Engineering design and social justice: A systematized literature review

Mr. Cristian Eduardo Vargas-Ordóñez, Purdue University-Main Campus, West Lafayette (College of Engineering)

Colombian Ph.D. student in Engineering Education at Purdue University. He is a Master in Education from the University of Los Andes in Colombia, a Master in Science, Technology, and Society from National University of Quilmes in Argentina, and B.S. in Chemical Engineering from the University of America in Colombia. He has belonged to Colombian educational formal and informal ambits like Pedagogic Consultant at the Planetarium of Bogotá for the project Centers of Interest in Astronomy, Innovation Mediator at the science and technology museum Maloka and Chemistry Teacher in school environments. He has worked in primary, secondary, and tertiary sectors, and in private and public companies throughout his professional life. He also develops as Hatha Radja Yoga Teacher.

Dr. Morgan M Hynes, Purdue University at West Lafayette

Dr. Morgan Hynes is an Associate Professor in the School of Engineering Education at Purdue University and Director of the FACE Lab research group at Purdue. In his research, Hynes explores the use of engineering to integrate academic subjects in K-12 classrooms. Specific research interests include design metacognition among learners of all ages; the knowledge base for teaching K-12 STEM through engineering; the relationships among the attitudes, beliefs, motivation, cognitive skills, and engineering skills of K-16 engineering learners; and teaching engineering.
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Abstract

United Nations, through the document “Transforming our world: The 2030 Agenda for Sustainable Development”, invited all the nations to defeat poverty and foster social justice for all humanity. The STEM professional, as a trained citizen with the abilities to help in diminishing poverty, discrimination, and inequality, is called to be an active agent in this aim. For that, design can be an integrative area where, through practice, as well as natural and social sciences, can come together and tackle social problems directly. But, are these professionals prepared for that challenge? According to previous research, Colombian student and professionals of Chemical Engineering consider that they do not perceive themselves as active agents in the solution of social problems like poverty or armed conflict. Alike, when it was investigated, in a later study, where they think this inaction comes from, the general answer was related to the weak or nonexistent education in human or social sciences during the college stage, phenomena that are possibly shared by other engineers around the globe. Although this is a specific case in one of the STEM areas, it is common to listen about the disconnection of many agents in society that natural scientists and engineers from social problems.

The first approaches to the academic literature related to this topic suggest there are few empirical studies related to how the integration of social justice and design in the educational context of STEM areas is, in particular, with engineering. This situation contradicts the high amount of conceptual and philosophical information found in books and academic articles. This systematized literature review seeks to tackle this situation by exploring the following research questions: What type of studies have been conducted to integrate social justice in design within STEM education?, and What methods have been used to achieve it? At the same time, a sort of
subquestions supported the research questions, configuring the categories used for the analysis of the information. In total, there were analyzed 19 peer-reviewed articles published between 2009 and 2019 and obtained from four education and technology collection databases. The findings were organized regarding the educational stage where the research configured (K-12, university, or professional) to structure the answer to each question. Within the results, it was possible to observe an extensive use of qualitative methods for researching around the interventions, mainly case study and ethnography, and a conception of design as a process for generating artifacts (technology). Three grouper themes contemplated the conceptions of design and social justice and their relationship. Finally, this research limited its focus on articles written in English only and not in other languages, which could be a possible limitation of the study.

**Keywords:** Design, social justice, sustainable development, engineering education, STEM

**Introduction**

Poverty, as a social justice problem, is considered a multidimensional phenomenon related to the "deprivations at the household level in health, education, and standard of living" [1]. This problem includes undernourishment, child mortality, poor access to schooling, lack of access to electricity, sanitation, and drinking water, and any holding of housing, assets, and cooking fuel. To address this situation, in 2017, during the seventieth session of the General Assembly of the United Nations, world leaders adopted the outcome document "Transforming our world: The 2030 Agenda for Sustainable Development". The report became the route for achieving sustainable development to free "the human race from the tyranny of poverty and want and to heal and secure our planet" [2]. However, according to the most recent results, for 2018, “across the 105 countries covered by the Global MPI [Multidimensional Poverty Index], 1.3
billion people live in acute multidimensional poverty” [1], which is an alarming number. It means that independently the conception of poverty or the methodologies for its measurement, this situation includes 17% of the total human population on Earth.

