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Exploring forward-thinking technology perspectives of sustainable development for the year 2030 in the identity of engineering students

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ABSTRACT: This study focuses on the identity of engineering students, to explore their future perspectives and the presence of a vision of technology in the transition to sustainable development. Students from universities in Norway and Spain were encouraged to situate themselves in 2030 as engineers. Qualitative and quantitative approaches were integrated in the collection of data. Possible selves were identified and analysis conducted on the self-descriptions of participants in the present and in 2030 from a technological development perspective. Participants' views about the likely occurrence of the key vision based on social scenarios were also explored. The sample was formed by two groups of engineering students in Spain (30 at the University of Barcelona) and Norway (27 at the University of Tromsø). The results indicate an identity with room for further integration of a transition vision, beyond today's unsustainable model of economic development, consumption and technological development. Finally, areas for further enquiry are proposed in the context of a long-term vision for technology-based sustainable development in the engineer of tomorrow.

Keywords: Identity, self, possible selves, sustainable development, future, vision, engineering education, forward thinking

INTRODUCTION

Considering the relation between identity, future and agency in professionals, the question of how identity in the engineering professionals of the future relates to a vision of sustainable development becomes relevant, but is scarcely studied. Without a vision of sustainable development embedded in the engineer of tomorrow, it would be more difficult to plan and act as an agent of change, as the integration of a vision in the perspectives of decision makers serves as a guide to advance towards a better future [1-5]. This article aims at studying the presence of a transition vision of sustainable development in the identity of engineering students. It highlights the relevance for the study of identity and the self in engineering education, and provides a basis to develop and shape identities that can favour a transition future in an emergent context of sustainable development.

This study is focused on possible selves in the year 2030, and particularly on future technology perspectives. The studies on possible selves in engineering education are scarce and often pertain to short terms only. A case in point is a short-term framework applied by Bennet and Male who studied possible selves of engineering students, and identified difficulties in the students to imagine the future and to integrate creative perspectives of the professional role [6].

The author of this article, attempted to engage a long-term framework in an earlier study on how engineering students describe their selves in 2030 in relation to a sustainable vision related to consumption and the economic system [7]. The findings indicated a weak predisposition to agency and a predominant embeddedness of today's unsustainable model of development in the self. The present study provides a step further in the study of the self in relation to a long-term future for sustainable development with a focus on technology.

THEORETICAL FRAMEWORK

Individuals make identity claims by transmitting how they view themselves or hope to be viewed by others. The awareness of who one is, and more specifically, where one is placed as an agent of change can determine actions that are in line with such identity. This is connected to the idea that identity is related to behaviour, and that can even introduce an element of prediction and understanding of behavioural choices [8-11]. For example, self-awareness has been pointed out as fundamental in the behaviour of entrepreneurs and identity is essential in understanding the behaviour of entrepreneurs [12].

A mechanism to explore identity and the relation between identity and behaviour has been the concept of possible selves, which falls into the category of conceptions of the self with a future dimension [13-15]. The self-concept has been considered the cognitive representation of the self [9] and involves …*people's beliefs about their personal characteristics; not only beliefs about their traits, abilities, and physical attributes but also about their values, roles, and personal goals* [16]. Within a future dimension, possible selves are perspectives on who one might or would like to become, or even would fear to become [14].

Conceptions of the self in the future are directly related to the position of the individual in his/her social context and may influence behaviour through comparison of the current self and a possible self [14]. Possible selves can influence motivation from different perspectives. First, by recognising a wanted self in the future, the individual can move towards that future self. Secondly, by comparing the present and future selves, the person can recognise differences and act to reduce them. On this basis, the study of the self from a future perspective would allow to access behavioural insights in the professionals of tomorrow with respect to the future and their position as agents of change. The study of possible selves can benefit from a reference to an aspirational social future from an identity perspective, and therefore a scenario or vision can be formed in the identity. Furthermore, a long-term social perspective in the individual also plays a role in the development of self-conceptions of individuals. In short, the self is formed through integration with the social outlook of the individual [17]. Thus, it is relevant to explore interrelations between a clear-cut social perspective based on a sustainable development-based future and the self.

Toward a Technology-centred Sustainable Development Vision

In this section are outlined the main characteristics of the future vision considered in this study. Some scenarios provide a basis for an ongoing discussion for the future that can bring insights regarding future vision-based perspectives. A structured example is the great transition initiative (GTI), which aims at constructing a planetary civilisation rather than rely on incremental changes within conventional systems. It envisions the emergence of new categories of consciousness - global citizenship, humanity-as-whole, and the well-being of future generations - alongside democratic institutions of global governance [18]. In relation to Raskin's work, Goldstein considers a future where sustainable communities expand in number [19]. Sustainable communities aim at quality of life for the community without compromising the well-being of other communities, and aim at preserving and developing healthy ecosystems, and effective governance supported by meaningful and broad-based citizen participation [19].

