prescriptions for policy makers and robot-designers for how to include the voices of new types of users and affected stakeholders. The project aims to present an agent-based simulation of the REELER research to be used by roboticists and policymakers. The working papers presented in this series present ongoing research results, literature reviews, and position papers.

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BRICKSTER: An interdisciplinary experiment between ethnography and programming

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Introduction

REELER - Responsible Ethical Learning With Robotics - was a highly interdisciplinary H2020-project that, in the years 2017-2019, involved European partners from the fields of anthropology, learning, robotics, philosophy, and economy. A part of the project's multidisciplinary profile aimed at exploring how ethnographic and SSH-based knowledge can be comprehended and used by the technical sciences. The project also aimed at developing a range of tools that sought to make engineers and other robot developers explore issues of normativity, distributed responsibility, and ethical and societal issues relating to robotics (see the REELER toolbox on responsiblerobotics.eu). As part of the project-work, a small group of interdisciplinary researchers took on the task of seeing if ethnographic research could be made useful in programming. This resulted in the work on the prototype BRICKSTER – a game addressing robot developers to make them aware of the importance of user involvement.

The development of BRICKSTER began with the idea of merging a quantitative method for mapping human design strategies with a large corpus of qualitative ethnographic material. Was it possible to model a realistic design process as a decision tree, while also taking advantage of the qualitative 'thick' (Geertz 1973) nature of the ethnographic data? Decision trees are deterministic; choice A leads to outcome B every time. Real-life design and implementation are rarely like this – in fact, whether a robot succeeds or fails often depends more on the implementation context than on the robot itself. In this paper, we explore and reflect on the process of developing BRICKSTER and discuss the insights gained and the problems we faced. We begin by briefly describing the development and concept of the game, to set up the discussions that make up the main part of this paper, which falls into four sections.

In the first section, we deliberate on the nature of ethnographic data. We focus, in particular, on its susceptibility to generalization and its dependence on and anchoring in specific contexts – i.e. the socio-material environment in which the research takes place. We argue that while it is possible to abstract general patterns from the ethnographic data, the concrete instantiations of the patterns vary from case to case.

In the second section, we reflect on the proper balance between, on the one hand, confronting players with the all the complexities involved in design processes and, on the other hand, making sure that the lessons taught through the game are clear, i.e. that players are able to reliably and easily identify when they made mistakes.

In the third section, we engage more deeply with the normative aspects of the game. Traditionally, engineers approach robots as solutions to problems. Problems are formulated and dealt with through technological discussions removed from the context of use. On the other hand, in the ethnographic fieldwork, we identified entirely different problems arising at sites of use. These are often framed in terms of technological components (the robot is slow), but the origins of the problem are often social (workers work on piece rates making speed a priority). One central aim of BRICKSTER was bringing to the fore, how context (and the information gained from observing and analyzing that context) plays a central role in the success or failure of the robot – and that robots seldom fail just because of a technological lack or problem, but because technology (robots) is deemed lacking *in situ*.

In the final section, we conduct an imagined play-through of the game, giving the reader a sense of how the game would have been played, what choices they would be faced with, and how they are incentivized (or not) to involve stakeholders and end-users, etc.

Introduction to BRICKSTER

BRICKSTER began as an attempt to integrate the insights gained through ethnographic field work in an Actor Based Model (ABM). ABMs are programmed systems where a collection of autonomous agents interact following rules particular to each agent (Bonabeau 2002). For instance, an ABM could model a marketplace, where some agents are 'sellers' and others are 'buyers'. The goal of the sellers is to 'maximize profit', while the goal of the buyers is to 'buy as much as possible' with some fixed amount of money. Then, agents are outfitted with different rules and simulations are run to see which rules maximizes profit (i.e. what is the optimal balance between selling good cheap robots and making a profit), and which rules maximize the total amount of goods bought (i.e. how to get the most bang for your buck). The dynamics of such a system are easy to model, since agents can easily be outfitted with rules to guide their behavior, and ABMs are able to model far more complex systems than the marketplace described here, e.g., the emergence of traffic jams or behavior of shoppers in mall (Bonabeau 2020).

On the other hand, ethnographers excel at describing particular practices and their practitioners with minute details, paying special attention to the process of meaning-making (or sense-making) through which practitioners organize their lifeworlds. Often, and this was the case with REELERS' data as well, the ethnographic data is rich in particularities and nuances, but lacking in the identification of general rules, which guide behavior. In fact, through the ethnographic fieldwork it became clear that design processes are non-linear, recursive, decentralized and highly particular to each of the companies. This made it highly complex to formulate the rules by which agents in an ABM should operate, in a way that mimicked the real-world design processes that we documented. This is a point that we will revisit, when discussing the interaction architecture of the game.

Faced with these challenges, we decided instead to base the development of BRICKSTER on a serious product design game, [1]which REELER researchers had previously developed for testing how subjects cope with technological and market uncertainty when designing a robot. For the purposes of integrating the ethnographic data, the game had to be redesigned. We decided that the central goal of the game and the key take-away for players should be: *to realize how the involvement of stakeholders and end-users (continuously or at different times throughout the design process) fundamentally changes the design process and the final outcome.*

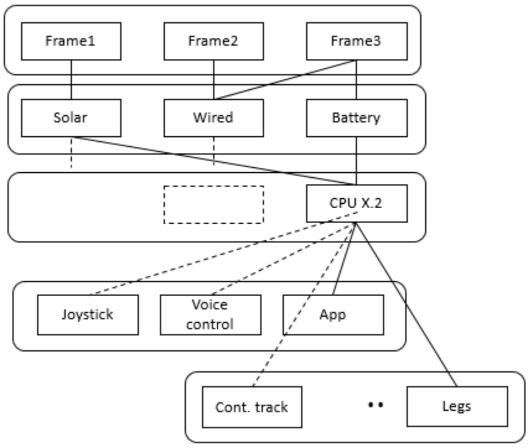

Figure 1 – early mockup of the technological universe. This shows how modules are grouped into categories. E.g., solar, wired and battery are different potential power sources for the robot.