Therefore, professionals in all areas, as trained citizens, are vital in the protection of human rights against the threats of this problem, like discrimination and inequality [3]. In specific, STEM professionals, such as engineers, medical doctors, and scientists, are called to address basic human needs, alleviate poverty, promote secure and sustainable development, respond to emergencies, reconstruct infrastructure, bridge the knowledge divide and promote intercultural cooperation [4]. However, these professionals may not be aware of the impact of their disciplines, do not know how to help, or simply are not interested. For example, in 2016, Vargas-Ordóñez [5] found, in exploratory research, that Colombian chemical engineers do not consider themselves as active agents in solving social problems like poverty, epidemics, or Colombian armed conflict. Also, in a later study, this author found that students and professionals of Chemical Engineering from Bogotá and Manizales (Colombia) do not consider they are trained in a humanistic approach during college their desire to help people [6] during their professional careers. These results suggest that universities, technical institutions, and associations, as engineering educational spaces [7], are essential for the creation of attitudes related to solving social problems as well as for developing the abilities that could help them.

This vision has been appropriated for American engineering curricula considering that engineering can have a humanistic approach through specific courses or methodologies, the assessment of their activities from a perspective of the ethics, and the reflection about the relationship between engineering and technology, including its impacts [8]. In that sense, the main objective is deconstructing engineering from a utilitarian perspective, based on effectivity and loyalty to institutions, to reconstruct it in a libertarian or communitarian perspective based
on equality and equity [9]. This last perspective is especially relevant to foster social justice.

According to Riley [10], defining social justice is difficult due to the different factors and perspectives associated with this concept. However, it is possible to use the working definition stated by Lucena [11] about the relationship between engineering and social justice for framing the present study. For this researcher, social justice is defined as the "practices, including those by engineers, [that] should attempt to an equal distribution of rights, opportunities, and resources to enhance human capabilities and reduce the risk and harms among the citizens of society" (p.10). If this concept is expanded to the other STEM areas, not just engineering, social justice is a practice that invites to create in and for the real social problems, such as poverty. It means, the knowledge of science, technology, engineering, and mathematics should transcend the hypothetical realm to articulate themselves as engines for defeating this problem. And for that, design is one possible transversal component in STEM areas through which the creation of solutions can materialize this idea according to the needs of each population. However, it seems that these professionals are not prepared for this task. How can education help with this?

This systematized literature review seeks to explore the following questions to clarify one part of this problem: What type of studies have been conducted to integrate social justice in design within STEM education?, and What methods have been used to achieve it? Likewise, these questions were supported by the following subquestions: 1. How is design conceived in these articles? 2. How is social justice conceived? 3. How is conceived the relationship between these two concepts? 4. What populations have been studied?, and 5. What were the main findings? Each of these questions configured the analysis categories for the analysis of the information. As a result, I present a review of the existing literature between 2009 and 2019, analyzing some of the different ways that social justice approaches and design has been considered together and explicitly in STEM education research. The structure of this paper is in
five sections, including the present Introduction, followed by the Literature Review, Methods, Results, Discussion, and Conclusions.

**Literature Review**

Sanders and Stappers [12], Nieusma [13], Thomas [14], and Seshadri, Joslym, Hynes, and Reid [15] has discussed the relationship between design and social justice. According to Sanders and Stappers [12], after World War II, two design movements arose in the USA and Northern Europe around the role of the designer and the final user: Human-centered Design (HCD) and Participatory Design (PD). The first one, HCD, is characterized by centering its attention in the creation of products and services close to the final user needs, considering the final user as a source of information consulted for obtaining a product with the desirable characteristics. Specifically, users only have a voice concerning the final product, and the designers consider users’ needs through methodologies useful for obtaining such information. On the other hand, PD considers the final user as a design partner who not only has the information, but also has, or can develop, the abilities to create next to the designer. In practice, these movements have been called in different ways, such as Interaction Design, Service Design, or Transformation Design, being this last related to “build on traditional design skills to address social and economic issues” [16].