Increasingly, it is argued that one needs to …*be better at handling early warnings and to create institutions that are able to deal with the form of environmental risks taken* [20]. According to Vatn, it is here where professionals need to integrate a vision of community that is fundamentally different to the one based on the traditional paradigm of consumption, and they have to be aware of the potential risks ahead [20]. This is supported by other foundational approaches that question the current model of development and consumption, and focus on the need to change the system and consider the central position of well-being [21-25]. A new reforming vision of the future would consider to lower consumption patterns and to aim at prosperity with less consumption [22]. In this context, the enhancement of production at the local level is another central element, which implies the local use of resources and a trend towards local manufacturing of products. This would aim at minimising the negative impact on the environment but also at reinforcing local economies and promote sufficiency and strategic supply, as well as social and personal development.

In this context of transition, the interaction and empowering of community in the decision-making process regarding technological development is fundamental and implies an in-depth, meaningful and goal-oriented participation of communities in projects with engineering companies, as well as with other technology-focused stakeholders and policy makers. From a different angle, technological developments that aim at the protection of the planet as a high investment priority, should consider equality as a foundational aspect [26]. Furthermore, the development of communication technology in recent years has not been proved to provide equality, and it is often related to the wealth of only some sectors in society. This is specifically relevant in engineering, where technology-based approaches to problem solving are dominant, or in other words, where technology can be seen as the best solution to our problems.

Finally, a paramount issue to integrate in this vision of a sustainable future is the risk to humanity emerging from technological development. In this context, the contribution of Bostrom is critical, who advocates for the need to become aware of the dangers embedded in technological development, with a specific focus on new emergent technologies, such as nanotechnology and intelligence enhancement by technological means in the future [27][28]. Bostrom provides the foundations for a structured evaluation of possible negative impacts on humanity. Several important ramifications to technology policy should be considered beyond investments implications, profit making and an unquestionable technology push, with the involvement of all actors in understanding the implications and impacts of technological development [28].

METHOLOGY

Collection of Data

The procedure for data collection involved a questionnaire with two parts, which was shared with other researchers and colleagues with the aim to improving some questions. The study was piloted with several students, and then, several modifications were introduced before implementation.

The first part of the questionnaire aimed at the apprehension of the self within two perspectives: self-descriptions in relation to technology and self-descriptions as engineers. First, participants were asked to focus on the present, and then questions were directed to the future in the year 2030. Guidance on how to answer the questions was provided by means of highlighting the importance of reflection in answering. The collection of data was structured by a sequence of questions that aimed at allowing participants to fully express themselves with minimal interference of the researchers. The questions were submitted one-by-one to participants, thus providing space for reflection in each question. This approach, with limited number of questions and directivity, was intended to facilitate the self-expression of participants. Therefore, the following questions were asked to participants:

Complete the following sentences about yourself in relation to the following:

- *With regards to technology, I…*

Continue thinking about yourself in 2030. Describe how you imagine yourself with regards to the following:

- *In 2030, with regards to technology, I…*

Continue thinking about yourself in the future. Particularly think about yourself as a professional in the engineering field. Describe how you imagine yourself as an engineering professional in 2030. We ask you to express yourself in five sentences:

- *In 2030, as an engineer, I…; I…; I…; I…; I... (5 statements)*

The second part of the questionnaire aimed at the collection of perspectives about the likely occurrence (between 0 and 10) of several scenario-based visions for 2030 about an alternative vision of community and technology related to sustainable development. These scenarios were examples of various paradigms of sustainable development, generated from a review of emergent paradigms. An adverse scenario for 2030 was also included, related to the collapse of the whole economic system. The following are the scenarios envisaged for 2030 that formed the second part of the questionnaire:

1. *In 2030, the investment in technological development aimed at the improvement of equality is the highest investment priority.*
2. *By 2030, communities will have developed more consciousness about the needs of other communities.*
3. *In 2030, there is a sense of a common future for communities at the global level.*
4. *By 2030, sustainable communities will have developed to the point that their proportional mass in relation to the whole mass of communities will be (mark from 0 to 10) … parts out of 10.*
5. *In 2030, global citizen movements are in place as principal agents for change.*
6. *In 2030, the economic system is not based on today's consumption system.*
7. *In 2030, an important part of manufacturing production is local.*
8. *By 2030, the economic system will have collapsed without a planned alternative.*

Participants

The sample was formed by two groups of engineering students from Spain (30 students from the University of Barcelona) and Norway (27 from the University of Tromsø). Their average age was M = 20.64 years (SD = 3.18), with 59.3% male and 40.7% female students.

