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# Toward the understanding of ‘the human’ in engineering: a discourse analysis

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## ABSTRACT

This study addresses the interpretations of the human in the discourse of civil industrial engineers in Chile and analyses their relationship with ethics and training. We argue that engineering is a heterogeneous activity that requires the alignment of multiple elements. Among these, assumptions about the human influence both the design of productive processes and the ways in which humans participate in organisations. Considering these aspects, we analysed the interpretative repertoires present in the discourse of civil industrial engineers, generated through individual and group interviews. We describe three ways in which the human is understood in engineering: in the casual, caring, and typification repertoires. After describing them in terms of how they discursively perform versions of the human, we discuss their ethical and practical implications for the engineer training processes. We conclude by discussing how viewing ethics as a product of daily practices can influence both training and daily professional activity.

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Ethics; human; industrial engineering; performativity; discourse

## Introduction

The last few decades have witnessed a growing interest in the social consequences of the presuppositions involved in the work of engineers, particularly regarding ethics (Harris Jr 2008; Hollander and Steneck 1990; Leboeuf, Pizarro, and Espinoza Lolas 2013; Lynch and Kline 2000). This approach has involved attaching great importance to the analysis of the practices of engineers, given that their work is not limited to the design and execution of operations related exclusively to their areas of application. Once this work is released, it starts affecting and transforming the multiple environments with which it interacts, therefore influencing the performance of human relations within them (Bijker and Law 1997; Law 2012). As Akrich (1992) points out, the design of technical procedures defines ‘actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science and economy will evolve in particular ways’ (208).

With these assumptions in mind, the aim of this study was to describe the notion of the human present in the discourse of Chilean civil industrial engineers. This enabled us to provide new insights into engineering education, especially reflections on the practical and ethical implications of engineers’ work that transcend the technical domain to influence people, society, and ultimately the planet. This discourse was accessed by means of individual and group interviews, transcribed and analysed by means of discourse analysis, an approach to text analysis that comprises a number of techniques that make it possible to interpret what people say, providing sense and meaning.

## A perspective of the human in engineering

Engineers working in process design and development – in particular those linked to industry, the markets, and technological development – constantly combine technical, scientific, and sociological analyses (Callon 2012). This means that the social component should neither take away from nor add anything to the design process or process implementation, but rather allow for the existence, delimitation, and performance of these processes (Law 2012). Ultimately, engineering design can in itself be understood as a social and technical activity (Callon 2012).

In this respect, the notion of ‘heterogeneous engineers’ advanced by Law (2012) describes agency, that is, the capacity to make a difference or produce change (Tirado and Domènech 2005) when building ‘messy networks that combine technical, social and economic elements’ (Bijker and Law 1997, 12), which is part of virtually any engineering activity. In these networks, the technical or scientific quality of a process is not exempt from a series of preconceptions regarding the nature of the actors involved (Latour 1996) or from ethical prescriptions which play a role in shaping how social relations are developed (van de Poel and Verbeek 2006). Even technical practices are sustained by discourses and values that set conditions for how their outcomes must be locally interpreted and how users must understand themselves to participate in them (Akrich 1992).

Engineering contributes to the creation of how humans inhabit society (Latour 1987). In Chile, Civil Engineering has gained preponderance in hierarchical outlooks due to its association with problem-solving, proactivity, and leadership (Forcael et al. 2013). One of its multiple branches, Civil Industrial Engineering in Chile focuses on productive aspects, quality and efficiency management, and the optimisation of a wide range of industries. Thus, actions and assumptions of industrial civil engineers have a large effect on the settings and procedures of problem-solving and how humans are considered in them (Lozano 2006). Beyond the technical or strategic aspects of organisations, decision-making involves an analysis of the potential consequences of engineering work, including health risks, environmental impact, adaptative processes, caring aspects, and time management, among several others (Harris et al. 2019). In this context, ethics seems to be a problematic subject, especially for young engineers, due to tensions between the mandates of efficiency and social responsibility (Pasmanik et al. 2016). Nevertheless, these issues may be tackled using concrete experiences during educational training (Valentine et al. 2020).