By their part, Nieusma [13] considers that the relationship between engineering design and social justice is connected with the attempt “to assist marginalized social groups by redirecting design thinking toward their needs” (p. 1). Likewise, they thinks that "technologies and other designed artifacts are implicated in larger social problems, such as rampant consumerism, sexism, ecological abuse, lack of user participation and autonomy, and restricted access to build environments, among others” (p. 1). As a consequence, this author proposes the
use of perspectives as Universal Design (UD), Participatory Design (PD), Ecological Design (ED), Feminist Design (FD), Socially Responsible Design (SRD) and, especially, Appropriate Design (AD), in addressing different aspects of social problems. In the same way, Thomas [14] holds that social justice is obtained considering participatory design as a means for the creation of technologies to social inclusion. As a result, this author creates the concept of Socio-Technical Systems, which discusses final users' participation as well as other stakeholders associated with the problematic. Finally, Seshadri, Joslym Hynes, and Reid [15] contemplate a different classification where user-centered design is a part of the human-centered design. However, in this conception, HCD is the base for types of design, such as Participatory Design (PD), Co-Design (CoD), Compassionate Design (CD), and Empathic Design (ED).

In summary, there are some common areas between these alternatives. For example, independent of the nature of the solution (product, service, or innovation), these approaches consider there exists a dominant narrative that establishes design as a process for creating solutions according to the goals and requirements of a client (third party). In that sense, designers become experts and hidden actors who do not have credit (fame) by the result [17]. Also, these approaches show themselves as non-dominant narratives that join the product with final user needs, impacting in the results of design and the definition of engineering design as a process that creates systems, where different agents and factors can be involved [17]. Nevertheless, this is just one consensus about this relationship with other lines of thought that may be contrary. For example, there is tough to conceive the relationship between social justice and design when it is still complex to define social justice or design. However, there is limited information about this topic. Just recently, in 2019, Jagtap [18] published a literature review about “what has been investigated, how these investigations were undertaken, in what context they were undertaken, and how marginalized people were engaged and positioned” (p. 42) in studies related to design.
and solving poverty. They focused on "contextual and methodological aspects, while considering the roles of resource-poor individuals" (p. 42). In consequence, the present document seeks to expand the research around the scope of design in social justice, addressed this phenomenon from the STEM education perspective.

Methods

As proposed by Grant and Booth [19], a systematized literature review “possesses the most easily identified elements of systematicity” as well as “search[es] one or more databases and then cod[es] and analyz[es] all retrieved results in a systematic manner” (p.103). In that sense, this section shows the used sources as well as the inclusion/exclusion criteria and the description of the data analysis process. For that, I used the four-phase flow diagram of the PRISMA Statement [20], as a recommended quality procedure that is used broadly in systematic literature reviews, for including and excluding the analyzed papers. As a result, I identified 21 articles in total.

Data Sources

I analyzed academic and peer-reviewed papers published in the period 2009 – 2019 related to social justice in the context of design and STEM education. The reviewed articles are part of peer-reviewed journals found in three EBSCO databases such as ERIC, Education Source, and Professional Development as well as in ProQuest (Compendex).

Inclusion and exclusion procedure

I focused only on papers that explicitly used terms often associated with social justice and design on STEM education as inclusion criteria keywords (Table 1). With these keywords, I
limited the search for the fields Abstract (AB), Keyword/identifier (IF), Title (TI), and Subject (SU) for each database. As a result, I found 105 items in ProQuest and 160 items in EBSCO’s databases (ERIC, Education Source, and Professional Development). On the other hand, I decided to exclude not peer-reviewed empirical articles—also called scholarly articles according to the database—, as well as those included in academic journals, written in other languages than English, and out the rank 2009-2019. Articles related to curricular design articles were also excluded.

Table 1. Keywords for initial inclusion criteria

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<th>Second level</th>
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<td><strong>Criteria</strong></td>
<td><strong>Keyword</strong></td>
</tr>
<tr>
<td>Social justice or Activism or Social change</td>
<td>AB or IF or TI or SU</td>
<td>Design</td>
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</tbody>
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Note: AB = Abstract, IF = Identifier/Keyword, TI = Title, SU = Subject. Source: Own elaboration.

The restriction of time was the result of an initial general search in the database Web of Science, which generates a citation report about the citation tendency that some topics have in academic documents. This report showed that this topic's citation started in 1990, and, in 2018, it reached its highest peak for a total of 5246 articles. In that case, for limiting the scope, this literature review is related to the last ten years due to logistic reasons related to my ability as a researcher for assessing the papers. Finally, I included five articles suggested by the academic community and related to the socio-technical systems. Figure 1 summarizes all the complete process, according to the PRISMA Statement.
Data Analysis

The 19 results were analyzed using a “hybrid deductive–inductive thematic analysis approach” [21], using the main and subquestions as categories to organize the information during the deductive phase. The resultant categories were population, methods, design conception, social justice conception, the relationship between design and social justice, and main findings of the study. The sentences or fragments related to each category were copied in an Excel matrix where the final information was contained and coded. The result of this phase was organized in a
list that includes the analyzed papers with their associated characteristics (Appendix). In the inductive phase, I identified some specific “themes in each topic area with particular emphasis on characterizing the ones most prevalent” (p. 385) [22], after three iterations.