The process of developing the revamped serious product design game, what came to be called BRICKSTER, began in early 2019 and continued throughout the year, culminating in a presentation of a prototype at the IROS 2019 conference on intelligent robots and autonomous systems. However, a working final product never materialized. One reason for this was simply that the connection between thick ethnographic data and the requirements for programming in a field new to all the involved researchers proved to be too time consuming.

In the book, *The Interpretation of Cultures* (1973), Clifford Geertz lays out a framework for what is now 'classical' anthropological methodology in the chapter, *Thick Description: Toward an Interpretive Theory of Culture* (Geertz 1973: 3–30). Inspired by the philosopher Gilbert Ryle, Geertz explain that there is a difference between a 'thin' detached description of a world, and a 'thick' description, which includes many layers of meaningfulness. Thus the 'same' world can be described in-depth as meaningful for all the agents involved, which make it possible to understand their actions on a deeper lever – and superficially in a 'thin' manner, where different actions are noted but not deeply understood.

"In anthropology, or anyway social anthropology, what the practitioners do is ethnography. And it is in understanding what ethnography is, or more exactly what doing ethnography is, that a start can be made toward grasping what anthropological analysis amounts to as a form of knowledge. From one point of view, that of the textbook, doing ethnography is establishing rapport, selecting informants, transcribing texts, taking genealogies, mapping fields, keeping a diary, and so on. But it is not these things, techniques and received procedures, that define the enterprise. What defines

[1] A serious game or applied game is a game designed for a primary purpose other than pure entertainment (Souce Wikipedia).

it is the kind of intellectual effort it is: an elaborate venture in, to borrow a notion from Gilbert Ryle, 'thick description' [Geertz 1973: 5–6].

However, when the thick descriptions of REELER (see *Perspectives on Robots*, responsiblerobotics.eu) hit the demands of coding and programming, a process of reduction is bound to take place.

The setup of BRICKSTER is simple: Players take on the role of CEO of a robot company tasked with building a robot to solve a particular problem. They construct the robot by researching modules, which costs money (coins) of which they have a finite amount. Modules are grouped into several categories (e.g., movement systems, manipulators, sensors) with each category containing multiple different options (e.g., wheels or continuous track), each with particular benefits and drawbacks. The choice of which modules to develop can be informed by interacting with different stakeholders and end-users, who provide a piece of contextual information in favor of one of the different modules – e.g., expressing a want for a particular module, prohibiting the use of a module or simply disliking a particular module. The information available from stakeholders and end-users is unfolded as the game proceeds. The player has to balance economic viability, legal constraints, customer, stakeholder and end-user wants and needs to construct a functioning robot, which succeeds in fulfilling its purpose. Mechanically, choices are made by players clicking through various screens (see Figure 2).

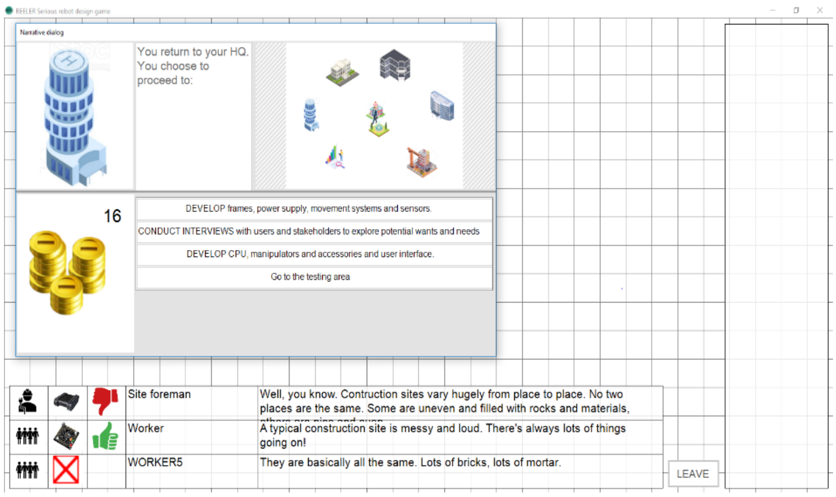

Figure 2 – The revamped design game. In the bottom panel stakeholders indicate their disposition towards particular modules. In the pop-out screen, players keep track of their remaining resources and review their current options. Clicking a button take you to a new screen with new options for

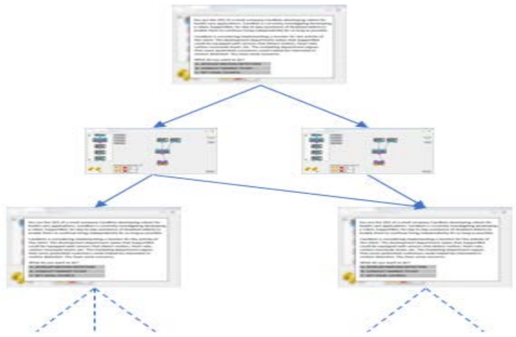

Figure 3 - Mockup of the original tree architecture.

Initially, we wanted to construct the interaction architecture of BRICKSTER as a decision tree, which would structure the development process and anchor design decisions to specific points in the process. This made the game simple to play, by making it linear and deterministic and easy to navigate. However, as mentioned above, real world design did not have this linear, deterministic structure. Rather, they were recursive and non-linear, where choices about particular modules might be revised throughout development. We were then faced with a dilemma: Should we choose to simplify the development process to make the game simpler to play, or should we embrace the 'chaotic' nature of the actual development processes studied? This would be a question which would return several times throughout development of the game, and it is the central topic of the second section of this paper: how to manage conveying a message in a game (e.g., by making the game simple) while doing justice to the nuanced nature of the ethnographic data?