In relation to ethics, the notion of ‘the human’ (the characteristics that define what it is to be human) and assumptions about its capabilities and conditions for working and living everyday life have a major impact on the design of processes and environments and, mainly, on definitions of the good and the bad concerning these aspects (Akrich 1992). In fact, as the philosopher and physicist Karen Barad (2007) has pointed out, the ways in which processes are implemented and how the world itself is configured are deeply ethical matters, as they entail very practical aspects related to what elements matter more than others and how they are materialised. In this regard, she notes: ‘Ethics is therefore not about right response to a radically exterior/ised other, but about responsibility and accountability for the lively relationalities of becoming of which we are a part’ (2007, 393). In that sense, ethics is not just a concern about questions about what matters, but rather is the very nature of what it means to matter (Dolphijn and van der Tuin 2009). How the human is thought and what practices are derived from it are mainly ethical questions.

Beyond the arguments regarding how ‘human factors’, ‘human resources’, or ‘human capital’ participate in the configuration of organisations and industries – and how to take care of them by addressing their experience, education, and abilities to improve results and production and reduce mistakes and accidents –, the assumptions on the part of engineers concerning the human affect the design of organisations themselves in terms of the emphases and arrangement of internal economics, social relations, and the spatial and temporal aspects of procedures, among other factors. It is only when assumptions about the elements in an organisation are relatively aligned with the actors’ actions (human and non-human) that some order and stability can emerge (Akrich 1992). Engineers’ reflections and assumptions about what counts as human

nature and, on that basis, what is relevant to people's well-being or care, are of great importance when we consider the implications of their decisions for all areas of organisations and human life. This is fundamental when we think about the education of professionals, particularly those involved in engineering, and most of all when taking into account how, in their daily practice, engineers align elements that define ways of working and living (Callon and Law 1997).

In this article, we raise some questions regarding the resources for interpreting human nature that Chilean industrial engineers possess – as observed in their discourse – and weigh up the implications of the fact that these definitions have ethical consequences. Our ultimate goal is to shed light on how to guide reflections on ethical concerns beyond the deontological subject in engineering ethics education.

## Empirical ethics in engineering

In this study, ethics in engineering is taken to consist in the practices of argumentation about legitimate actions (e.g. the good or the bad elements of decisions or implementation processes) observed in concrete scenarios. This could be understood as an empirical approach to ethics or, in the words of Willems and Pols (2010), an *empirical ethics* which refers to 'understandings of theory and practice, in particular, understandings that locate theories in our practices rather than underlying them' (Hoffmaster 1992, 1428). It combines empirical social research (usually qualitative) with analysis of normative aspects in discourses and everyday activities, for example, common conversations about movement flows of people in a given structure, how to make a certain calculation, or which elements to integrate in this operation. These conversations can be normative, since they integrate relatively static views – accepted by the participants of the interaction – about what is appropriate or inappropriate for certain situations. Empirical ethics implies an attempt to avoid the traditional normative-descriptive distinction, i.e. 'what ought to be' vs. 'what is', assuming that there is no obvious distinction between what is considered good and what people approve of (Willems and Pols 2010). From this perspective, practices and discourses between engineers do not 'simply reflect opinions on the good, but show how participants invent and develop goods and activities to bring them about within those very practices. These are not applications of ethics in practices; they are normative inventions' (163), that is, they produce the social realities that they refer to. This proposal is important because it highlights the fact that these understandings not only contribute to 'thinking about' the reality devised by engineers but also express how reality is itself practised and created.

The abovementioned aspects of the implications of everyday practices can be conveyed through the notion of *performativity*. This derives from a philosophical tradition of exposing how everyday processes and categories, even those which we consider 'natural' or 'real' categories (like gender, sex, or humanity itself), are a product of discursive and practical iterations, i.e. are socially produced and sustained (Butler 1997). This approach is grounded in the notion of speech act advanced by Searle (1969), who notes that language, besides allowing us to state certain facts, also carries out or *performs* certain actions. This not only leads us to focus our attention on how our daily social actions, including discursive and conversational ones, represent or describe a reality external to us (for example, qualities about a person), but also highlights how our talking about it outlines and shapes this reality as it emerges from our relationship with it. In other words, we only describe the qualities that we are capable of perceiving or about which we have knowledge, previous experiences, or even language to refer to.