**Results**

I organized the results using the research questions as analysis categories. The main questions “What type of studies have been conducted to integrate social justice in design within STEM education?”, and “What methods have been used to achieve it?” constituted the categories Types of Studies and Methods, and the subquestions “How design is conceived?”, “How social justice is conceived?”, “How is conceived the relationship between these two concepts?”, “What populations have been studied?”, and “What were the main findings?” constituted the categories Design Conception, Social Justice Conception, Relationship between Design and Social Justice, Population and Main Findings. Likewise, after the first exhaustive reading, it emerged the category STEM area related to the specific STEM field that each article was discussing. As a consequence of the analysis, the resultant information was organized according to the researched population (Appendix): K-12 students and teachers, college students (undergraduate and graduate), and non-formal students (communities and professionals).

**K-12: Students and teachers**

In total, six articles represent the research around the education of students enrolled in the K-12 ranks, principally 5th grade and secondary school, to foster social justice. In the first case, I found that the researchers used design as a means for learning (problem-based learning), associating the concept of social justice with how the participants addressed or solved social
problems. For example, some of the researched teachers believe that social justice is associated with: 1. the development of skills related to environmental awareness in local, communitarian or national terms [23] [24], 2. racial stereotype disruption [25], 3. self-identification as members of a community and agents of social change [26], 4. the construction of critical citizens and knowledge producers [27] or 5. the development of their autonomy [28]. To do this, the researchers mainly used qualitative research methods such as case study [25] [26] [27], narrative analysis [28], or ethnography [24]. In particular, it is worth highlighting the case of Mildenhall, Cowie, and Sherriff [27]. They used qualitative methods for the collection of information such as interviews, observation, and evaluation of prototypes without linking a particular method. Only the article of Karahan and Roehrig [23] used mixed methods using a survey and observation in parallel.

In this same theme, I could see that two studies looked for focusing their attention on teachers or a combination of students and teachers of this educational level. The study of Rodríguez [28], composed by a self-narrative study and the analysis of fifth-grade students in his math class, described the change of his students' mindsets around racial discrimination awareness and the kind of curricular strategies he had to create to address this topic. Likewise, the investigation of Stromholt and Bell [24] analyzed the impact of training sciences teachers in subjects such as the impact of neoliberalism in the environment and its relationship to science learning (critical thinking and collective involvement in doing science), on their students' awareness in social justice through hands-on activities. As in the previously analyzed studies, these last two consider design as a strategy to promote skills for the solution of social problems. In general, all the interventions were able to identify the potential of social justice as a framework to provide support for equity in access to education [24] [25] [26], decision making according to the needs of less favored groups through activism (shoes) [27] or emotional
connection with these communities [28].

**College: Undergraduate and graduate students**

In the case of the university stage, I analyzed six articles related to classroom interventions through Capstone Design Projects (CDP) or specific courses for the development of solutions aimed to achieve social justice, focused on the lack access to specific products, from a welfare approach to social problems, and its effects on particular products. The researchers were, for the most part, engineering instructors in areas such as mechanical engineering [29], IT Engineering [30], Building Engineering [31] or interdisciplinary groups where there are at least one engineer [32] [33] [34], who also looked for fostering interdisciplinary teamwork. For this, these investigations conceived the design from different approaches of user-centered design: 1. appropriate technology [33], 2. service-learning related to social intelligence design [30], 3. socio-technical systems [35], 4. innovation [32], or 5. multidisciplinary design [31], and 6. as a resource for student learning using problem-based learning [34], as in previous school stages.

On the other hand, the results present an improvement of communication skills given by the interdisciplinary [32] and cross-cultural experiences [29], the possibility to prepare future engineers for fieldwork according to what is stated by ABET outcomes [30] or due to humanitarian engineering courses [34], and the stimulation of collaboration and the exchange of ideas [31]. Also, it was possible to find that, although interdisciplinary teams improve communication skills, the dominant conception of technological functionality, as a synonym for success, creates unilateral actions from the engineers in the team without paying attention to power relationships that were generated [33]. Finally, in this population, the research methods used were qualitative-case study [30] [33] and grounded theory [32]-, mixed-surveys and
observations [34]-, and quantitative-quasi-experimental [31].