In the case of the interaction architecture, we chose to move away from the simplistic picture painted by the decision tree for several reasons. For one, we wanted our game to mimic the actual development processes that we had identified through the ethnographic fieldwork. But more importantly, the structure of interactions that a game affords helps shape the way players think about the game. We did not want players to think of development processes as linear, non-recursive or deterministic. Rather, we wanted to open up for thinking in new ways about development, in order to facilitate the central point of developing the game in the first place. We wanted to give the players the freedom to 'design' their own development process, as they played through different iterations of the game. This meant, for instance, that in one play-through, a player might focus too heavily on just developing and assembling the modules and race to finish the robot. They would then have their robot do poorly in on-site testing, because they had failed to account for the environment into which the robot was embedded or the end-users who would be using the robot. On another play-through, the player might expend too many resources on interacting with many stakeholder/end-users and be left with too few resources to develop the modules required to finish the robot.

In other words, we wanted an interaction architecture that could facilitate experimentation and learning. As in real life, there are no perfect strategies, and the game was designed to not degenerate into an optimization problem. This meant that more often than not, players would find themselves with robots that fulfilled some-but-not-all of the wants and needs of customers, stakeholders and end-users. Thus, a tertiary point of the game became that there are no perfect solutions, but that gathering a large amount of information helps ensure that you make your decisions on the firmest possible grounding.

After some discussion, we settled on a maze-type interaction structure (Ryan 2006), where players could move freely around the maze and go freely from developing modules to interviewing stakeholders. Thus, the game did not dictate that players adopt any one particular strategy for developing a robot. Through these discussions, another question also arose, which will be the center point of the third section of the paper. While the discussion surrounding the decision tree revealed that there were downsides to departing too much from reality, it is worth questioning if there could be an upside to *departing* from mimicking the development processes identified in the data. We argue in section three that this is the case.

Section 1 – The nature of ethnographic data and its resistance to formalization.

The general and the particular

In evaluating the process of the construction of BRICKSTER, we realize that ethnographic data may be more difficult than foreseen to transport into a programming language. In order to understand the problems we ran into, consider the concept of the *electron*, a prototypical scientific object. The defining properties of the electron are very well understood; for example, it is a fermion, has spin ½ and charge -1 (Gribbin, 1984). These properties are completely universal, i.e. shared by all electrons. Knowing about the general properties of the electron and how it interacts with other particles lets you predict, with remarkable certainty, what you will measure when you conduct experiments with electrons. In fact, all electrons are alike to the point that physicist John Wheeler suggested that the universe might be inhabited by just a single electron, whose world line (its path in 4-D space) intersects space-time multiple times at each 'slice' of space-time (Gefter 2014).

On the other hand, consider the concept of *religion*. It is almost universal among human societies, but it is concept of an entirely different form. As an empirical phenomenon it is established well beyond any reasonable doubt that religion exists, and it has been studied as much and as carefully as any particle. It can be described thinly by simply describing what people do, when they are religious. However, it can also be described thickly by including all the thoughts and emotions behind the actions tied to be religious. An electron is completely defined by its properties; if a particle fails to have just one of these properties (e.g., spin ½) it is not an electron. On the other hand, there are religions that fail to have one or more of the characteristics of a religion[23] - e.g., it can fail to have gods (Jainism), but a thick description would still place the actions of agents as religious acts.

Thus, it is plausible to suggest that there are empirically demonstrable concepts (such as religion), whose instantiations are not completely determined jointly by all the scientifically identified and programmable characteristics of the concept. We might say of these concrete instantiations that they share what Wittgenstein (1953) called a *family resemblance.* They are *practices* bound together by similar (but not identical) behaviors, which can carry widely disparate meaning. In fact, they are at their core, practices imbued with meaning, which is only available to the initiated or the ethnographer engaged in exploring thick description. For this reason, we say that what binds them together, i.e. that which makes us say that they are indeed instantiations of the same concept, is a *pattern*, which every instantiation of the concept contributes to and is part of. By this we mean that looking at a sufficient amount of phenomena (finding a pattern of phenomena which can be argued not to be accidental), we begin to see their family resemblances: the patterns, which makes us theorize that they indeed are instantiations of the same concept. Our use of the word 'instantiations' in the preceding discussion might thus seem somewhat circular, since we say that something or other is an instantiation of a pattern, which of course presupposes that there is a pattern, which is exactly what we are trying to establish. However, this apparent circularity is illusory: something or other exists as a phenomenon, and through continued studies and analysis, we might argue that there is a family resemblance between a wide range of very diverse phenomena, at which point we say, we have established a pattern. This pattern appear all the stronger based on the diversity of the REELER case materials making each case of the phenomena a instantiation of this pattern (see REELER methodology at responsiblerobotics.eu). Hence, by initially working inductively, we establish the potential existence of a pattern, before deducing which phenomena (gender, lack of consideration for affected stakeholders, normativity etc.) should be classified as instantiations of this pattern. On a side note, this problem of *demarcation* (i.e. what is and is not an instantiation of, or part of, a pattern) is not unique to traditional humanist or social scientist endeavors. The same problem exists in the natural sciences, which has been extensively documented in the philosophy of science (e.g., Popper (1959) or Fleck (1981).

However, the world in which the ethnographer does this work, and in particular, it is the world in which REELER has conducted its studies, is full of complex meanings tied to materials and concepts that only make sense when connected in thick descriptions. Over the course of a three-year period, REELER conducted more than 100 interviews across 11 different cases, ranging from traditional manufacturing robots to humanoid and social robots. The data output was more than 100 hours of recorded interviews

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[3] Which properties or characteristics might serve as defining characteristics of a religion is a topic of some debate. For an influential account of some of these see Frazer (1906-15).