For engineering, this approach has several practical implications. For example, it promotes accountability in everyday relations, serves as a reference point to reflect on the effect of organisational calculations or management design, and aids in processes connected with human management decisions (Aggeri 2017; Muniesa 2014). Language and practices not only represent or shape the world: they also constitute and produce it. This perspective focuses on describing how things – identities and other discursive and practical effects – are performed under certain social conditions.

From this perspective, humanity is not a given condition but a performed one. In that sense, humanity is not an intrinsic characteristic of a person, but an achievement of several routines and discourses (Bernasconi 2015). That is, the practices related to the ontological connotation of the human – what we suppose that the human *is* – can be variable and are adopted in inconsistent ways (Law et al. 2014; Law and Lien 2013). A subject can acquire a number of identities: consumer, citizen, and part of a community or the public as s/he moves through multiple locations in which a given disposition is performed while constituting themselves at the same time (Ureta 2015). In this regard, Hacking (2004, 281) notes: ‘there is not and never will be any universally applicable theory of making up people’ (281). Whenever we identify something like ‘human’, we are dealing with an entity moving or manifesting itself differently from what it was and what it will be (Ureta 2015). Thus, it is possible to think that the definition of the human is in a constant state of controversy. In any case, the role of technology, science, and engineering is extremely important when it comes to comprehending how the human is understood and practised (Jasanoff 2012). And, as we have addressed above, these roles entail ethical connotations, as the versions of what a human is or can become are not neutral, but yield explicitly or implicitly different valuation processes about their relevant aspects and how they fit into natural or artificial, leisure or productive settings.

## Method

This is a qualitative study exploring the performative nature of the discourse of civil industrial engineers in relation to the human. The qualitative approach adopted allows us to describe and analyse meaning production and discursive dynamics in situated contexts (Denzin and Lincoln 2012). Specifically, we employ a qualitative method with a pragmatic perspective, which makes it possible to understand what discourse means in the context where it is produced (Bernstein 2014).

### *Sampling and information production process*

We carried out a theoretical sampling procedure (Maykut and Morehouse 1994), which consists in the intentional selection of participants following initial conceptual guiding criteria, to progressively select new cases in consideration of emerging information, oriented by research objectives. Three selection criteria were employed. First, the university from which the participating engineers had graduated. Only State universities were considered, based on the assumption that they share a matrix of values and an institutional tradition informed by laicism, as conveyed in their mission statements. This opened up the possibility of exploring discourses related to heterogeneous training processes and work experiences. Second, gender. We aimed to interview an equal number of men and women (the gender ratio was relatively similar, although male engineers predominated at a similar rate as that observed nowadays in Chilean undergraduate civil industrial engineering programs, according to the interviews). Third, diversity in terms of the participants’ organisation types and job areas. This process yielded 29 participants, which enabled us to produce 17 individual interviews with 10 men and 7 women working in different contexts who had graduated at least a year before each interview was conducted. They had work experience in a variety of settings, namely education in either academic and non-academic settings and operations in industrial settings, retail, and banks, performing human resources and process modelling tasks. Also, no more than one year after graduation, two group interviews were held with three men and three women each, all of them students who had finished the last work placement module at the end of their engineering program. Each group comprised students from a single university who had been allocated placements in different companies. Group interviews were expected to increase the amount of information that the participants would be able to provide concerning their curricula and their relevance to their work placement experiences. The interviewers encouraged debate and the sharing of experiences.

Interviews were semi-structured and followed three thematic axes: (a) education and training experiences, (b) operations and areas of performance, and (c) potential dilemmas or ethical conflicts in the participants' work environment. Each axis made it possible to conduct a deeper exploration, informed by the content provided by each interviewee, while also partly homogenising the areas explored during the interviews. The interviewers were psychologists who served as research associates in the project. Interviews were conducted in Spanish.

### **Analysis strategy**

To examine argumentation practices in everyday engineering activities and their implications for the notion of the human, we have adopted the perspective of discourse analysis. In this approach, *discourse* is defined as any practice through which individuals give meaning to reality (Ruiz 2015). In discourse analysis, language is seen as a way of building relationships in which agreement on certain ideas can be expressed in diverse ways, combining a variety of language resources (e.g. argumentations, metaphors, examples). The aim is to show how certain processes are considered more important or appropriate than others (Glee 2011; Magnell 2020). Also, discourse analysis lets the analyst establish the functions performed by specific parts of discourse, which makes it possible to identify patterns of language and related practices (Wetherell, Taylor, and Yates 2001).

