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Social Responsibility of the Engineer grounded in the Critical Theory of Technology

Johny Antonio Álvarez Salazar[1], Luis Humberto Martínez Palmeth[2] and Juan Gonzalo Ardila Marín[3]

Abstract

Technological advancement brings with it ethical challenges and unforeseen consequences, making it essential for engineers to evaluate the human and social impacts of their creations. This research sought to answer how the Critical Theory of Technology (CTT) can guide engineers towards a more inclusive and socially responsible technological design, questioning for whom it is designed and the resulting power distributions. This study managed to determine the contribution that CTT makes to Social Responsibility (SR) in engineering. Using qualitative analysis and Atlas.ti software, 28 documents were reviewed, applying inductive coding for CTT and deductive for SR. Key elements were identified and correlated. The research highlights which elements of CTT have greater or lesser relevance in SR during technological design. Key subcategories such as critical thinking skills and instrumentalization in CTT, and SIS competencies, morality, and innovation in SR were identified. CTT emphasizes the importance of individual criticism, social interest, and ethics, while SR focuses on self-management and moral awareness. Both categories contribute to responsible technological design and positive social impact. Elements of CTT such as social interest and the democratization of technology are vital for SR, promoting engineering solutions with a human and ethical focus. This research highlights how CTT can improve engineering practices through more inclusive and sustainable technology.

Keywords: *Technological Change, System Design, Professional Ethics, Social Studies, Citizen Participation.*

INTRODUCTION

The Critical Theory of Technology (CTT) is a perspective that invites reflection on how technology intertwines with society (Feenberg, 1991). If one can identify the contribution that CTT makes to the concept of engineer's Social Responsibility (SR), a better understanding of the ethical and social implications of technological decisions can be achieved (López González, 2017). In this way, it becomes possible to analyze the social impact of engineering practice by considering technology from a critical perspective (Lehmann et al., 2013). Engineers can then evaluate how their creations affect people, the environment, and society at large (Serna Montoya, 2010). Moreover, it would enable the promotion of equity, as CTT encourages questioning inequalities and designing more inclusive solutions, allowing engineers to contribute to a fairer world by applying these principles (Veak, 2006). It also facilitates citizen participation by understanding technology as a social process, allowing engineers to involve the community in technological decision-making, ensuring diverse perspectives and needs are considered (Jiménez Becerra & Rojas Álvarez, 2022).

In this context, the need arises to explore how CTT contributes to the concept of Engineer's Social Responsibility. The central problem is that as technology advances, so do ethical challenges and unforeseen consequences (Barry, 2001). Engineers not only design and build technical systems but also influence people's daily lives and shape society as a whole (Quintanilla, 2017). Therefore, it is essential for them to consider not only technical aspects but also the social and human impacts of their creations (Edgar Serna & Alexei Serna, 2017). Some of the key questions driving this research are: Who is technology designed for? What are the unintended consequences? How is power distributed? CTT reminds us that engineering is not merely a technical

[1] Electromechanical Engineer, Master in Automation and Industrial Control, PhD in Educational Sciences, Full-Time Professor at Instituto Tecnológico Metropolitano. ORCID: https://orcid.org/0000-0002-7041-8619, Email: johnyalvarez@itm.edu.co, Phone: +57 310 4157644

[2] Mechanical Engineer, Specialist in Pedagogy and Teaching, PhD in Advanced Design in Mechanical Engineering, Assistant Professor at Universidad Industrial de Santander, ORCID: https://orcid.org/0000-0002-4336-1215, Email: lhmarpal@uis.edu.co, Phone: +57 311 2146525

[3] Mechanical Engineer, Master in Industrial Energy Management, Assistant Professor at Universidad Surcolombiana, ORCID: https://orcid.org/0000-0003-4461-7195, Phone: +57 321 4599743, Email: juan.ardila@usco.edu.co, (Corresponding Author)

discipline but also a profoundly social and ethical activity. By considering these dimensions, engineers can contribute more responsibly and consciously to societal well-being.

Recent research on the topic has shown that by applying CTT, engineers can assess how their creations impact people, communities, and the environment (Osorio Marulanda, 2022). CTT helps engineers consider equity in technology access by designing more inclusive solutions, benefiting marginalized groups and reducing social gaps (Villa-Enciso, 2023). Furthermore, CTT encourages engineers to collaborate with end-users and other stakeholders to ensure more responsible solutions (Serna, 2021). CTT emphasizes the importance of designing sustainable technologies; some studies have explored how engineers can minimize environmental impact and promote responsible practices (Figueroa Negrete et al., 2023). Engineers have used CTT to evaluate the impact of existing technological projects (Rojas Mesa et al., 2023) or address cultural and social issues in product design, including understanding technology implications in different global contexts (Lopezosa et al., 2023). Additionally, research has explored integrating critical theory into engineering education, fostering professionals who are more aware of their societal role (Fernando Herrera et al., 2023).