with people involved in very different ways with different robots, cataloging the width and breath of how people designed, developed, interacted with, thought about, and were affected by robots. Through analytical work, patterns emerged across cases, and these patterns are documented in the publication *Perspectives on Robots*. However, patterns are actualized in highly context sensitive ways, and their instantiation differs significantly from case to case. E.g., one key finding of REELER is the existence of a *conceptual gap* between robot makers and the end-users and affected stakeholders. One part of this gap is non-inclusion of end-users in the development process across all of REELERs cases. However, the reasons for not including users vary from case to case. In one case, the non-inclusion is caused by a lack of sensitivity to potential actual users (as the company owners who buy the robot are considered 'users' though that shall never touch a robot). In this case, developers are simply not aware of the end-users as a potential source of useful input. In another case, the developers misconstrue the nature of the end-user – seeing them as 'spoilers' of otherwise well-functioning robots. Even when end-users are specifically recognized as for instance patients in need of a robot that can help them, other affected stakeholders are overlooked. What REELER names 'directly affected stakeholders' are not end-users, but are nevertheless directly affected by the robot's presence.[4] As a pattern of 'absence' REELER find that these people are most often completely overlooked by the designers. Such a directly affected stakeholder can be the nurses who need to mount an exoskeleton on an end-user and need training to implement the robot properly. As a result of this 'blind eye', in the development of robots to facilitate physical retraining after a health incident, the developers involve the hospital owners or the leading physician, who are not, like the nurses, involved in everyday care or retraining activities. The robot developers think of users in an institutional sense and talk to the people representing the institutions, not as concrete individuals, e.g. nurses or physiotherapists, who has to work with the robot. Alternatively, they rightly identify the end-users, but engage not with the end-users but with spokespersons, who are meant to represent a group of end-users. However, these spokespersons are rarely end-users themselves. Still, in other cases, they might identify the end-users, engage with them, but nevertheless fail to understand them.

Each instantiation of the pattern helps draw out and make visible the general pattern, but they do this through their specificity; by their very nature, they are different from each other. Some of the patterns are characterized by their asymmetrical nature. Analyzing each of the cases brings the pattern into view, but knowing the pattern does not, a priori, bring each of its instantiations into view. In other words, every instantiation carries significant information about the general pattern, but the pattern does not carry an equal amount of information about its instantiations. Just knowing the pattern will not be enough to predict precisely in which form one is likely to encounter the pattern in particular cases.

[4] See the Human Proximity Model at https://responsiblerobotics.eu/.

To make a game, where each move leads to a predictable outcome, is a challenge, and what is lost may be that the pattern is not recognized and that individual cases are presented in a way that glosses over their diversity in order to prioritize the predictability needed in programming work.

2. Weighing complexity and clarity in game design

Confronted with an overwhelming amount of data and an overview of the preliminary analysis, we faced the challenge of weighing complexity and clarity. On the one hand, we wanted to do justice to the informational wealth contained in the data. On the other hand, we were constrained by our technical skills, the structure of the original serious design game puzzle, and, primarily, wanting the game to convey a clear message. In the following sections, we present (i) some of the reflections on the complexity of the data, (ii) the influence of technical constraints, and finally (iii) how this balancing act was influenced by our stated objective with developing the game.

Multi-dimensional data

The REELER data contained information about the development trajectories of more than 10 different robots. The data covered disparate areas ranging from supply-chain management to legal altercations. Furthermore, the data was multi-dimensional, covering different areas from different angles. For example, regarding a technical problem, we had data from the engineer engaged in construction of the robots, the customers, to whom the robot was being sold, and the end-users and stakeholder who were, at the time, either solving this problem or suffering from it. Furthermore, REELER's data was not primarily about the purely technical part of robot development, but more so about the sociotechnical systems (culture), in which the robots where developed and into which the robots were introduced.

Throughout our analysis it became clear that precious few of the problems that some of the robots encountered could be reduced to simple causes. At the theoretical level, there were often significant disparities between the expectations of the end-users about what the robot should do and the engineers' vision of what the robots would do. Furthermore, technical problems were rarely isolated to being just a technical problem. What engineers considered a functioning robot, was sometimes found to be technically lacking due to problems arising in the context of use.[5] Some examples of the working papers published in the context of REELER on this topic are from Nickelsenn (2018), Sorenson (2018) and Hansen (2018). Mossfeldt Nickelsen (2018) discusses the importance of understanding the particular situations of user, through analyzing the processes of *tinkering* that occurs in implementation of assistive feeding technology. Sorensen (2018) sheds light on the robot developers'

[5] REELER researchers have documented many of the practical and theoretical problems involved in the design and development in the 11 cases studied. These are available in our publication *Perspectives on Robots*, available from responsiblerobotics.org.

engagement with ethics throughout the design process. Hansen (2018) analyzes, through the lens of Aristotelian concept of *phronesis*, practices of decision making in the development of new technology, paying special attention to the role of virtues and vices.

Technical constraints

Choosing to expand on an already existing program architecture narrows the scope of development considerably, but also had several benefits. The primary benefit was avoiding having to program an entirely new architecture for the game to run on. In the short run, this meant that we were quickly able to test a primitive prototype of the game and get a feel for what was possible with the structure and what was not. However, for the same reasons, starting from an existing architecture was also a significant constraint, since it meant limiting the scope of our game to what was possible to implement in the architecture.