To address these different patterns, we used the approach of interpretative repertoires [IRs], developed by Potter and Wetherell (1987) based on Gilbert and Mulkey's (1982) research on the ways in which scientists interpret their work. The analysis of IRs underscores the diverse cultural resources that we use to explain our positions on certain issues or to describe what we do. It takes into account the fact that language can be better understood as a social practice (Wetherell and Potter 1996). In fact, IRs can be seen as patterns of discourses used to construct explanations about events or their relationships. To that end, we commonly resort to recurring ways of speaking which are provided by the socio-historical and cultural context in which they occur (Garay, Iñiguez, and Martínez 2005; Garay, Iñiguez, and Martínez 2002). In this context, IRs are defined as: '(...) building blocks speakers use for constructing versions of actions, cognitive processes, and other phenomena' (Wetherell and Potter 1996, 66). IRs are linguistic resources – such as metaphors or specific vocabulary, familiar clichés, anecdotes, recognisable argumentation routines, descriptions, or evaluations – which perform a function in relation to a topic and which speakers use for rhetorical purposes, i.e. to present certain positions about a given subject (Potter and Wetherell 1987). IRs can be recognised as explicit or implicit modes in which some relevant topics are interpreted using cultural resources established to that end (Edwards 2004).

To describe the IRs present in interviews, we developed a three-stage process. First, the description of discursive assumptions (Grice 1998) and speech acts present in discourse (Austin 1975; Searle, Kiefer, and Bierwisch 1980). Discursive assumptions consist of explicit or implicit meanings in conversation sentences which enable speakers to assess the success of a statement in a communicative situation, i.e. what we have to take for granted to understand a sentence (Iñiguez 2006). In contrast, a speech act is an action that is realised when we utter a sentence (Austin 1975). Thus, for example, an expression can legitimise, note, promote, compromise, etc. To analyse them, we first placed all the paragraphs of the interviews in a matrix, considering the sentences and sets of sentences as units of analysis (when they remained on topic) and describing in separate columns to the right of each the assumptions and speech acts found. Secondly, we selected the assumptions and speech acts in reference to the human condition (for example, in relation to how to take decisions that affect workers, relationships with colleagues, or definitions about what persons are, among others). Finally, we organised the repertoires considering the argumentative effect of each selected sentence. To do this, we asked ourselves what function each sentence plays in relation to the performance of a version of the human, considering both the assumptions made and the speech acts performed.

## **Ethical considerations**

Informed consent was obtained from all individual participants included in the study. The study was evaluated and approved by the authors' institutional ethics committee.

## **Results**

It was possible to detect three interpretative repertoires that integrate diverse ways of explaining or describing explicitly or implicitly a vision about the human in relation to various processes in industrial and service provision areas. Each pattern has a specific function of defending or sustaining what is human. We have labelled these patterns (a) causal repertoire, (b) caring repertoire, and (c) typification repertoire.

### **Causal repertoire**

The first IRs present the human as an effect of the material conditions which configure it, environmental variables establish a determinant connection with its qualities, and its constitution is conceived as susceptible to these parameters. This is illustrated by the following interview excerpt, in which it is assumed that humanity or dignity is related to the organisation of spatial conditions:

... for example, a decent job means more than a decent salary. It's not related to financial aspects but rather to the availability of spaces where people have adequate lighting, adequate lavatories and washing facilities, adequate canteens; places which are not overcrowded, where a sense of aesthetics is important in participation and cooperation in projects, where group work is promoted instead of isolation in small individual offices. So, it is related to the way you build the space you inhabit, the lighting, ventilation, comfort; your wages can be one among these many things but, the way I see it, satisfaction goes beyond the economic sphere and has to do with human development. (Interviewee 3)<sup>1</sup>

Thus, values such as dignity and human development, along with socio-emotional states such as satisfaction, emerge as a product of modifying or shaping the conditions of the immediate environment where the actors are situated. For the interviewees, a decent human being is the result of the manipulation of external variables which have an effect on him/her. This view presupposes that the modification of conditions such as lighting, space, and aesthetics co-varies with human disposition.