Non–formal spaces: Communities and professionals

In the selected articles, non-formal learning spaces included training for health sciences professionals, CDP in interdisciplinary groups of professionals, and project-based learning in conjunction with communities. In the seven articles included in this theme, the researchers seek to portray each case separately through qualitative research methods such as case study, ethnography/historiography, or grounded theory. For this, the engineers find themselves as one more participant of the project, but their overall impact in the research process and results is not clear. In this population, the approach to social justice was from the perspective of human quality life improvement (diseases or prevention of them) [36] [37], environmental awareness [38] [39], child mortality prevention [35], equity (decrement of the lack access to information or technology) [40], critical activism (creation of small companies as a way to resist and make visible middle-class initiatives) [41] or the preservation of cultural property in the city [37]. In these articles, design is conceived from the perspectives of social design, social innovation, participatory design, and co-creative design in which the engineer does not have a leading role but as another integrant of the team. However, contrary to the college population, I found that optimism increased in the participants (users and interdisciplinary teams), the awareness about the opinion of others, and the participation and scientific literacy of the end-users.

Discussion

In general, the results showed that the empirical studies related to design and social justice in the framework of STEM education depend on the population that is educated/investigated. For example, in K-12 and college education, the concept of social justice
is related to the promotion of aspects like activism or social change where the students address the expert's role in and for the solution of technological problems due to needs of the intervened communities. In that sense, through problem-based learning (PBL), students simulate a situation where it is needed to solve a social problem such as shoes for people displaced by violence [27] or soap with certain characteristics in an African country [29]. This situation reproduces vertical power relations where engineers stills hold the power of knowledge.

Likewise, this phenomenon was observed in the research carried out by Nieusma and Riley [33]. They found that, during an interdisciplinary teamwork project, the engineering students focused more on the technological functionality of the solution rather than on the dominant power relationships generated throughout the process over their partners. These results suggest that the engineers’ identity around social problems, in the scholar and college stages, is related to design perspectives such as Socially Responsible Design (SRD), Appropriate Design (AD) [13], or Empathic Design [15]. In that sense, the designer is an agent aware and sensible to the context but still distant from the final user. This tendency is reduced during the professional stage in the type of training or work-life, where engineers are the secondary actors within interdisciplinary groups or where the final user is the main actor in the process.

It means that there is a gradual change in the use of design as a tool for searching social justice through problem-based learning in formal education to project-based learning in some university spaces and practitioners stages. In that sense, during the school, it is considered the engineer as an expert agent who seeks to solve the needs of the end-user without considering them during the design process, teachers indirectly foster power relationships where the engineer is the authority to develop such activity. On the other hand, during practitioner stages, engineers lose their power as the main actor and distribute it on the other agents, including the final users. In other words, engineers become closer to design perspectives such as
Participatory Design [12], Co-Design, or Compassionate Design [15].

However, the objective of the interventions found in this literature review was not specifically the development of social awareness about the role of the engineer as a designer. In particular, the initiatives at the school stage mainly looked for sensitizing students to the social problems that afflict society. In this way, teachers linked environmental problems [42], the forced migration and its connection with product development [27] or discrimination [23] [25] [26] as social contexts to develop a solution. As a consequence, through social justice problems-based design, the students learned about interdisciplinary content while developing social awareness about the problems that other person has. By its part, during the college stage, it is not observed this as a quality to pursue and developed. In that sense, the focus of research in this stage is on how engineers work in multidisciplinary team works which are addressing social problems [29] [30] [33] or in how they make decisions during the process for solving this kind of problems [31]. In consequence, it seems that in the university stage, the engineer is constructed as an agent with certain unique knowledge that cannot overlap or dialogue with other disciplines, for which they must be the only responsible when working in a team and where other areas have no place. An engineer is constructed, through design education, as a machine for solving problems independently of the social context. Finally, in the case of non-formal learning spaces, it is not possible to identify the essential learnings obtained by the engineers during the development of the projects, all based on co-design and participatory design for solving environmental (pollution), political (access to technology) or health (child mortality) problems.