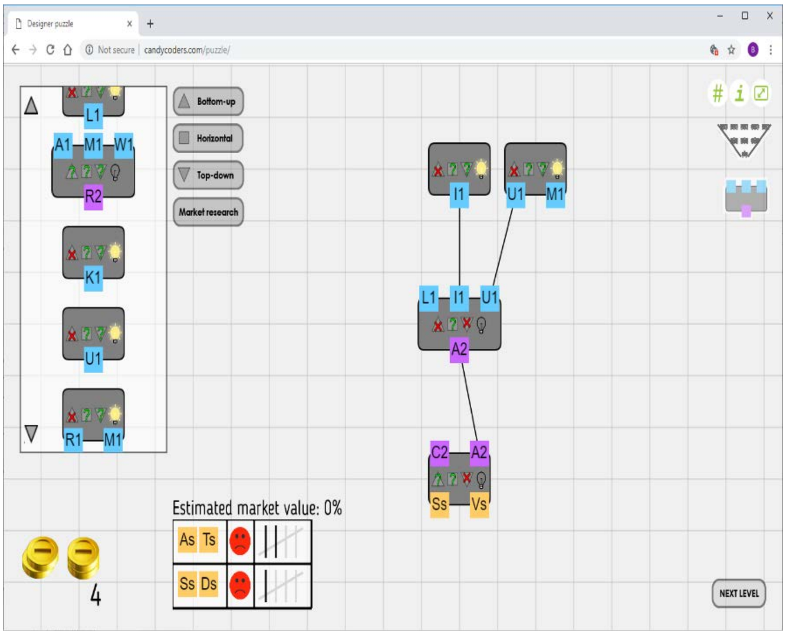

Figure 4 – The original game. In the left-hand column, the developed modules are available. In the bottom the remaining resources are shown, as well as a 'estimated market value', a measure of how well your design is doing compared to market wants. Every action was initiated from this screen by clicking one of the four buttons next to the module list: three technology buttons and one market research button, which extended the

The original game (see Figure 1) had been focused on players dealing with informational scarcity and having to connect particular generically labeled modules (e.g., L3) with other modules suitably labelled (e.g., LV342) in conformity with market needs, which were for a generically labelled service (e.g., Ss). This meant that the original game was devoid of all context (all narrative elements) and centered squarely on the technical tinkering of connecting the

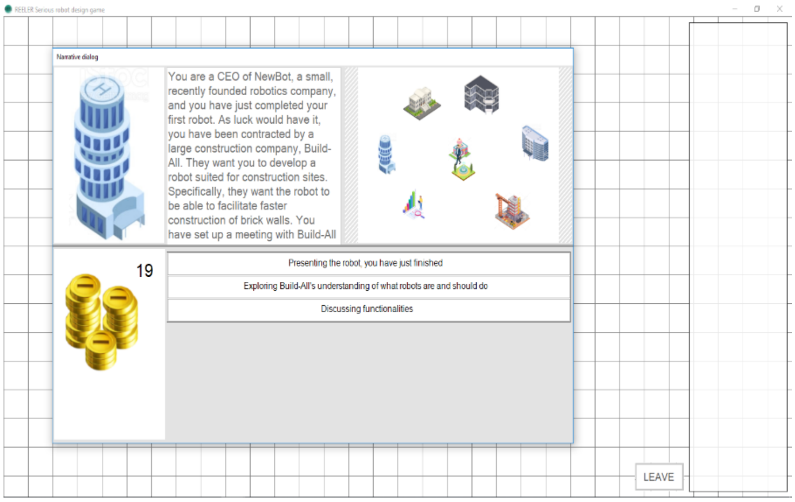

Figure 5 – The revamped game. All interactions are initiated through the buttons on the overlay. All actions are contextualized, and each decision is presented with a small introduction.

modules. In contrast, we wanted our game (see Figure 2) to focus on the particular design and development context of the robot. When we tasked players with constructing a brick-laying robot, it was important to impart players with knowledge about the concrete wants of the customer (e.g., X bricks pr. minute, able to operate outdoors), and, in particular, the wants and needs of stakeholders and end-users (e.g., "the robot should not slow me down, since I am paid on a piecework basis"). It was important because the point we wanted to convey with the game was exactly how players could learn to take end-users and affected stakeholders seriously early in the design process.

Managing technical constraints and data complexity

We knew from the beginning that emulating a realistic design process would be quite an ordeal, but we nevertheless endeavored to do this initially. However, this quickly turned out to be infeasible for several reasons. Firstly, the amount of work needed to process the REELER data and rewrite it to fit a fictional robot, which was unrelated (for reasons of anonymity and NDAs) to any of our studied cases, and which showcased all of the problems identified in REELER was not possible within the timeframe. Secondly, the architecture of the original game was not programmed to present so much text, and there was no way, programmatically, to present all of the information in one screen in a way that was clear to the player. Furthermore, since the architecture was, to some extent, premised on a linear progression through the story, the players would lose interest or get lost in the maze of screens required to convey all the information necessary to address the problems presented by the particular case.

3. Identifying problems and solving problems are not the same.

In REELER, ethnographic research has found that engineers often believe that what they see as a problem is the same as what the people who are going to use a robot see as a problem – though this is rarely the case. This raises some questions for the game-design. What constitutes a problem? And what is suffices to be a solution? These are the central questions we concern ourselves with in the following section. The questions relate both to how we formulate problems within the context of the game, i.e., what are the problems that we want the players to potentially encounter in the course of developing their robots, and to the problems identified in the REELER data. In general, engineers seem preoccupied with the problems that are narrowly technical, concerning e.g., a faulty sensor. This might be due to their anchoring in the natural sciences, a world that is, to a large extent, linear and deterministic, and thus, in principle, predictable. In this sense, technology exists as something in and of itself, to a large degree independent of its environment. This world contrasts heavily with the world as studied by anthropology, which is attested by the nature of the data the ethnographic fieldwork produces. From this view, technology is never an isolated entity, but always technology-in-use. In the following section, we shall see how these ways of viewing the world interact, and how we adopted a hybrid version in the game.

What is a problem? And what is a solution? A look at REELER research.

These problems are again two-fold. The robot developers, stakeholders and end-users interviewed by REELER pointed to a set of problems. These were the ones they had experienced through developing, using, and being affected by the robot. By the nature of these problems, this is by no means a homogenous set. Very few of the problems found by affected stakeholders and end-users are reducible to merely a technical problem (engineers tend to do that)[6], e.g., a malfunctioning sensor. The majority of the problems arise in the context of use, becoming apparent only in the implementation phase of the robot. They can involve social and physical issues that appear only in relation to the technical issues focused on by engineers.