Considering the above, CTT is a perspective that critically examines the interaction between technology and society. In this context, the engineer's social responsibility becomes relevant. Engineering and technology applications aim to faithfully represent real system behavior and endure over time. Therefore, any technological development entails deep social responsibility and a transdisciplinary approach to problems (H. Giuliano, 2013; Ramírez, 2016). The professional profile of an engineer, according to this perspective, should include a solid scientific, technical, and professional foundation, fostering a critical and creative attitude in problem identification and resolution. This involves considering political, economic, social, environmental, and cultural aspects with an ethical and humanistic vision (Mersé, 2014). In this context, the present study sought to elucidate CTT's contribution to ESR, analyzing its scope and impact on society.

Conceptual Theoretical Framework

Documents on Critical Theory of Technology (CTT)

Initially, Feenberg (1991) posits that technical codes can be modified through democratic interventions that enable technological changes, technological abandonments, or new uses of existing technology. CTT aims to bridge the gap between social theory and empirical research. Later, Feenberg himself Feenberg (1995) explains that the driving force behind technological change is modernity, and rational use of technology can occur when there is a distancing from technocratic orientations. This distancing is essential for creating a technologically democratized society based on individual critique. By the end of the 20th century, the prolific author clarifies that technological advancement is fundamental in the social and political structure of modern societies. Technology is indispensable in daily life, and every technical change has economic, political, religious, and cultural repercussions. Feenberg concludes that the technical and social domains must intertwine in a modern and democratic society (Feenberg, 1999).

Subsequently, as we enter the 21st century, Feenberg addresses his Latin American audience, emphasizing that technocratic administration threatens the democratic use of technology. Technical codes preventing technology from aligning with social interests need modification. This should happen through individual critique and within the margins of maneuverability, guided by normative and social regulations (Feenberg, 2005). Furthermore, he asserts that technology and modernity are intertwined. Democratic rationalization goes hand in hand with the relationship between technology, power, and freedom. Society must engage in democratic interventions to ensure rational technology use, focusing on values, environmental care, and anticipating future technological advances' societal impact (Feenberg & Callon, 2010). Feenberg also highlights the need to identify and understand ideological aspects related to education, environmental quality, job satisfaction, radical democratization, operational autonomy, increased responsibility, and social power. Recognizing that the benefits of modernity may lead individuals to resist change, he advocates for transformative technology (Feenberg, 2012).

Later, another significant thinker emerges in South America, building on Feenberg's work. This thinker outlines considerations for reflecting on technology, including (1) the presence of indecisive analytical elements; (2) the necessity of taking a position; (3) integrating diverse social actors in the face of expert dominance; (4) the counter-hegemonic nature of the struggle for technological reform; and (5) the urgency of seeking an alternative democratic-based rationality. Education in technology from early schooling years and the search for new epistemic and political contexts enabling responsible participation in technological development are highlighted (G. Giuliano, 2008). Giuliano (2013) further explains the relationship between CTT contributions and the theory of instrumentalization. Engineers' rationality in creating new products and services, emphasizing social impact and interest, plays a crucial role in technological projection. Giuliano, in the same year, directed Parrilli (2013), who clarified that the concept of a technical code operates invisibly, stratifying values and interests into norms, rules, criteria, and procedures that guide the process of designing new technology. It is essential to identify this code to ensure alignment with democratic principles. Later, Tula Molina & Giuliano (2015), in their review of CTT concepts, assert that collective technological practices can be built through individual critique fostered in the education of engineers and technologists. This approach aims to democratize technology use and contribute to greater awareness of the interplay between technology and society.

Other Latin American authors have also studied Feenberg's work. For instance, in Brazil, Habowski & Conte (2018) and Szczepanik (2020), point out that technological development has social impacts, prompting anthropological, philosophical, and educational reflections related to technocratic technology use. These reflections on technology can inform educational reviews concerning consumerism and the power of technology in society. Meanwhile, Costa (2020) highlights that considering the boundaries of innovation in healthcare services through the lens of CTT could lead to reduced restrictions, enabling better technology use and improved healthcare services.

In Colombia, Mejía Reátiga (2011) stated that CTT underpins the concept of Social Responsibility (SR) and establishes links from the perspective of change generated through the education process. This change can impact the reconfiguration of companies based on a humanistic industrial approach. There is a significant difference between a company with SR and one that is socially responsible.