Analysis of Data

In the first part, the data related to self-descriptions was collected, respecting the uniqueness of each answer, and 399 self-descriptions were classified into categories. Most self-conceptions were provided in the form of sentences. For example, a description of the self in the year 2030, such as *I really feel that I have a role in shaping technology in the future*, would correspond to the category *shaper of technology*. In the second part, the considerations of occurrence (0 to 10) of social scenarios in 2030 were introduced.

The analysis was based on the frequency of self-descriptions provided by the group of participants both in relation to the present and the future, and on the correspondence with the considerations of occurrence of social scenarios. Differences between the present and the future were identified that enabled grouping of self-conceptions into specific categories. To detect significant values in the grouping of participants, χ^2 and p were considered, with p smaller or equal to 0.05. The calculation of these values was applied when at least 10% of the participants corresponded to a self-description.

The data corresponding to the considerations of occurrence of social scenarios was analysed from two perspectives: 1) in isolation; and 2) in conjunction with the analysis of self-descriptions. In the first case, the analysis was based on the values of M and SD. In the second case, the considerations of occurrence and frequency of self-descriptions were analysed with the Mann-Whitney *U* test, according to the values of M, SD, U and *p*. This test was used to find associations between each group of self-descriptions identified in more than 10% of the participants, and the considerations of likely occurrence (in a scale of 0 to 10) of the given social scenarios.

The results of this study are not intended to be generalised as they may not apply to the whole population of engineering students. This study has a qualitative basis, required in the study of the self, and therefore, it does not focus on a large sample, and the actual sample is considered homogeneous from the outset.

RESULTS AND DISCUSSION

The study results are presented and discussed in two blocks: 1) conceptions of the self in relation to technology (present and future) and when participants were placed in 2030 as engineers (Table 1 and 2); and 2) perspectives on the possibility of occurrence of social scenarios and the self (Table 3 and 4).

Conceptions of the Self: Technology and the Engineer in 2030

Regarding the results on the self in relation to technology (Table 1), conceptions of the self are related explicitly to the statement: *I am a consumer of technology*, with 22.8% and 26.3% when situated in the present and in the future, respectively. Only in this case, when comparing the results, significant differences in the self-conceptions between present and future (information not tabulated; $\chi 2 = 10.775$; $p = 0{,}001$) were obtained. This result points out to two different blocks of participants for the present and the future in this case.

Table 1: Participants' self-conceptions related to technology.

	Percentage of participants			
	Present		Future	
Category (self-conception)	n	%	n	%
Consumer of technology	13	22.8	15	26.3
Developer of technology	6	10.5	10	17.5
Technology expands rapidly and progress	4	7.0	12	21.1
Interest in technology	16	28.1	3	5.3
Technology is for a better world	5	8.7	2	3.5
Shaper of technology with less impact	0	0	2	3.5
Slow in caching up with technology	2	3.5	1	1.8
User of new technology	4	7.0	1	1.8
Aware of negative impact of technology	4	7.0	3	5.3
Balance between technology and nature	0	0	1	1.8
Other (technology)	2	3.5	3	5.3

In addition, participants provided self-conceptions as *developer of technology* (10.5% and 17.5% in relation to the present and the future). Furthermore, the idea that *technology will continue to expand and will help progress in societies* was also present (21.1% of the participants in relation to the future, and 7.0% in relation to the present). Despite this, there is no reference to technology for the protection of the planet and for promoting equality. Self-conceptions related to the *interest of technology* were mainly identified in relation to the present (28.1%) and in a minor percentage (5.3%) to the future.

The rest of self-conceptions corresponded in all cases to values under 10% of the participants, and were classified in the following categories, with percentages related to the present and the future, respectively: *technology is for a better world* (8.7%; 3.5%), *shaper of technology with less impact* (0%; 3.5%), *slow in caching up with technology* (3.5%; 1.8%), *user of new technology* (7.0%; 1.8%), *aware of negative impact of technology* (7.0%; 5.3%), and *balance between technology and nature* (0% and 1.8%).