There are many reasons for this, which we discuss at length in *Perspectives on Robots*. However, one of the central reasons is that robots are tested in experimental setups that do not accurately reflect the realities 'on the ground', and end-users are not consulted to a degree sufficient enough for them to point out potential problems, which might arise in the implementation phase. This is due, in part, to the way most robot developers conceptualize robots, namely as primarily technological entities, largely removed from the environment into which they must ultimately be imbedded. Being trained in this way of developing robots, engineers are experts at identifying and solving the technical problems that arise during development. However, this also risks blinding them to the problems that are not narrowly technical. These are the problems identified by end-users and by REELER's researcher through the analysis of the data material. The problems that become apparent in implementation, or on-site testing, have, at their core, a cultural component, but they might be framed as a technical problem. For example, WIPER, a construction robot, was meant to relieve workers of heavy burdens and was perfectly functional in a technical sense, but the robot was never used by the end-users, who deemed it to be too slow. Speed was crucial for the workers, since they were working on piece rates.

The other set of problems were higher-level problems identified by REELER. These concerned more general misalignments between how end-users and robot developers conceptualized robots, their work and their work place. Once again, robot developers conceptualize robots as technological entities, and they see their robots as a liberating force, which frees workers from menial work and alleviates the physical strain involved in manual labor, such as construction or cleaning. Connected with this conceptualization of robots, robot developers often conceive of manual (and other 'menial') labor as schematic, highly rigid forms of work, easily decomposed into atomic parts, some of which can then be easily automated. From this view, the autonomy of the individual workers doing this type of work is very limited.

This view is often opposed by end-users doing manual work, who express satisfaction with their work (although not always with the socio-economic conditions surrounding their work). [7] The people who are intended users of robots often view robots through the lens of popular media, in particular science fiction movies such as *Wall-E*, *Terminator*, or *I, Robot*. Finally, end-users rarely find robpots autonomy to be limited to quite the degree robot developers imagine. Cleaning, considered *in*

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[6] See *Perspectives on Robots* , p. 45: https://responsiblerobotics.eu/wp-content/uploads/2019/12/perspectives_on_robots.pdf

[7] See *Perspectives on Robots* , p. 189 *ff.*: https://responsiblerobotics.eu/wp-content/uploads/2019/12/perspectives_on_robots.pdf

abstracto, as an activity, might be divided into distinct sub-activities that lend themselves well to automation from the point of view of the engineer. However, cleaning, considered *in concreto,* as practiced by cleaning staff, is always is highly context sensitive. Different workers have different routines, which are often synched with each other, to make it possible to share cleaning supplies and machines. These routines are planned by the individual workers, and this autonomy is described by the end-users as being immensely valuable.

For the purposes of BRICKSTER, we were primarily interested in the problems that were not narrowly technical, but rather the problems that concerned the robots as *technology-in-use*. Thus, the potential problems that we wanted players to face when developing their robots were problems that required an understanding of the *lifeworld* of the end-users, for their solutions. For example, we took the problem presented by the slow construction robot, which was meant to relieve workers of physical strain, but ended up not being used because it was too slow, and integrated it into the game. This was done by having stakeholders/end-users stating their concerns about whether or not the robot would be fast enough to speed up their bricklaying, rather than slow them down. While the real robots in REELERs case studies did not include a bricklaying robot, it was the same general type of robot, i.e. a construction robot, which made adapting the case to fit BRICKSTER quite easy, since the salient variable (workers on piece rates) was easily transferable to the context of bricklaying.

This brings us to the discussion of potential solutions, and what would qualify as such. For most of the developers interviewed by REELER researchers, solutions are framed in the same way as problems. Technical problems require technical solutions. Of course, this cannot, on its own, be a critique of developers, since their occupation depends critically on them being able to identity a technological solution to a given problem. Indeed, this was the solution space that we adopted for our game as well, since initially we wanted the game to be played by robot developers. There are reasons to criticize this choice, since it does imply that we accept that technology is the solution. However, it should be noted here as well that the purpose of the game was centrally to have developers reflect on their development process and how it might have been different, if they had involved stakeholders/end-users early on in the design process. It was to show that involvement of stakeholders/end-users through-out the development process changes this process and shifts the emphasis from robots as a solution to a specific problem to robots as technology-in-use. Thus, the game presents a hybrid model, fusing ideas about technology-as-technology and technology-in-use, which acknowledges that technology can, by itself, be a solution, but it has to be situated in the context of technology-in-use.

Furthermore, it should be noted that accepting, within the context of the game, that technology is the solution does not mean that there are, in general, no other potential solutions. In the broader context of REELER research, we have suggested such different solutions to the broad range of problems identified. These are available in *Perspectives on Robots* (responsiblerobotic.eu).

Presenting the problems and the solutions within the game

Once we had identified the problems and solutions we wanted to be part of our game, we had to come up with a way of linking the two together in the architecture of the game. Initially, we wanted the game to mimic what we had found in the REELER data: problems with the robot as technology-in-use only become apparent at the final stages of development. Thus, players only became aware of the potential problems with their robot, when they had assembled an entire robot and went on to test at a worksite. However, we went away from this way of structuring the progression of the game, since in the test plays, the feedback from our testers was that it was too hard to make out the connection between choices made earlier in the game and their effect on the final outcome of the game. This was due to two things. Firstly, players could not test their robot before they had developed a 'functioning'[8] robot, just like robot developers do not test manipulators or movement systems isolated at the test sites but rather as an ensemble of parts; as a robot. Thus, players would have to develop a significant number of modules and connect them on the puzzle screen before being able to test their robot. Since there was no way to track your progress or your previous choices, some of the testers found it hard to link the test results to particular choices made previously. Secondly, the test results were presented to the player in the form of a narrative piece of prose, which told a story about how the testing had gone, whether it had been a success or a failure. One example is:

> *You go to the worksite and set up the rail system needed for your robot to function. After covering a sizeable part of the site in rails, your people start mounting the robot on the rail and preparing for the presentation. Meanwhile, you are approached by an angry worker, who tells you that the rail system is very inconvenient for the workers, who are forced to go around the rails with their wheelbarrows and machines. You assure the worker that this was not your intention, and that, indeed, this is an unfortunate side effect, but such is progress. The demonstration goes off without a hitch, and the Build-All executives are very happy with the product.*