Together with the aforementioned assumptions, the above perspective places the engineer as a person who has the possibility of transforming the variables or conditions that make up the humanity of workplaces or workers themselves. The same interpretative resource is used to refer to a value such as the responsibility attributed to engineers:

That is, an engineer is a professional who delivers solutions to problems causing distress. Therefore, they are actors who generate well-being, bringing solutions with the aim of creating positive externalities in any environment. If they want to generate ... ensure capital, maximize utilities, well that will be an externality that will have to preserve that which is ethically agreed on in the discipline at all times. (Interviewee 1)

The reference to being 'an actor generating well-being' presupposes that the person is the product of relationships which can be managed through the creation of 'positive externalities' and 'in any environment'. At the same time, it presupposes, first, that this well-being is not an existing condition and thus has to be created and, second, that 'externalities' can be assessed in different ways. Seen in this light, the aims pursued by the organisations linked to the production of capital can be articulated with material conditions allowing for the preservation of the same well-being through the use of ad hoc strategies. In this regard, responsibility is associated with interpretative resources which account for specific and contingent aspects linked to the creation of adequate conditions for the emergence of a dignified human being. Engineering is conceived of as a series of specific practices aimed at shaping externalities leading to these conditions:

This is none of our business; some even say that we deal with abstractions of mathematical models, that we do not work with people. A far from naïve abstraction of engineering underlies those words, which frees you from responsibilities. (Interviewee 3)

As the extract shows, instead of regarding engineering as a field free of responsibilities, operating in an exclusively abstract field, the interviewee depicts it as a practice that relates directly to people and their conditions. This IR connects engineering with people, but asserting that the former is an external field which can affect the latter. Thus, the human is associated with what is created under certain conditions. Depending on the settings created for the workers, the outcome of the interplay with the conditions created by engineers can be variable, with different possibilities for building their humanity:

If it was up to me, I would apply for a position in the so called fourth-sector private enterprise, which values the action of people and the environment and where sustainability is a significant factor. That is, a business has no reason to be divorced from human and environmental balance and respect and decent working conditions should be basic. I would not work in a place which did not consider the human dimension. (Interviewee 3)

Interviewee number 3 lists a number of settings or contexts in which the practice of engineers can be deployed and influenced by organisational values. This person explicitly states that 'business' should not necessarily be dissociated from the value of the human. In that sense, and in terms of assumptions, organisational contexts must be produced for these conditions to emerge.

In sum, the causal repertoire organises various arguments and presents examples and situations in order to legitimise the action of engineering as an 'externality' that has the possibility of arranging materials and environments that generate conditions of dignity and humanity. This IR states that the necessary conditions of human dignity are, for the most part, the result of the organisation of material conditions. In that sense, material limitations or possibilities in working environments shape the properties of the human in these places. Therefore, the human can be said to be an effect of heterogeneous material relationships.

### ***Caring repertoire***

We have labelled this repertoire as 'caring', given that it shows how the human is susceptible to or affected by different conditions not only in the material spectrum but rather in the social and relational one. In other words, humanity must be cared for. Multiple arguments are aligned to depict the engineer as a figure responsible for expressing and establishing care as a relevant dimension in organisations, mainly in terms of the relationships s/he establishes with others. This perspective is found in the following observations:

... things like this make you think and assume right from the start that you are going to be someone with great responsibility and that your decisions will influence many people. (Interviewee 5)

How we deal with others has always interested me, for example ... when somebody is suddenly told something and how that affects that person, sometimes only one word. Then I think that is the point; being more aware of the consequences of our actions, that these consequences should be positive most of the time when we deal with other people. (Interviewee 2)

In the two above extracts, the influence exercised by an engineer is assumed. This places the engineer in a position of responsibility in the face of the effects of his/her social influence. However, as assumed in the second paragraph above, by pointing out the 'personal interest' in this type of influence, many times the consideration of the effect of the engineer over persons is not part of the explicit accounts of decision-making. The way this responsibility is presented points to the emergence of an asymmetric relation of affection between engineers and dependent people. In that sense, the social influence generated by an engineer can be intentionally addressed:

Yes, they have to be in charge of operations and monitor that production in the company runs properly. So, the human factor is not only connected to production –what I don't like–, and one needs to be concerned about



one's workers, about the relationships established, and monitor that working relationships are at least good. (Group Interview 1)

The above quotation illustrates how the purpose of caring for social relations with workers assumes an instrumental character, since it can be used to promote stable company production. In this regard, the function of the discourse exercised by this IR is to legitimise care as a process in productive relations, integrating the human as an entity susceptible to social relations. At the same time, this repertoire legitimises responsibility as an inherent quality of engineering, asserting that the practices exercised by actors playing this professional role affect others. Both responsibility and care are identified as relevant to a human being who is configured in eminently social and relational terms. At the same time, the human being is conceived as socially susceptible to the decisions adopted in the organisation and as situated in a social environment whose conditions can also be influenced by engineering decisions. This perspective is present in the following extract:

... regarding dismissals, in times of crisis, firing people was seen as the solution, at least in my company. They once told me that when it comes to deciding who will be fired, one needs to see who will cause the least impact: it is easier to fire an intern who has their whole professional life ahead of them than a person who is about to retire and has a family. So, the ethical problem one has to face is knowing how to dismiss people in times of crisis. (Group Interview 1)

The cultural resources that this repertoire brings together produce a version of the human being as an entity entwined in social relations that can be guarded by the actions of engineering. This perspective rests on the assumption that engineers will reflect on the variability of the effects associated with the multiple criteria involved in decision-making processes, as well as on the various social and communicative styles adopted in daily relations.

### ***Typification repertoire***

In the conversations held with the interviewees, it became evident that, sometimes, in order to justify making generalised decisions about large numbers of people, cultural tools are used that segment or group workers or dependents into broad categories. The function deployed by the *typification repertoire* is to justify and perform the existence of different social or human classes, types, or segments to which are attributed specific qualities to support the legitimacy of operations, decisions, and task distribution. In other words, it is a cultural resource which establishes that humans are discrete in terms of essential characteristics that separate them. The following account exemplifies this:

... most female civil industrial engineers do not work in production management or as heads of production departments, which is what we are trained for. We work in other areas: human resources, research, and other areas but not in hardcore civil engineering, there is still no place for women there. And that puts us at a disadvantage because we women know how to deal with men better. (Interviewee 9)

In the previous citation, gender emerges as a discrete quality which establishes concrete effects in terms of possibilities of participating in an organisation. The human emerges here as belonging to a particular social segment, linked to specific potentialities in a given work environment. The segmentation of work and tasks according to broad categories – such as gender – is linked to the presentation of practices that produce and reproduce organisational hierarchies, which define and sometimes limit workers' scope of action. For example:

... there was a specific area, the sales area, which was staffed only by women and the man in charge of that area had been there for a long time. A young woman started to work, a technician with a lot of expertise, with more up to date knowledge in fact, and who tried to contribute with her knowledge. And this man, who was like the boss, would ignore her and assigned her tasks beneath her capacity; that is the truth. That kind of discrimination was extremely frequent in these cases when the person in charge is older and this experience makes them underestimate newcomers; I suffered that myself. (Interviewee 8)

In the extract, dimensions like gender or age operate to qualify and classify persons in organisations. Capacities are not seen as a property immanent to the person but as a quality linked to a certain

social status. The statement 'assigned her tasks beneath her capacity' reveals the primacy of social or gender status over merit or the possibility of displaying competencies. This repertoire can be used both to justify and understand the decision-making processes involved in the classification of people in terms of broad social categories. As can be seen below:

Professional people were generally well treated, but workers did not receive very caring treatment; in my view they were exploited. Therefore, there was a high turnover of staff and when I got the job, for instance, everything was fine, but I realized that people were rotated regardless of whether they were from the offices or the factory. (Group Interview 1)

According to this IR, people acquire the possibility of being treated in a certain way within the organisation depending on the network of relations they belong to, i.e. depending on their status. In the quote, it is assumed that engineers enjoy a different status in relation to workers or office staff, a point made explicit in the following extract:

In my case, as I mentioned before, factory workers were like, too replaceable. I sensed they were excessively exploited and their wages were bad and on top of that they did not have much work stability. (Group Interview 1)

Through this resource of interpretation, differentiated social segments are performed, which in turn make up the hierarchies of the organisation. Discourses promote an image of engineering as privileged in these hierarchical scales. The human is shaped in terms of characteristics that are attributed to the group to which an individual belongs, which defines his/her range of possibilities of action and recognition. The function of the repertoire is to constitute and legitimise these segments by describing the qualities and potentials associated to categories.