Regarding the self-conceptions as engineers in the future (Table 2), *working/with occupation* is identified as a conception of the self specifically when participants were placed as professionals (40.4%). In addition, the results suggest the integration of aspects related to how to experience the profession in several ways. This is seen in conceptions, such as being a *good/excellent professional* (45.6% of the participants); *research of technological solutions* (43.9% of the participants); *helps as engineer* (35.1%); being *satisfied with what he/she does* (28.1% of the participants), and *manager/director*, which was present in a 14.0% of the participants. Self-conceptions related to *having money and properties* were also identified in the self in 26.3% of the participants, when placed as professionals in the year 2030.

Table 2: Self-conceptions of participants as engineers in the year 2030.

	Numbers and percentages of participants as future engineers	
Category (self-conception)	n	%
Working/with occupation	23	40.4
Is a good/excellent professional	26	45.6
Researches technological solutions	25	43.9
Helps society as engineer	20	35.1
Satisfied with the work	16	28.1
Having money/properties	15	26.3
Has interest in knowledge	11	19.3
Manager/director	8	14.0

To this point, the results show that ethical and environmental perspectives could have been integrated to a further extent in the self of participants. Perhaps, this can be related to the lack of concreteness in almost 50% of the participants in their self-conceptions, such as *finding technical solutions*, which might suggest a general conception that views technology as the solution to the problem that a society may have. In this regard, social impacts associated with technological development could have been also considered. Here, there is also room to explore the consideration of the potential negative impacts of technological development.

From a different angle, participants provided future selves that included components related to being competent and working in reputable projects, developing excellence as a professional in their field and becoming a manager. Helping society as a characteristic of the self was present in near to 50% of the participants. It would be useful to further explore the understanding of how engineers and engineering companies can help society in the context of revenue-making priority and institutional pressures that put demands on corporate survival, progress and growth.

Perspective on the Possibility of Occurrence of Social Scenarios and the Self

The overall results about the consideration of likely occurrence of scenarios based on a transition in 2030 (Table 3) show conservative perspectives which in other words suggests a social future perspective that is not very different to the present**.** Furthermore, conservative values in relation to the occurrence of sustainable development with a community-based development perspective are also visible. This is seen in the values of the consideration of occurrence of the scenario *global citizen movements are in place as principal agents for change* (M = 5.47; SD = 2.66). The values are similar in relation to *there is a sense of a common future for communities at the global level* (M = 5.55; SD = 2.335), and the scenario where *communities will have developed more consciousness about the needs of other communities* (M = 5.61; SD = 2.447).

Table 3: Considerations of occurrence of scenarios in 2030 - median (M) and standard deviation (SD) values.

Social scenarios in 2030	M	SD
In 2030, global citizen movements are in place as principal agents for change.	5.47	2.660
In 2030, the investment in technological development aimed at the improvement of equality is one of the highest investment priorities.	5.71	2.643
By 2030, communities will have developed more consciousness about the needs of other communities.	5.61	2.447
In 2030, there is a sense of a common future in communities at the global level.	5.55	2.335
By 2030, sustainable communities will have developed to the point that their proportional mass in relation to the whole mass of communities is … (mark from 0 to 10) parts out of 10.	5.26	2.928
In 2030, an important part of manufacturing production is local.	3.25	2.532
In 2030, the economic system is not based on today's consumption system.	3.91	2.980
By 2030, the economic system will have collapsed without a planned alternative.	5.23	2.873

In addition, conservative values are recognised in the scenario where *investment in technological development aimed at the improvement of equality is the highest investment priority* (M = 5.71; SD = 2.643), and *sustainable communities will have developed to the point that their proportional mass in relation to the whole mass of communities is …* (from 0 to 10) (M = 5.26; SD = 2.928). Regarding the economic system, the results show low values in *the economic system is not based on today's consumption* (M = 3.91; SD = 2.980), *an important part of manufacturing production is local* (M = 3.25; SD = 2.532), and values of M = 5.23 (SD = 2.873) regarding the risk of *the economic system collapsing without a planned alternative*.

Now, significant associations found between the self and the perspectives of the likely occurrence of several scenarios are presented in Table 4. This shows a self that is connected with an explicit social future that at the same time forms the self.

Participants that provided self-descriptions explicitly related to *research technological solutions* (with 43.9% of the total number of participants), rated with a median value M of 4.26 (SD = 2.632; p = 0.029) the likely occurrence of a social future where *an important part of manufacturing production is local*. Secondly, participants that provided self-descriptions as *manager/director* (14 % of the participants), considered a low probability of occurrence in the following scenarios: 1) *citizen movements are in place as principal agents for change* (M = 2.75; SD = 1.982; p = 0.002); 2) *the economic system is not based on today's consumption system* (M = 2.0; SD = 2.07; p = 0.044); 3) *an important part of manufacturing production is local* (M = 0.75; SD = 1.165; p = *0*.001); and 4) *the economic system will have collapsed without a planned alternative* (M = 2.38; SD = 3.204; p = 0.004).