To the testers, it was clear that this problem stemmed from the utilization of rail-guided movement system, which caused workers to be unhappy, but, in this instance, satisfied Build-All, which is the customer in the game. Thus, the robot is a commercial success, although it might not be popular with the end-users (the text mentions nothing of the robot's fate following the test run). However, many of the testers were unsure about how the text related precisely to the choices they had made in regard to developing particular modules. In particular, they wanted to know how they could have predicted that this problem would arise. They were, in some sense, developing modules in the dark. This was due to how the game was structured. When these tests were conducted, the game consisted of a puzzle screen, where players connected the modules and a menu screen, initially titled "Headquarter" which let you go into either stakeholder/end-users interviews or module development. If players wanted to go from interview to module development, they had to return through the menu. This was done to reflect how stakeholder/end-user studies are usually separate from module development. When choosing to interview stakeholder/end-users, players would go to work sites or offices, where end-users were found. Development, on the other hand, took place in the company's R&D department. Thus, it was up to the players themselves to gather the relevant information from stakeholder and end-users to avoid the potential problems associated with particular choices of modules. Furthermore, if the player did decide to interview stakeholder and end-users, they also

[8] By functioning robot we mean, in the context of Brickster, that players have connected, as a minimum, a movement system, a manipulator, a power supply, a frame, a central processing unit, and some simple sensors.

had to interpret the implications of the end-users' statements. One example of such feedback is:

> *Honestly? I'm paid for every brick, I lay. So I want it to help me speed up my brick laying - not slow me down.*

Thus, players had to figure out for themselves how to operationalize the feedback provided by the stakeholder/end-users, and while players were given the option to interview stakeholder/end-users, they were not directly incentivized to do so. This meant that few of the testers engaged deeply with the stakeholder/interviewers focusing instead on developing modules.

Following these tests, we decided to remove the two-part menu, and instead merge development and interview submenus into one menu. Thus, players would have access to the relevant stakeholder/end-user feedback tied to particular modules, as they were developing those modules. This meant doing away with some of the complexity of the game by making it easier to engage with stakeholders/end-users at crucial times throughout development, as well as making it easier to interpret the stakeholder/end-users' statements, since it was clear which category of modules it belonged to.

Furthermore, to our minds this also meant removing the game one step further from the real world, since the processes of gathering stakeholder or end-user information is often separate from the development of the technical modules. When considering the best interaction architecture to facilitate the central point of the game, that involvement of stakeholders and end-users changes the design process fundamentally – and make designers aware of potential problems before the final stages of robot development - we had discarded the decision tree architecture on exactly these grounds. However, in this instance there is something to be said for departing from reality. Such departures can make the contingent nature of current practices visible, and players realize that they could actually structure their development process differently – even if they can't structure it exactly how it is presented in the game. Presented as a game about learning (about the value of including stakeholders and end-users in design), it has the potential to change the way developers think about the role of stakeholders, and where they fit into the design process.

Thus, the game introduces a new, synthetic reality, where processes that are separate in the real world are suddenly joined at the hip. This reconfiguration of the structure of reality might be construed as a didactic fiction. We fully acknowledge that the real world is wonderfully complex, but by imposing a simple, and not entirely realistic structure on the design process, we can help bring out things, which were hidden or ignored previously, and, in the best case, bring about a reappraisal of the value of stakeholders and end-users.

4. Scenes from a play-through

In this final section of the paper, we present some snippets from a play-through conducted by one of our anthropology researchers. In particular, we focus on some of the key take homes from the game, which might be of use to robot developers.

The first screen that meets the player is a small introduction, which sets the scene for the developments of the game. The text reads:

> *You are a CEO of NewBot, a small, recently founded robotics company, and you have just completed your first robot. As luck would have it, you have been contracted by a large construction company, Build-All. They want you to develop a robot suited for construction sites. Specifically, they want the robot to be able to facilitate faster construction of brick walls. You have set up a meeting with Build-All to discuss the details of this robot. You start your talk with:*

From here, the players has to choose between one of the three options, which are:

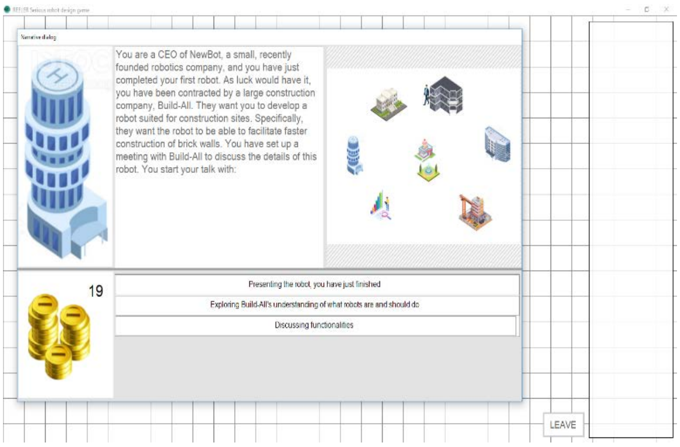

Figure 5 – The game's starting screen.

1) Discuss the robot you've just finished.
2) Explore Build All's understanding of what robots are and should do.
3) Discuss the functionalities of the robot.

Here the anthropologist remarked that, being an anthropologist, she would start by exploring the customers' (Build All's) understanding of what a robot is and should do, since this serves the practical goal of establishing a common understanding about what the robot should do. She stated that, more importantly, it is the beginning of establishing a common vocabulary for discussing the robot, i.e., establishing the ground for collaborative learning. Through the next screens, our player clicks through different screen, making decisions and coming to an agreement with Build All about the functional requirements of the robot. Afterwards, the player is taken to the menu page, from where they can get into the development of the specific modules.

Here, players choose between which modules to develop next, having the ability to choose between seven different categories. Initially, our player chooses to get into the development of the power source, where the battery is quickly decided upon as the superior choice. The choice is made without expending resources on interviewing any stakeholders or end-users.