Documents on Social Responsibility (SR)

In Colombia, Law 842 of 2003 (2003) outlines mandatory ethical standards that Colombian engineers must consider in their professional practice. Internationally, Guide on Social Responsibility (2010), aims to promote Corporate Social Responsibility (CSR), encouraging stakeholders to contribute to sustainable environmental, social, and economic development based on the products, services, or processes developed by an entity. Viteri Moya (2010) asserts that social responsibility is a commitment shared by companies, the state, and universities. They must identify public interest issues, take action, and generate positive impact by providing solutions grounded in transparency, ethics, pluralism, and sustainability. Yepes et al., (2018) emphasize the importance of sensitizing engineers to address social issues through applied engineering. Marín-González et al., (2018) clarify that engineering plays a vital role in humanity's technological advancement, necessitating socio-humanistic competencies in education, supported by meaningful learning experiences.

Brightwell & Grant (2013) explain that for any curriculum to be useful, desired objectives must be described and outcomes framed, ensuring that learning experiences lead in that direction. Considering that competency-based education emphasizes individual skills more than overall learning experiences, González & Wagenaar (2006) introduce the Tuning methodology for understanding proposed curricula and approaches. This includes generic competencies that students should acquire to promote comprehensive education. In this context, Vélez Bedoya et al., (2018) refer to the competency-based model, specifically generic competencies. They affirm that these competencies align with sector-specific needs and involve the ability to identify, formulate, and solve problems with ethical and quality commitment. They also note the need to adapt competencies to the current globalized context. Herman & Collins (2018) define social and emotional competencies, categorizing and emphasizing their importance across all education levels. Dueñas Buey (2002) argues for the significance of emotional intelligence in the context of internationalization and globalization competencies. The necessary dimensions for achieving emotional intelligence and the tools institutions of higher education should provide are discussed. Corcoran et al., (2020) explain that educational institutions play an essential role in providing academic, social, and emotional learning. Developing students' socioemotional competence is crucial, contributing to acceptance of diverse viewpoints. Deardorff (2006) highlights the importance of intercultural competencies for professionals entering globalization. Global citizenship and emotional intelligence competencies are presented as fundamental in this process. Additionally, UNESCO (2014) describes global citizenship competencies, their importance, implementation experiences, and achievements. Gacel Ávila (2017) analyzes the significance of global citizenship from its UNESCO definition to radical critiques by authors regarding globalization and its alignment with Social Responsibility. Yepes et al., (2021) enumerate socioemotional and intercultural skills (SIS) and associate them with internationalization strategies, demonstrating their impact on social, emotional, and intercultural competence acquisition in engineering students.

METHODOLOGY

This qualitative research conducted a review of 13 documents on Critical Theory of Technology (CTT) and 15 documents on the concept of Social Responsibility (SR), exploring their importance in competency-based education, regulations, and global trends. These documents were reported in the previous section.

Critical Theory of Technology: Inductive Coding

Using Atlas.ti software and following procedures described by Strauss & Corbin (2002), each document in the CTT category was independently loaded, and content identification was performed by creating free-form quotes for each. Subsequently, inductive coding was applied to establish key elements with accompanying comments. This process allowed for later identification of commonalities between CTT and SR.

Inductive coding is an analytical approach that involves proposing a broader theory related to the research topic based on the data used in the study (Raymond, 2005). It's a bottom-up approach where researchers construct knowledge and propose new theories emerging from the data (Vives & Hamui, 2021). Atlas.ti is software that provides sophisticated tools for systematic data analysis. It's particularly useful for qualitative analysis of large sets of textual, graphical, audio, and video data (Muñoz & Sahagún, 2011). To perform inductive coding using Atlas.ti, textual and graphical data are loaded. Researchers begin by reading, annotating, and highlighting important parts. Codes are then created for these annotations or highlighted sections. These codes can be single words or short phrases representing the essence of the content. As patterns emerge in the codes, related codes are grouped, capturing important themes in the data (Vasilachis de Gialdino et al., 2006). It's essential to remember that inductive coding is an iterative process; researchers can revisit the data and codes as needed until they feel the codes accurately represent the data (Quijano A., 2021).