## Discussions

As Callon (2012) points out, engineers are required to adjust their interpretations to match the highly demanding and fluctuating operational conditions that they face. The notion of the human is one of the many elements which can be strategically used to justify decisions or positions within particular organisational designs. In this section, we would like to characterise the three interpretative repertoires of the human that have been presented and how these relate to ethical practice and engineering education.

First, the causal repertoire promotes a notion of the human as a product of external material conditions which can be generated by engineers. In this regard, human dignity and well-being are not inherent but instead produced through the appropriate management of spatial or technical variables. For this IR, an engineer is an 'actor who generates well-being' (Interviewee 1). With this resource, humanity is the repository of expert practices, serving as a justification for technical interventions in industrial or productive settings. In these, humanity is a manipulable and susceptible part of a more general machine.

This repertoire is akin to the hygienist movement that emerged together with industrialisation during the nineteenth century, based on a preventive health approach where hygiene was linked to urban spaces and the notions of progress and modernity (Cotelo García 2017). Engineering played an important role in these urbanisation efforts, which included interventions aimed at fostering well-being in cities by means of health care improvement, as shown in studies on urban subjects during the mid-nineteenth to early twentieth centuries (e.g. Fernández Domingo 2015; Lafuente and Saraiva 2004).

With respect to ethics, the causal repertoire establishes a vision of the human as a malleable entity, definable by the adequate management of vectors external to it. Beyond the performativity of the human as a given condition, the human is a consequence of the arrangement of elements in a complex material scheme. In this regard, the engineer is portrayed as a manager of diverse materialities that can produce certain conditions to promote human dignity. Although this performs engineering as an eminently technical practice, it also lays the groundwork for promoting reflectivity on

the consequences that designs considered only in terms of efficiency may have on the human being. From an educational perspective, together with a review of its historic roots, this IR might be discussed and extended to more recent concerns about stressful working conditions encompassing subjects such as violence and bullying (Finstad et al. 2019) and the Decent Work and the Sustainable Development Goals included in the International Labour Organization 2030 Agenda (International Labour Organization 2018).

Second, the caring repertoire is linked to the previous one as it depicts humans as being susceptible to externalities. However, the latter are mainly social in nature. This is a repertoire which refers to affection. The human is conceived as an element that requires care, which highlights the special responsibility of engineers in this respect. However, care is a central part of instrumental rationality, as a tool to promote productivity itself. In this IR, humanity is portrayed as susceptible, but in terms of relational elements that need to be cared of.

From the perspective of the caring repertoire, the relationship is asymmetric. As in the causal repertoire, responsibility is focused in the engineer again, oriented to the workers' well-being, but establishing the existence of a relational climate in the working environment. Caring and asymmetry define a power relationship that must acknowledge subordinates as human beings with needs, while also seeking to balance these needs and the company's productivity and well-being. This repertoire refers to the need to address the interests of multiple stakeholders to whom the engineer is accountable within a framework of social responsibility (Lefkowitz 2014).

In ethical and normative terms, relating to the conception of the human, this repertoire performs sociability as a fundamental component of its ontology. In this way, engineering is associated with the daily implications of the selection of the social processes to be considered in decision-making and the effects of relationships on workers. From an educational perspective, engineering can be associated not only with the exercise of leadership, but also with communication. Well prepared engineers should be able to establish relationships with a variety of subordinates and acknowledge the responsibility inherent to their asymmetric relationship, where greater power determines a greater responsibility. Furthermore, engineers should be able to influence the establishment of targets and the means to achieve them in a way that considers the well-being of all parties involved.

The third IR, the typification repertoire, is linked to the promotion of the human as differentiated by class, which affects the attribution of potentialities based on pre-experience categorisation processes. Efficiency is a trait attributed to individuals according to their class affiliation. Humanity is dependent on the category to which each person belongs. Humanity is discretionary, which means that its value derives from classification based on a typology.