At the same time, there is a relationship between the educational level and design conception following the objectives to achieve. On one hand, for K-12 school, Karahan and Roehrig [23], Mildenhall, Cowie, and Sherriff [27], Rodriguez [28], Stromholt and Bell [24],
design is a tool for learning (design thinking mainly). On the other hand, in the professional stage, the other participants are active design agents from perspectives such as the co-design or the participatory design. In that sense, it is possible to speak about the existence of a reflective exercise during professional practice that could be associated with the autonomy, the work experience post-graduation, and the particular interest to address these design perspectives [43]. On the other hand, it was possible to observe that, in the cases related to the university stage, design is a teaching tool that helps to introduce issues related to social justice, considering it on the practice as a conscious and thoughtful design process. This approach is similar to Nieusma’s [13] Ecological Design or Feminist Design, and Seshadri, Joslyn, Hynes, and Reid’s [15] Compassionate Design, which suggest the continuous reflection during the design process.

Finally, qualitative methods such as case study or ethnography are the most predominant in this type of research, being consistent with the search of social phenomena understanding from the perspective of the subjects investigated in the context of social justice. It means that the reviewed articles reflex the characteristics of qualitative research based on stories of small numbers of stories that can help to understand education experiences concerning social justice [44]. Nevertheless, not all the studies looked for that. Some studies observed quantitatively, surveys, specific changes in the populations investigated as consequences of a certain intervention previously designed. It means that, despite the predominance of qualitative studies, it is possible to consider quantitative methods to explain specific aspects related to social justice, such as the attitudes in interdisciplinary or multicultural teams.

**Limitations of the study**
I recognize that this study has several limitations, given the characteristics of the object of investigation. In the first place is the nature and certainty of the databases consulted because some of the found results did not meet the criteria, contrary to the academic referenced articles. Likewise, this limitation could be associated with the search language since studies that incorporate themes related to social justice seek to generate impact in the nearby communities mainly. For example, Latin America has a network of databases in Spanish and Portuguese, which are widely used by the academic community of the region to promote local scientific production. In this way, I excluded investigations carried out in different languages from English, diminishing the number of articles. On the other hand, several of the documents analyzed contemplate studies of science, technology, and society, in particular for the category of non-formal education, given that it is a field little analyzed in education's literary reviews.

Conclusions

When studying the conception of social justice and design in STEM education, it is inevitable to think about the objective of education. While formal education conceives design as a method to develop characteristics associated with social justice such as teamwork, cultural awareness, social change, or the promotion of activism, non-formal education identifies it as a process where the different agents or actors involved in solving a social problem have a voice. In the first case, the design is related to problem-based learning; meanwhile, the second one considers it close to project-based learning, both from learning-doing as a pedagogical bet. It means that, in the analyzed documents, independently of the formality in education, social justice is valued as an explicit or implicit objective to achieve, and that shapes the identity of the participants, as an essential agent for the educational process.

Mainly, the results showed that participants' purpose in the design process was the
generation of social justice through artifacts designed for them, creating two different consequences. On one hand, the creation and perpetuation of vertical power relations between the expert and the user and, on the other hand, the use of design as a method to generate social justice where the end-user has a constant voice in the process. In the first case, the solutions tended to the creation of a product focused on solving the particular problem and, in the second one, on the construction of specific solutions, products, or services that address these problems in a contextualized way. Independently of these considerations, this question lies in what is the relationship between the instructors' and students' concept of technology and the promotion of social justice. It means that more than a design problem design, it is an issue of the conception of technology as a product of this. In principle, this relationship is based solely on the functionality of certain artifacts to solve a problem. However, it usually does not conceive the particularities, even aesthetic, of the impacted population and which, over time, could generate more rejection than relief. In that sense, only the document of Bortz et al. [35], despite not being a specific STEM education-related document from the spirit of formal education, shows the need to create transdisciplinary exercises that could be appropriate by the formal education. In other words, it is essential to consider the design as a construct mainstreamed in STEM education, dissolving the frontiers between these areas and projecting as a means to solve social problems.

As an advance to this ideal, the analyzed studies sought the interdisciplinarity, as a step before transdisciplinarity, with areas other than natural sciences in implicit or explicit ways. For that, these studies propose to expand formal education's boundaries to communitarian spaces outside the classroom or the academy, as a symbol of this desire. In this way, STEM education would be considered in non-formal spaces where the learner is the community impacted (scientific divulgation and communication). Likewise, professionals related to these areas,
especially engineers, become sources of knowledge and learning given their proximity to communities and other agents. In that sense, when the design is related to social justice, it is required to consider what are the skills that an engineer needs to educate society under the framework of action that the Other allows.