Social Responsibility: Deductive Coding

For the SR category, deductive coding was employed based on reading the reviewed documents loaded into the software. Main quotes were extracted, and comments were added to each SR element. Deductive coding is a method of qualitative data analysis where a predefined codebook guides the coding process. This codebook is developed before data collection and field research begins (Schettini & Cortazzo, 2015). To perform deductive coding in Atlas.ti, the text is read again, and free-form quotes highlighting relevant information are created. Researchers then select the quote and drag the code from the code system that best fits the content. If necessary, new codes are created by clicking the "add" button and naming them. The process is repeated until all text is coded, and code frequency and network views are reviewed to explore connections between codes and quotes (ATLAS.ti, 2024).

Correlation and Frequency

In the first part, information from the 28 reviewed documents was collected using both inductive and deductive coding with the assistance of Atlas.ti. Graphical relationships between subcategories or code groups and established elements or codes were visualized. Once the codes for both categories were established, a graphical correlation between them was determined, allowing for the presentation of corresponding frequencies in the results section.

RESULTS

Coding of Representative Elements

Elements of Critical Theory of Technology (CTT)

As a result of reviewing selected documents in the CTT category, two subcategories were identified: 1. Critical Thinking Skills and 2. Instrumentalization. In Figure 1, it can be observed that the subcategory of critical thinking skills in CTT is related to the tools students need to determine the type of knowledge to apply in specific situations. This subcategory serves as the starting point for consolidating elements such as individuality for critique, margin of maneuver, social interest, and their connection to ethics and normative regulations. These elements directly impact social influence in technological projection and the dignification of human beings through their role in work performance.

Similarly, Figure 2 illustrates how the instrumentalization subcategory in CTT encompasses elements such as technical codes, which depend on corporate and state power. However, these codes are against the critical thinking fostered in university education. This pathway can bridge the gap of technological ambivalence, allowing for democratization of technology where it is used as a means for social transformation with equity and sustainability.

Figure 1. Critical thinking skills in CTT. Own elaboration in Atlas.ti.

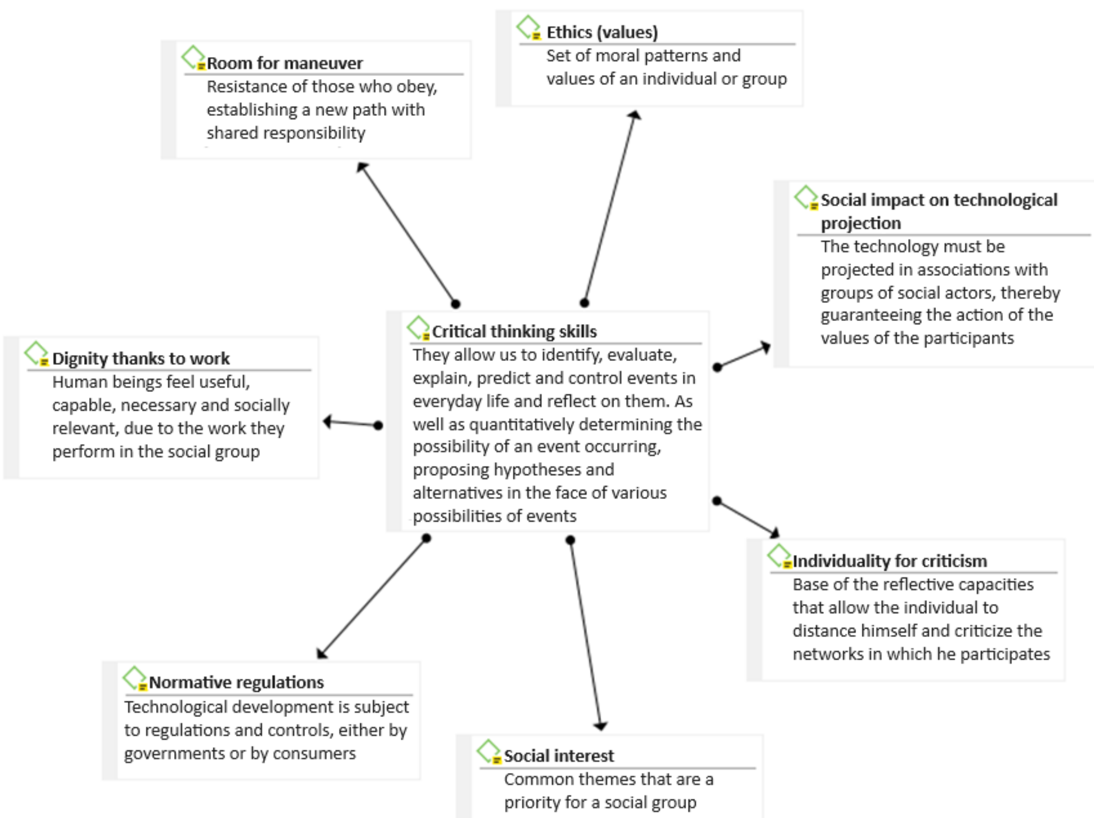
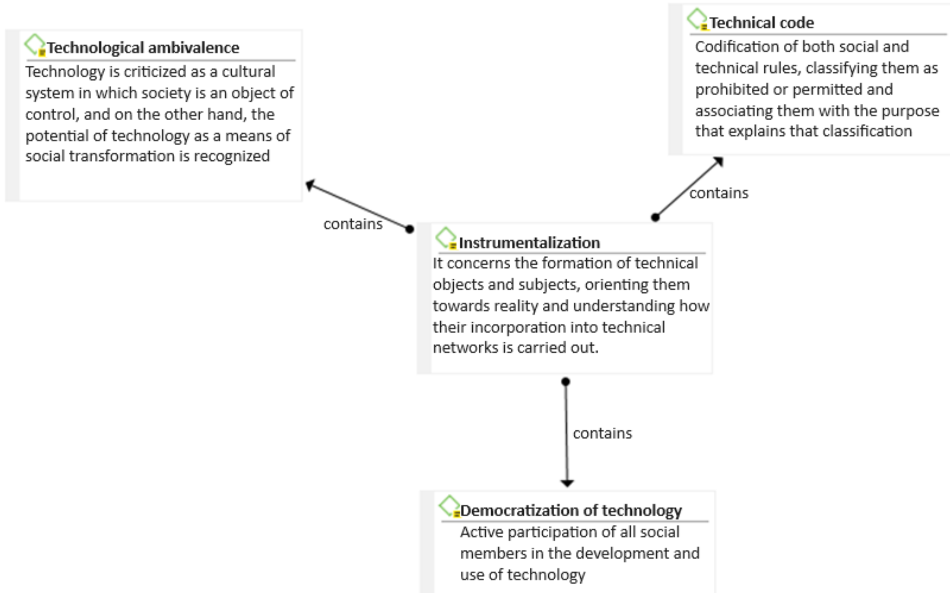