In ethical terms, this repertoire reduces the complexity and variability of human phenomena, establishing humanity as a simple process of ascription to general categories formulated by culture. The categories of the typification repertoire reflect a common perspective based on prejudice and hasty judgement that naturalises entrenched social conditions and whose immobility is undermined by movements for social change. From a didactic perspective, reflecting on social changes from a historical perspective and in connection with the role and position of the engineer in his/her working environment, as well as critically analysing these conditions in the present context, may open interesting opportunities for engineer training and civic education.

The three repertoires are linked to evaluative processes which perform different versions of the human. As Steen (2014) shows, different decision procedures and argumentation processes have inherent ethical reasoning approaches with practical implications. In everyday activities, engineers' interpretations have normative functions which promote different conditions for the definition of how the human is practised. In this regard, everyday practices in the field of engineering are marked by inherent ethical issues. All definitions, even the most technical ones, can assume or resonate with a certain way in which the human is performed. As Mol (2012) points out, the articulation between local practices, discourses, and materials promotes ontological effects; in other words, it enacts the *nature* of entities themselves.

IRs can account for some processes inherent to the activity of engineers, which link their discursive practices to the shaping of human phenomena through a variety of alternatives engaged with ethics. As Willems and Pols (2010) have pointed out, ethics not only express a vision of the good or the bad, but also produce activities to realise them in practice. Whenever one world is promoted over another in terms of technical design, organisational structure, or process efficiency, there are *valuation practices* which are an integral part of decision-making processes. As the philosopher of scientific activities Isabelle Stengers (2010) has pointed out: ‘Other than that of a “neutral fact”, the (...) [object]’s identity will find stability only in a network of relationships through which new “immanent modes of existence” for our practices are invented’ (27). In other words, the very idea of what an entity is, whether human or non-human, is performed via the same method of creating processes, establishing designs, and making decisions, ‘and those relations can also be read in terms of value, evaluation, and meaning’ (33).

## Conclusions

The daily practices of engineers have implications beyond the technical aspects with which they are usually associated. In designing spaces and processes, they perform possible worlds which we humans inhabit. And not only that: at the same time, the designs themselves presuppose a human being who can inhabit and operate in the environments created. Engineering not only creates processes, but also promotes versions of the human, evaluating what is human or what is relevant to it. On this basis, we have described discursive resources (interpretive repertoires) that are used to refer both explicitly and implicitly to the human. These modes of interpretation of the human entail different educational challenges, as well as possibilities regarding how to diversify the relationship established between engineering, social change processes, and human diversity.

In this regard, we would like to outline how the study of IR can be linked to engineering education. These guidelines may be general, but they open up the possibility of developing future work on how ethics are put into practice in everyday activities and in various situations. Accordingly, and as a first aspect, it seems to us that making explicit the variety of ways practised to understand the human generates training opportunities. These are associated with the possibility of promoting reflexivity or awareness about the situation in which engineering is exercised and the implications of decisions, even the most mundane ones. In this regard, it is possible, for example, to design training situations in which different conceptions of the human are put into practice in order to design processes or scenarios; or, conversely, based a certain design, to examine the implications that these perspectives have for the humans who will inhabit or implement them. In any case, being aware of the different ways in which the human can be conceived facilitates the creation of designs consistent with the values promoted by each training scenario.

Secondly, we have identified a practical implication linked to the diversification of design opportunities. In this regard, it is possible to consider how the variability of the conditions for conceiving the human enables us to establish ways to evaluate processes that not only consider their technical aspects, but also their implications for human beings. In other words, the diversification of design opportunities shed light on how the technical sphere contains versions of what we humans are, how we behave and, in short, what worlds we should inhabit (Akrich 1992).

Finally, the conception of the human as an ethical product implies the possibility of integrating into the training or evaluation of daily engineering practices the fact that ethics (reflections and definitions upon the good and/or what is adequate for a situation) is defined by contingent and everyday practices. These practices delineate what good is, and at same time, promote an idea of what human nature is.

## Note

1. All the citations have been translated from Spanish by the authors.

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