Finally, the relationship between social justice and design has the potential for exploring and consolidating educational proposals and mechanisms outside the traditional ones, and that allows some progress towards social justice. For example, the integration of social studies of technology, as well as the history and philosophy of engineering, in formal and non-formal education might be a possibility that would help to think about and apply the different frameworks related to social justice and design. Likewise, in the research realm, it is crucial to consider the investigations that have been carried out in other languages because the interventions around social justice are usually documented in the local language for communicating the information to those who require it. With that, it is possible to identify advances, challenges, and strategies that could be transferred and probed in other locations.

Acknowledgment

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<th>Author(s)</th>
<th>Source</th>
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<th>Social justice conception</th>
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<td>Acharya (2019)</td>
<td>L</td>
<td>Health sciences</td>
<td>12 medical practitioners in a hospital at Nepal</td>
<td>User-centered</td>
<td>“advocacy for those in our society who are economically, socially, politically, and/or culturally under-resourced” (p.7)</td>
<td>Non-formal education: Training in contextual spaces for professional practitioners</td>
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| Aguayo & Eames (2017) | L | Engineering: Environmental | A community in southern Chile | Human-centered design | ● Social change towards ecological sustainability and socio-ecological sustainability  
● Community empowerment | Non-formal education: Communities - citizen science |
| Bortz et al. (2018) | R | Engineering: Food | Engineers, nutritionist, community, and government | Socio-technical systems | Solving social and environmental problems | Non-formal education: Capstone design projects in engineering practitioners |
| Burleson et al. (2017) | R | Engineering: Mechanical | Oregon State University (OSU) student team of Mechanical Engineering, a non-governmental organization (NGO) in Uganda, and an Oregon-based team of professionals with expertise in different areas Multidisciplinary Undergraduate Senior Students (Information and Technology Engineering, Industrial Design) at Tecnológico de Monterrey | User-centered | ● Social Justice criteria by Leydens and Lucena: Listening contextually, identifying structural conditions, acknowledging political agency/mobilizing power, increasing opportunities and resources, reducing imposed risks and harms, and enhancing human capabilities.  
● Humanitarian engineering by the lenses of service-learning | Undergraduate capstone design projects in formal education |
| Cárdenas (2011) | L | Engineering: IT | Citizens from Amsterdam, Barcelona, and Pristina | Social Design (SD) / Service Learning related to Social Intelligence Design (SID) | ● Social change associated with developing "solutions to socially relevant problems."  
● Promotion of higher-order cognitive skills (HOCS) on the society | Undergraduate course |
<p>| Coulson et al. (2018) | L | Environmental sciences | 25 faculty, program directors, and alumni from different disciplines in an American university | Transformation design in participatory sensing | Environmental challenges (environmental awareness) through the making sense approach | Non-formal environmental education: Citizen science |
| Faludi &amp; Gilbert (2019) | R | Engineering: General | 25 faculty, program directors, and alumni from different disciplines in an American university | Invention and innovation related to a mixture of engineering, design, and business | Social justice for broader sustainability to environmental responsibility | Undergraduate design course |</p>
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Source</th>
<th>STEM area</th>
<th>Population focus</th>
<th>Design conception</th>
<th>Social justice conception</th>
<th>Educational focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irani (2015)</td>
<td>L</td>
<td>Engineering: IT</td>
<td>Participants hackathon in Delhi</td>
<td>Innovation and participatory design</td>
<td>Redistribution of financial abundance through the middle-class civilian entrepreneurship, evidenced in “activist”, “reformist” or “heritage” festivals</td>
<td>Non-formal IT education: Citizen science</td>
</tr>
<tr>
<td>Karahan &amp; Roehrig</td>
<td>L</td>
<td>Environmental sciences</td>
<td>Twenty-two diverse 10th to 12th graders between the ages of 16 and 19 from an environmental science class including four White, nine African-American, five Asian, and four Hispanic students</td>