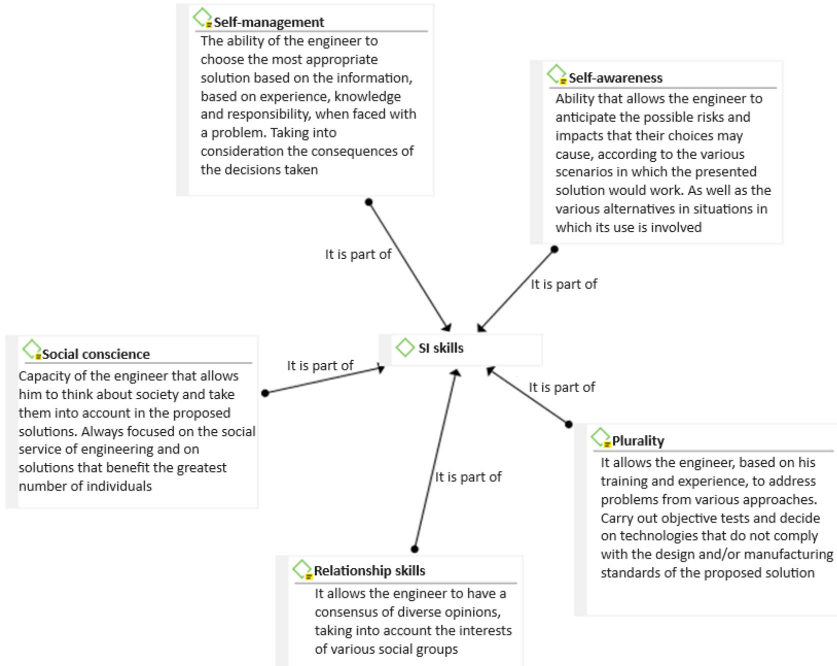
Figure 2. Instrumentalization in CTT. Own elaboration in Atlas.ti.