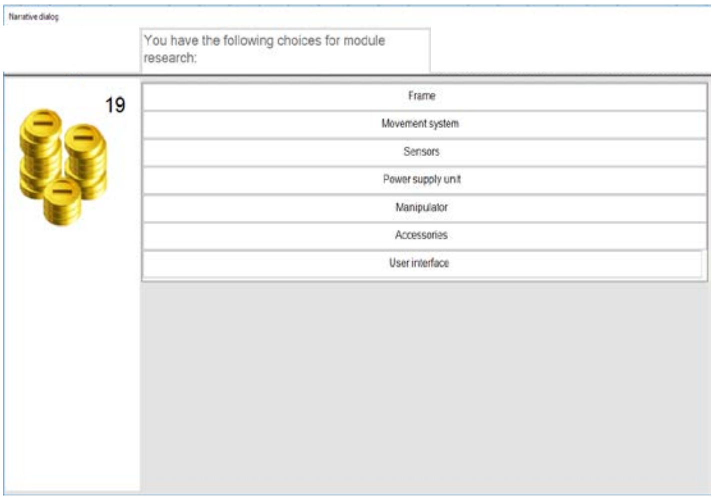

Figure 6 – The menu page.

Then, having chosen the battery, our player is returned to the menu screen, and initiates the development of a movement system. This time, she expends quite a few resources to interview some of the relevant end-users and stakeholders.

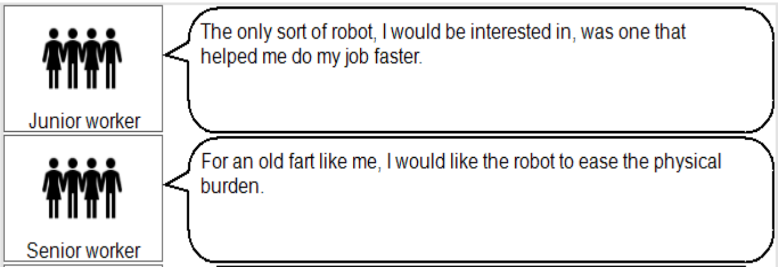

Figure 7 – Example of end-user feedback.

Explaining why our player chooses to expend resources on gathering stakeholder and end-user feedback she argues:

It's not enough for me to know that the robot can move around in the environment. I have to know this environment [to pick the best option]

Elaborating on the need to involve several more stakeholders before making the decision, our player mentions the importance of understanding the different motives of the end-users for engaging with the robot. In the example above (Figure 7), the junior workers favor speed, which in this business often comes at the expense of physical wellbeing, while the senior workers would prefer robots that help prevent physical harm, even if it might come at the cost of reduced speed.

However, she also has a few critical points, which mirror the discussion from section two and three about the relationship between the real construction site and the construction site of the game:

> *Of course already here the game becomes much poorer than real life. Because when I go out to a construction site, I see not just the people; I don't just hear what they answer to my questions, but I'm already taking in all kinds of information from their lifeworlds, you could say. I see how thing are in connection to each other, I see relations, how they lift, how they carry. But also how they have breaks, how they talk to each other. How they stumble over stuff, all kinds of stuff. So complicated that it would be impossible to put in this game.*

At the end of the deliberations, our player decided on developing the continuous tracks as a means of movement. We then asked the player to develop one final module before ending the play-through. Our player chose to look into the development of an interface through which the workers could issue command for the robot. Here, our player consulted only a single stakeholder – the foreman. He spoke about the noise levels at the construction site, which our players interpreted as a reason for not developing a voice-controlled interface. However, as the player notes, it is something that one could have also gotten from simply being at the construction site.

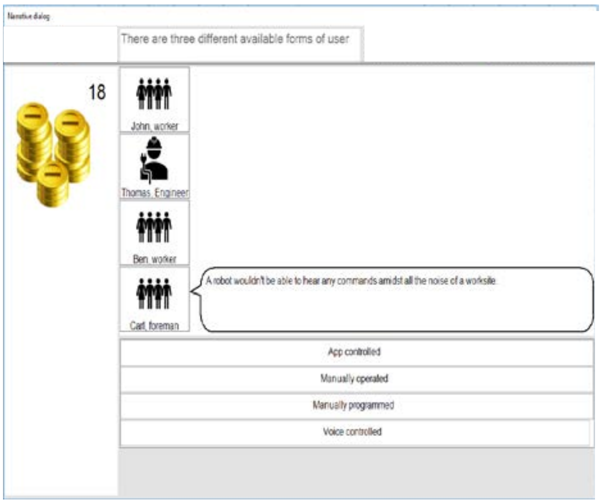

Figure 7 – Interface development page.

From this short play-through, our player found that there were two main take home lessons. Firstly, there is a need for be conscious of the end-users and their motives for engaging with the robot. If you want the end-users to engage with (i.e. use) the robot, you have to know what would make them want to interact with the robot. Secondly, there is a need to be aware of the environment into which your robot is embedded and to design accordingly. In a wide context, this means being mindful not just of the specific environment you are conducting your tests in, but also potential environments, where the robot might be deployed in the future.

5. Conclusion

The point of this short play-through was to showcase what kind of stories are possible to tell within the framework developed with this game. The game is best at facilitating fairly simple points, which can link stakeholder/end-users' statements to a particular module, either problematizing or praising it. However, it might be possible to implement a more 'grand' narrative, which focuses on one particular area. This would be a version of the game, where all the problems that you might face as a developer are related to a particular pattern. For example, the game might revolve around *enveloping* (Floridi 2014), the process of adapting an environment to fit the needs of the robot, and the problems that arise from this. The architecture of the game lends itself well to such adaptions, but this would require adapting – which involves decontextualizing – the ethnographic data collected by REELER. Given the concerns revolving around the generalizability of ethnographic data expressed in the previous sections, this is an endeavor, which should be undertaken with some care. The work begun in REELER may inspire others to carry on in a similar way – however with an awareness that this kind of project work, although rewarding, is also time consuming.

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