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Contextualization courses for engineering students based on sociotechnical thinking

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Abstract

Engineering education faces grand challenges to contextualize societal issues for students. This paper evaluates the contribution of contextualization courses for engineering students based on sociotechnical thinking. Sociotechnical thinking articulates engineering work with social concerns, explicit engineers positionality, and diverse human and non-human actors perspectives. The courses are inspired by a worldwide effort of Engineering, Technology and Society Education. Focus groups based on students reported contributions to understand technology as a human phenomenon, a social constructed system and a dynamic relationship between artifacts, organization, and culture. These courses improve argumentative tools and analytical capacity linked to a wider perspective for design and management technology, and made it possible to enhance situated knowledge on the practice of engineering with conscious social impact.

Keywords: *engineering education; contextualization; sociotechnical thinking.*

1. Introduction

Engineering education faces grand challenges to contextualize societal issues for students. Cultures of disengagement narrow engineering students as technical experts and disconnected from society (Cech, 2014). Sociotechnical thinking articulates engineering work with social concerns, explicit engineers positionality, and diverse human and non-human actors perspectives (Kleine et al., 2021). Courses built upon sociotechnical thinking aims to expand engineers' roles as social agents because their profession organize, design, create, manage and implement societal changing projects through technology (Downey, 2009; Hughes, 1993). Sociotechnical thinking increases accuracy of the portrayal on how engineering occurs beyond the classroom (Claussen et al., 2019).

This paper evaluates the contribution of contextualization courses for engineering students based on sociotechnical thinking. The courses are inspired by a worldwide effort called Engineering, Technology and Society Education (Johri, 2011; Leydens & Lucena, 2017; Lucena & Schneider, 2008). Authors involved in this field agree on the understanding of engineering and its professional practice is the path to comprehend technology's role in our society because that profession is responsible of the development and maintenance of technological systems (Hughes, 1993, 2005). Engineering is also strongly associated with innovative processes. It is the profession where social, organizational and physical components of an innovative process come together (Callon & Law, 1998) and through it the boundaries of technical rationality are analyzed because, in relation with technology, our distinctive feature as a society is an engineering issue (Hynes & Swenson, 2013).

Since 2002 the School of Engineering at Universidad de los Andes (Colombia) offers contextualization courses, as part of the Ciclo Básico Uniandino (Basic Undergraduate Cycle), promoting a reflection on the role of technology in today's society. Some of those courses are Technology and Society, Technology and Globalization, Techno-cultures in Latin America, and History of Technology. Each semester more than 280 undergraduate students from diverse programs these courses, especially from engineering, industrial design, economics and related programs. This paper will focus to evaluate the Technology and Society course. This course enrolls between 60 to 70 students per semester.

2. Course design

2.1. Course main themes

The Technology and Society undergraduate course follows the pedagogical developments of the ARGO Educational Group (Arribas Ramírez & Fernández García, 2001; Grupo, 2003b, 2003a). ARGO focuses on students' reflection of the role of technology in current society trough frameworks inspired in Science, Technology, and Society studies. The reference of this analysis was the theoretical framework of a systemic vision of technology (Jiménez Becerra et al., 2003; Osorio Marulanda, 2003; Pacey, 2014; Vinck, 2012). The course differenciates between a static to a dynamic approach to technology. A static approach understands technology as neutral and artifactual, in addition to evolving through linear courses of action. Instead, the course shows technology as a social, dynamic, and discontinuous process. The course shows how and where this process is configured; identify modes of production, maintenance and legitimation of technological knowledge, diverse uses and conceptions, showing to what extent and why this can be understood as a social process. The course provide the following main themes:

- Dynamic vision vs. static vision: popular visions of technology show the technological practice as linear, the result of a series of concatenated events that lead to certain results in a "natural" way. From this perspective, the problem of technology would be mainly how to implement certain advances in certain contexts. The courses show another perspective of technology as a social process: technology is created by society and it is essential that it steers its development.
- Technology as a human phenomenon vs. artifactual vision: closely related to the above, expand the popular vision of technology where which technology are only artifacts and tools. The course shows technology as an eminently social phenomenon and proof of this is that currently almost all, if not all, human activities involve technology or are related to it. Human being depends on technology and therefore it is important to reflect on the role that we assign to technology in society, its limits and scope, where it is pertinent to approach to the ethical, moral, and political dimension of human activities based on technology.
- Technology as a tool for social construction: the course shows that the question about technology is also a question about the society we want and the influence that the type of technology used has on the kind of society we are building. Depending on the technology that a society chooses to supply itself (e.g., water), educate itself (e.g., Internet), and who is selected to manage it (e.g., multinationals, the state, the communities), the course shows aspects such as equality, equity, opportunities and its future development in general terms.

2.2. Course goals and sections

The course structure had two linked activities. On the one hand, it was about context and the problematic relationship between technology and society. On the other hand, it was the construction of possible scenarios to implement a solution for a technological controversy through a context design. The general objectives are detailed below.

Table 1. Pedagogical sections of the course.