1.1.1. Elements of Social Responsibility (SR)

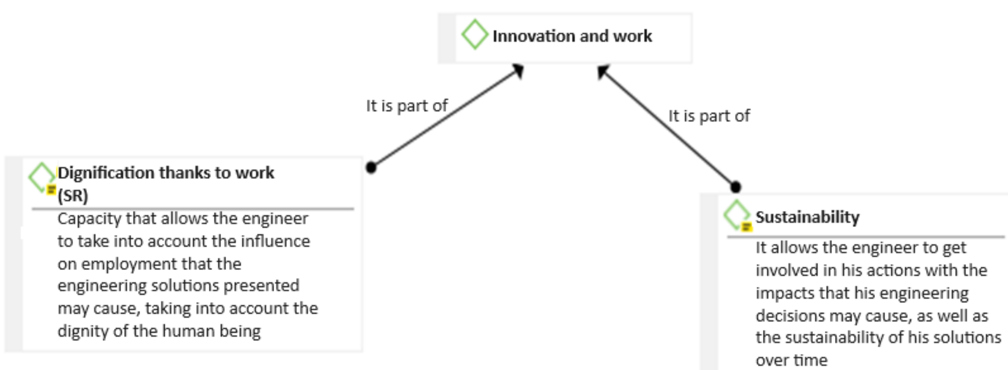
From the review of documents in the SR category, three subcategories were identified: 1. Socioemotional Intercultural Skills (SIS), 2. Innovation and Work, and 3. Morality. Figure 3 demonstrates how SIS competencies in SR enable independent thinking and problem-solving in engineering based on acquired social experience. Self-management, self-awareness, pluralism, social consciousness, and relational skills all components of SIS competencies empower engineers to develop technology with a human-centered approach.

Figure 3. Socioemotional Intercultural Skills (SIS) in SR. Own elaboration in Atlas.ti.



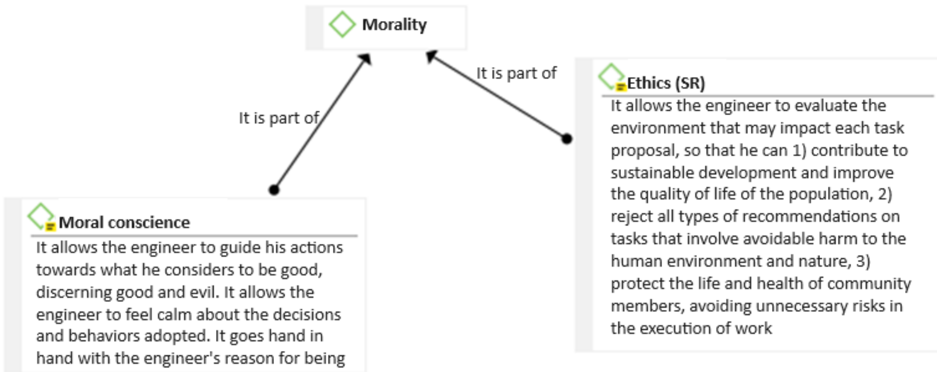
The subcategory of innovation and work relates to the engineer's ability to engage beyond product delivery. It involves critical decision-making, anticipating social and individual impacts, and extending responsibility over time. Innovation not only enhances work performance but also eliminates manual labor or creates new job opportunities. Figure 4 outlines the elements within this subcategory.

Figure 4. Innovation and work in SR. Own elaboration in Atlas.ti.



Lastly, the morality subcategory pertains to norms designed by regulatory bodies to protect social and individual interests. Contrasted with moral consciousness, it allows engineers to discern right from wrong and find peace with their decisions' societal impact. Figure 5 depicts the constitutive elements of this subcategory.

Figure 5. Morality in SR. Own elaboration in Atlas.ti.



Correlation Between Elements of the CTT and SR Categories

The subcategories of critical thinking skills and instrumentalization in CTT relate to the subcategories of SIS, morality, and innovation and work. Figure 6 illustrates how both fronts aim to address social problems related to the design and manufacturing of engineering solutions that significantly impact social changes. There is a parallel between the key aspects concerning rational technology use and the responsibility associated with delivering technology to humanity.

Figure 6. Relationship between the CTT and SR subcategories. Own elaboration in Atlas.ti.