<td>Strategy to teach and learn: Planning, designing, testing, and sharing</td>
<td>Social awareness as a step before the social activism</td>
<td>K-12 education: Students</td>
</tr>
<tr>
<td>Lindtner &amp; Lin</td>
<td>L</td>
<td>Engineering: Electronics</td>
<td>Shenzhen region (China)</td>
<td>Participatory Design: The maker movement</td>
<td>Democracy: Open source hardware prototyping platforms to DIY (do it yourself)</td>
<td>Non-formal education: Science and technology made by citizens with different backgrounds</td>
</tr>
<tr>
<td>Marti et al. (2016)</td>
<td>L</td>
<td>Interdisciplinary</td>
<td>Master and Ph.D. students in design: • Eindhoven University of Technology: Social Stairs Project</td>
<td>Participatory and co-creative design: Systemic innovation (interconnected products, services and solutions that grow and adapt with the user to bring new value and meaning)</td>
<td>Democracy through the user-centered approach, giving a voice to the final user Participatory Sensing (PS): Citizen science</td>
<td>Non-formal health and political education: Citizen science</td>
</tr>
<tr>
<td>Mildenhall et al.</td>
<td>R</td>
<td>Interdisciplinary</td>
<td>The 24 Year 3 children aged between eight and nine years old</td>
<td>Strategy to teach and learn: PBL</td>
<td>Equal access to wealth, opportunities, and privileges is less prominent</td>
<td>K-12 education: Students</td>
</tr>
<tr>
<td>Nieuusma &amp; Riley</td>
<td>L</td>
<td>Engineering: General</td>
<td>Nicaragua: Multidisciplinary engineering students group from a local university</td>
<td>User-centered: Appropriate technology</td>
<td>Democratic society to be able to participate actively in and contribute to society</td>
<td>Non-formal health and political education: Citizen science</td>
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<td>Country competitiveness in the global economy, country well-being, and individual employment opportunities</td>
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<td></td>
<td>Social justice considerations include questions about power inequities inherent in development assistance, evidenced in concerns of technical functionality which generates social power imbalances and epistemological divergence</td>
<td>Undergraduate capstone design projects in formal education</td>
</tr>
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<td>Author(s)</td>
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<tr>
<td>Smith et al. (2018)</td>
<td>R</td>
<td>Engineering: General</td>
<td>Students from The Australian National University starting a HumEng research project courses ENGN4200 or ENGN4221</td>
<td>Strategy to teach and learn: PBL</td>
<td>Service-learning / Humanitarian Engineering: In Australia, HumEng encompasses the broadest range of assistance, from disaster response and recovery to long term community development, both domestically and overseas</td>
<td>Undergraduate capstone design projects in formal education</td>
</tr>
<tr>
<td>Stromholt &amp; Bell (2018)</td>
<td>L</td>
<td>Environmental sciences</td>
<td>Nine Fifth grade students who attend the class of science at Granite Elementary</td>
<td>Co-design: Teacher, Strategy to teach and learn: PBL</td>
<td>• Neoliberalism could create profound issues of access and equity in science education for non-dominant communities including African American, Hispanic/Latino, female students, and those living in degrees of poverty in the United States: Teacher • Environmental issues solving: Students</td>
<td>K-12 education: Students</td>
</tr>
<tr>
<td>(Thomas, Rankin, Minor, &amp; Sun, 2017)</td>
<td>L</td>
<td>Engineering: IT</td>
<td>Supporting Computational Algorithmic Thinking (SCAT) African American middle school girls</td>
<td>Strategy to teach and learn: PBL</td>
<td>• Social change: Social issues from gun violence to environmental sustainability • Inclusion</td>
<td>K-12 education: Students</td>
</tr>
<tr>
<td>Tucker-Raymond et al. (2016)</td>
<td>L</td>
<td>Mathematics</td>
<td>High school-aged students from underrepresented groups</td>
<td>Strategy to teach and learn: PBL</td>
<td>Access to science, technology, engineering, and mathematics for economic mobility and civic enfranchisement related to the intellectual power of the knowledge and practices of non-dominant youth.</td>
<td>K-12 education: Students</td>
</tr>
<tr>
<td>Zeiler (2018)</td>
<td>L</td>
<td>Engineering: Building</td>
<td>Students Master Program “Integral Design: Architects and engineers Multi-disciplinary design method: Integral design”</td>
<td>Social transformation looking for sustainability as an effect of social change</td>
<td>Graduate education teamwork and decision-making model</td>
<td></td>
</tr>
</tbody>
</table>

Note: L = Literature search, R = Reference search

Source: Own elaboration
References