Self-conceptions in the future were associated with social scenarios without an embedded alternative model of development based on more sustainable consumption, local production, citizen movements or the possibility of the economic system's collapse. Here, work on projects on sustainable consumption and production and the active involvement of students in learning the craft of management, as well as the interaction with community-based projects, would be relevant. This would, therefore, further define identity and work towards the integration of sustainable development principles in management. Broadening and defining more sustainable images of futures could have a positive influence on the self of students.

Table 4: Significant associations between the consideration of occurrence of social scenarios in 2030 and self-conceptions.

	Categories in self-descriptions									
	n	Researches technological solutions (n = 25; 43.9% of the participants)				n	Manager/director (n = 8; 14% of the participants)			
		Consideration of occurrence					Consideration of occurrence			
Scenarios		M	SD	U	*p*		M	SD	U	*P*
In 2030, global citizen movements are in place as principal agents for change.	-	-	-	-	-	8	2.75	1.982	63.5	0.002
In 2030, the economic system is not based on today's consumption system.	-	-	-	-	-	8	2.00	2.07	106.5	0.044
In 2030, an important part of manufacturing production is local.	23	4.26	2.632	241	0.029	8	0.75	1.165	54	0.001
By 2030, the economic system will have collapsed without a planned alternative.	-	-	-	-	-	8	2.38	3.204	74	0.004

CONCLUSIONS AND FURTHER STUDIES

The results of this study suggest a need for exploration of what agency means to engineering students and what is their place in shaping and changing the world. Also, an emphasis on business for sustainable development with ethical and environmental considerations could be integrated to a further and more detailed extent in the students' identity. Particularly, embedding a concept of a society that manages resources to meet current needs, while ensuring that adequate resources are equitably available for future generations would be beneficial.

Limitations and related potential for further studies are indicated as follows:

- this study has not been focused on the consideration of cultural differences, and social and economic characteristics of countries, and therefore, there is room for further studies in this direction; such research could provide further insights on hopes, fears and challenges in becoming agents of change for sustainable development;
- the current study has dealt with possible scenarios, but research on visioning the future offers potential for further insights;
- the present study has been focused on specific images of the future, and could benefit from other different social scenarios, integrating both favourable and unfavourable scenarios.

An important point for further consideration is how to influence identity and shape the self in engineering education. Here a project-based approach focused on the co-participation of stakeholders that can provide a critical view about the impact of technology offers the opportunity to shape the identity of those who will be the engineers of tomorrow. Some examples are the participation of engineering students in community-based socially responsible projects and the intersection with identity. In this context, the integration of in-depth studies on corporate social responsibility offers new avenues for exploration. Also, further detail would need to be provided on the relation between technology and protection of the planet and equality. Examples would be needed of new models of production and consumption in a transitional vision to sustainable development, new models of community engagement in the engineering process. This must include an enquiry that interrelates vision, self and the challenges faced at local, national and global levels, with the main emphasis on the issues of inequality. It is paramount to identify key specific projects on forward thinking, where students can get involved and develop awareness about themselves in an experiential way that allows the shaping of their identity (e.g. futuristic energy systems, smart city developments, emergent information technology that considers positive and negative impacts on human beings and their development including existential risks).

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BIOGRAPHY

Dr Manuel Fernández-López holds a degree in technical industrial engineering from the University Polytechnic of Catalonia (UPC-Barcelona Tech), Barcelona, Spain, a Master degree in science (sustainable development) and a PhD in social psychology from the University of Barcelona, Spain, 2015. Over the last 15 years, he has worked in economic and environmental assessment of energy projects, research in sustainable development and strategic and long-term planning, education projects, and lecturing in higher education institutions in various countries. He is currently a researcher and lecturer at UPC-Barcelona Tech, and is affiliated with the Institute of Educational Sciences. He has worked in projects in Spain, Ireland, Seychelles, Cuba, México and Norway. His recent research at the Centre for Ecological Economics and Ethics under the funding of the European Economic Area (EEA) at the Nord University in Norway has focused on the study of forward thinking of key stakeholders in the engineering arena, and he is now integrating the study and development of forward-thinking competencies for development in the education arena and in engineering companies.