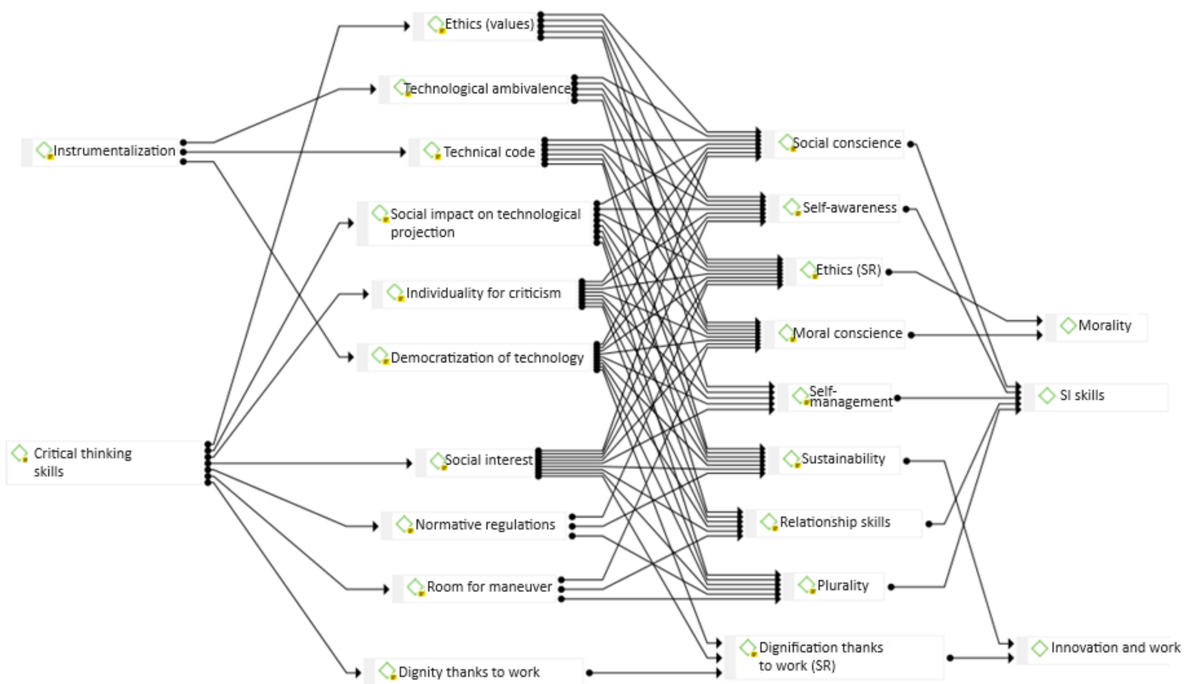


Figure 7 presents the relationship between elements of Critical Theory of Technology (CTT) and Social Responsibility (SR). The concept of margin of maneuver contributes to diverse opinions coexisting on the same topic and establishes links to align individual and/or collective interests, clarifying what is good and what is bad. The concept of technological ambivalence is closely related to the ability to discern viewpoints and apply technology according to contexts of sustainability, ethics, and moral consciousness. The technical code concept can be minimized by considering moral consciousness, ethics, and other social competencies, which guide the selection of technically, economically, and socially viable engineering solutions.

Correspondence Frequencies Between Elements of CTT and SR Categories

Among the nine elements proposed for Social Responsibility, social interest and democratization of technology receive the most significant contribution from CTT elements (see Figure 8). Similarly, individuality for critique and social impact make substantial contributions, reflecting the human capacity to discern right from wrong and take action to rectify it. The technical code, ethics, technological ambivalence, normative regulations, and margin of maneuver have moderate contributions, as they are closely associated with morality and the permissible use of engineering solutions. The concept of dignifying work receives a lower contribution from CTT, while adaptation and technological rationality show minimal impact, as they are part of post-solution development interventions to improve or repurpose technology.

Figure 7. Contribution of CTT elements to SR. Own elaboration in Atlas.ti.