Main idea	Learning goal	Activities	Assesment
Technology is inherent to the human being and a systemic vision allows us to understand the importance of this aspect.	Students will recall the three major dimensions of technology as a system: organizational, artifactual and cultural (Pacey, 2014; Vinck, 2012)	• Define a systemic vision of technology and its various aspects • Discuss personal experiences of using technology. • Identify issues and controversies in the use of technology.	Students accurately identify technology in systemic terms under every day examples. They identify purposes and relationships of a technology within an known context.
	Students will be able to analyze a socio-technical system in an specific context (e.g., information and communication technologies for education in Colombia) and relevant aspects to take into account from the systemic view.	Elaborate an exploratory text or presentations describing the central elements of a socio-technical system: definition of relevant social groups, history, phases of a socio-technical system.	• Students explain coherently and precisely the relationship between a socio-technical system and Pacey's systemic vision dimension. • Students use sources and course texts to justify this relationship.
Technical artifacts must always be seen "situated". They belong to a specific social and environmental context. Their design must include all social groups who participate in that context.	Students will be able to design core elements of the solution from a socio-technical perspective: user-centered, co-creative (inclusion of relevant social groups).	Students design in group a canvas to describe a technological proposal considering contextual issues in Colombia.	Students present coherent relationships between a social problem, core values of a solution, and strategies to include social groups.

- Introduce an issue and questions about technology and its relationship with society. This introduction is based on personal concerns and experiences of the participants, guest professional experts, and scholars of the field.
- Study a relevant socio-technical system in Colombian society, through an active learning methodology.
- Contribute to the knowledge of the sociotechnical system studied with an emphasis on contextual design.

The course was divided into pedagogical sections, including a main idea, a learning goal, student activities to reach an understanding of the central idea exposed, and assessments to establish that the student reached this understanding. The table 1 summarizes these elements.

3. Evaluation

In the spring of 2019, the course Technology and Society at Universidad de los Andes (Colombia) had a length of 15 weeks, 3 hours a week. There were 65 students enrolled, 67% from engineering and 33% from other programs. By the end of the course, the instruction team evaluated with the students the contribution of the contextualization based on socio-technical systems.

The evaluation team organized heterogeneous focus groups of ten students when possible. A total population of 48 participants took part in the heterogeneous focus groups. The groups were heterogeneous regarding the students' program: 67% engineering, 31% economics and related programs, and 4% social sciences and the humanities. An advantage of this approach was that participants could interact with one another and come up with ideas as a group (Smith & Leith, 2015). Also, a focus group allows accumulating experiences, reactions and attitudes in respect to core topics, making the discussion more meaningful (Gibbs, 1997). Students feel more comfortable and find a more amenable space than having individual interviews (Kitzinger, 1995).

Focus groups offered a qualitative insight on these core topics:

- Dynamic vision vs. static vision: Compare their perceptions between a popular and dynamic vision of technology.
- Technology as a human phenomenon vs. artifactual vision: Inquire if the course expanded the popular vision of technology where which technology are only artifacts and tools.
- Technology as a tool for social construction: Asks how they understood engineers relationship with technology.

In relation to the usefulness of the dynamic vision of technology, 80% of students affirmed that the course helped them to understand a contextual issue. Students reported that conversations with professional guests who participated in the course and have been part of the design and development of technological systems were informative. They reflected that the course show that not all technology is benevolent or the most appropriate. It is necessary to contextualize the technology according to the place where it is going to be implemented, since the technologies that benefit the population in a first world country, in an underdeveloped country they can be harmful to the population or useless to solve a certain problem.

About technology as a human phenomenon, 58% of the students indicated how significant these aspects are for the design and management of technologies. They emphasized their learning that behind a technological system there are always people in charge of maintenance to ensure its constinous service. For example, one of the special guests showed how the public seem to think technological tools appear "out of thin air," but at the end it was clear that there are human beings providing such service. The focus groups reported that 57% of participants recognize that as our society becomes more technological, engineers take a part as core social agents. Sociotechnical thinking increases engagement of students towards public good and citizenship. Finally, students recognize that technology is a social phenomena.

Regarding contextual problems and a multidisciplinary teams in technological systems design, students emphasized how strategies used helped them to better apply a systemic vision of technology. They thought that class exercises showed them how the question about technology is also a question about plans, purposes and values of our society. Consequently, criteria mentioned by scientists and engineers can interact with community participation for every technological decision, determining equality, equity, opportunities and future development in general terms.

In the focus groups, students also considered that audiovisual material was a valuable complement because conferences offered experts' opinions about weaknesess, positive features, and possibilities of technological systems. Comprehension of the subjects and the empirical experiences of successful cases would have been more complicated without audiovisual material, making it harder to value implemented methodologies, problems and contexts to be considered for a social project.

4. Conclusions

Regarding the vision of technology, the students who have taken these courses state that they have had access to a non-traditional vision or perspective of technology, a vision that seems to correspond to a large extent to what is intended to be shown in the courses as it is a critical, contextualized and non-linear approach. It is equally satisfying that students can identify different approaches by contrast with elements of the traditional view of technology.

These courses improved argumentative tools and analytical capacity linked to a wider perspective for design and management technology, make it possible to enhance situated knowledge on the practice of engineering with conscious social impact. We also believe these types of courses help to create active and dialogic spaces, allowing students to reach significant agreements on the world they want. By this means, there is a contribution to the development of necessary skills for decision-making of socio-technical design and implementation, the analysis of their implications and influences on society, and the role of engineering to build the world.

Participation of professional experts, researchers, decision makers in the courses to exemplify how technology and society relationships occur in our society, increased students' sensitivity around the importance of reflecting on technology and society interactions, both in macro terms, as in everyday life in contemporary society given the high degrees of incorporation of technology.

Contextualization to study complex technological systems has created flexible and autonomous approaches useful for students' learning by visualizing different standpoints of a technological problem and formulating contextual reflections on the relationship between technology and society. There will be a need for new systematizations about this experience from the student's perspective regarding contextual design in this course.

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