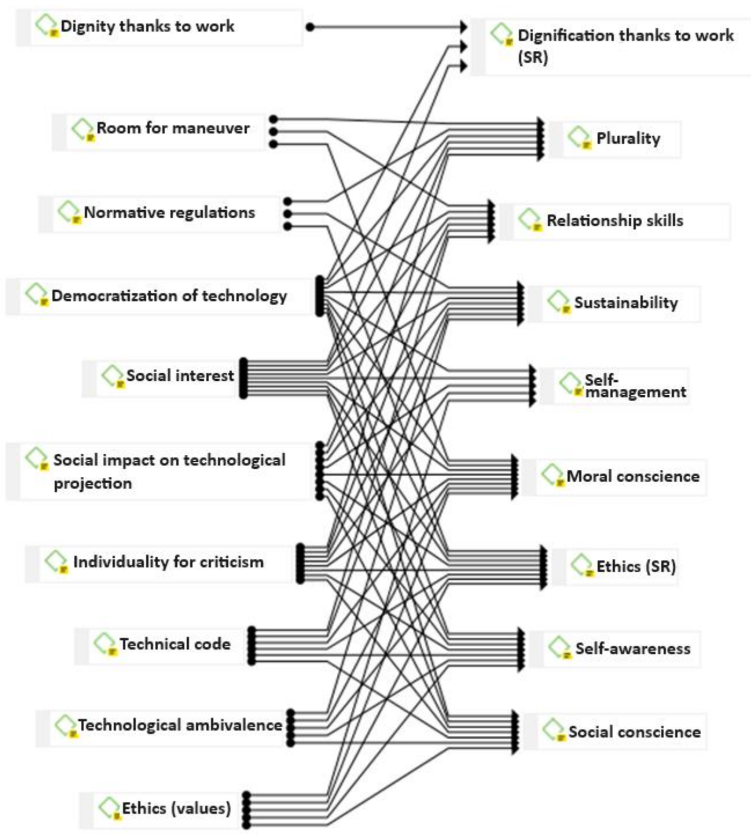
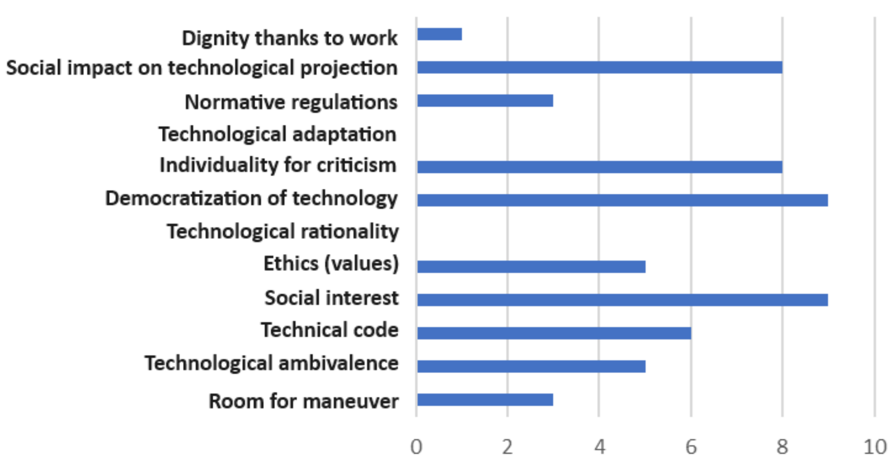
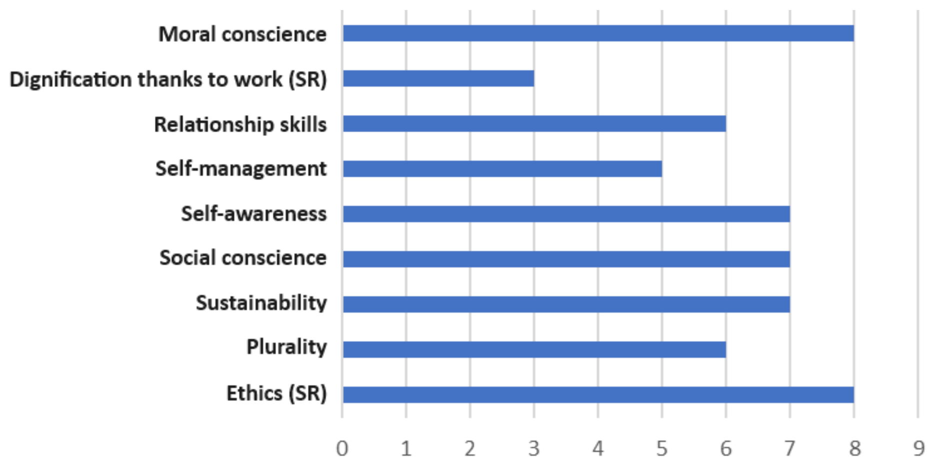


Figure 8. Correspondence of the elements of CTT with SR. Own elaboration in Atlas.ti.



Of the twelve proposed SR elements, ethics and moral consciousness receive the most significant contribution from CTT elements. Self-awareness, social consciousness, sustainability, and self-management also receive substantial contributions due to CTT's emphasis on responsible technology generation. Plurality benefits from CTT, reflecting an inherent capacity in engineering education, influenced only by technocratic societal codes. Figure 9 displays the correspondence frequencies.

Figure 9. Correspondence of SR elements with CTT. Own elaboration in Atlas.ti.



CONCLUSIONS

Critical Theory of Technology (CTT) provides a valuable framework for developing socially responsible and ethically grounded engineering practices.

Critical thinking skills and instrumentalization are essential for addressing social challenges through innovative and human-centered technological solutions.

Social Responsibility (SR) in engineering is strengthened by SIS competencies, fostering technological developments that align with morality and ethics.

There is a significant correlation between CTT and SR elements, emphasizing the need to design and apply technology with consideration for its social and ethical impact.

Democratization of technology and social interest are influential aspects of CTT within SR, highlighting the importance of accessible and equitable technology.

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