Design and 3D Technologies in the Humanitarian Sector

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Abstract

Every year, thousands of people are affected by the expansion of disasters caused by climate change. These disasters trigger situations that demand assistance. The responses, through organizations that operate in the context of humanitarian aid, are complex to be put into effect due to problems of physical, material, and emotional structure. Design and its various approaches can help in the elaboration of solutions that improve the service provided by those organizations, both through the mastery of techniques for the quick production of concrete objects and in the structuring of projects to meet demands, such as service design, participatory design, and co-design. This paper presents a literature review on the topic and uses examples of projects developed and under development to elucidate the possibilities of using both design approaches and tools disseminated by design professionals, such as 3D technologies and techniques for digital fabrication, in the field of humanitarian aid.

Keywords: humanitarian aid, 3D printing, digital fabrication, social sustainability

Introduction

The COVID-19 pandemic has affected the global supply distribution chain. The international community, therefore, needed to rethink and develop production methods and strategies to face the challenges posed by the pandemic caused by the Sars-Cov2 virus. Without the operation of the necessary logistics, in addition to everyday consumer goods and food, the world population was impacted, mainly, by the shortage of personal protective equipment and other essential devices for the work of health professionals who worked in the line at the front (Boseley, 2020; WHO, 2020).

Teams involved in the research and development of 3D technologies, such as 3D printing and 3D scanning, quickly decided to use these techniques to digitally manufacture items in short supply. Soon, this response found by the first locations affected by the pandemic began to spread to other countries affected. Subsequently, several projects and research reporting the use of these technologies were published (Amin et al., 2020; Maracaja et al., 2020; Oladapo et al., 2021).

However, the use of technologies for digital fabrication, such as 3D printing, as a strategy in environments where logistics are compromised and there is a lack of access to certain materials, had already been put into effect in similar situations to those caused by the COVID-19 pandemic. The application of 3D technologies in humanitarian contexts had already been reported by the United Nations Office for the Coordination of Humanitarian Affairs (James & Gilman, 2016).

Millions of people are forced to leave their homes due to floods, droughts, tropical storms, melting glaciers and other natural hazards. These displacements occur every year. Although many victims find help in their own country, some people need to move abroad. Even though some of these movements are well documented, the entirety is unknown. These displacements have devastating effects on people and communities and climate change is expected to increase their occurrence in the future. This produces humanitarian challenges that require urgent partnerships and actions (United Nations Office for the Coordination of Humanitarian Affairs [OCHA], 2020).

For Corsini and Moultrie (2019) social sustainability is necessary to support positive changes that address urgent social challenges. The increased demand for humanitarian aid, and the need to develop new solutions, made designers working in this field begin to use digital fabrication techniques to produce essential items. However, the social aspect of sustainability has been forgotten and many organizations are failing to develop the intended impacts.

Design can be a transforming agent in the context of humanitarian aid. Through the literature review on the topics addressed and examples of projects previously carried out and under development, this paper presents the possibilities of applying design approaches, such as participatory design, co-design, and service design in the context of humanitarian aid. Additionally, it addresses the opportunities of applying tools popularly used and disseminated by design, such as 3D technologies and other technologies used for digital fabrication, in projects developed through these approaches.

3D Technologies and Digital Fabrication in Humanitarian Aid

Approximately 1900 disasters caused 24.9 million new displacements in 140 countries and territories in 2019. This number, three times greater than the number of displacements caused by conflicts and violence, was the highest recorded since 2012. These incidents were recorded in countries with low and high incomes. In 95 countries and territories, around 5.1 million people are displaced by disasters (IDMC, 2020). It is estimated that 216 million people needed humanitarian assistance in 2019. This part of the world population is distributed in 69 countries (Thomas & Urquhart, 2020).

For James and James (2016) anyone working in the field of humanitarian aid has already been frustrated with supply chain failures. Obtaining items, even simple ones, can take weeks or months, due to uncertainties and interruptions regarding physical and communication structures. The cost of logistics structures is responsible for approximately sixty to eighty percent of humanitarian aid costs. In addition, at certain times, there is a need for specific items, such as spare parts for medical equipment and/or machines. These demands require new approaches to making aid more efficient. The Field Ready organization uses agile and iterative techniques and practices to propose new ideas, quickly evaluate them and make necessary adaptations. One tool used in this process is 3D printing technology.

The origins of 3D printing technology date back to the 1980s. In 1984, Chuck Hull registered a patent for the Stereolithographic (SLA) process, along with this technique the file in Standard Tessellation Language was born (STL) (Balletti et al., 2017).

3D printing technology allows the materialization of objects through digital files, digitally modelled or digitized three-dimensionally. The variation of techniques follows the possibility of materials used for printing. Shahrubudin et al. (2019) suggest a classification for printing techniques into Binder jetting, Direct energy deposition, Materials Extrusion, Materials jetting, Powder bed fusion, Sheet lamination, and Vat Photopolymerization. Three-dimensionally printed pieces can be used in a variety of applications, such as the development of resources to aid teaching (Ford & Minshall, 2017), the elaboration of reproductions of cultural heritage objects (Ballarin et al., 2018; Wilson et al., 2018; Adami et al., 2015) to solutions for the medical field (Haleem & Javaid, 2020).

Field Ready organization is a pioneer in the use of 3D printing in disaster relief situations (Figure 1). They also strive to share knowledge with other organizations. The organization has already offered training for aid workers and local partners in

using 3D printing and maintaining the printers. Another technology used in their works is 3D scanning. The approach used involves producing and testing the designs in collaboration with people who will use them, involving both humanitarian workers and those affected. 3D printing enables low-volume production of parts that are not available in the field and complex parts. This technology allows the modification or adaptation of items to meet local requirements. Local manufacturing allows items to be available more quickly, eliminating procurement and delivery systems, as well as shipping packaging (James & James, 2016).

Figure 1. (a) 3D printer operating using battery power from a vehicle in field operation; (b) Field Ready organization prototyping station. Field Ready (2017)

In 2014, while working in Haiti, Field Ready discovered, through research conducted with midwives, a supply chain issue that affected the availability of umbilical cord clamps. These clamps, although simple, are pieces that prevent dangerous infections. When they were available on the market, they usually cost a dollar but could cost as much as three, while a printed piece costs the equivalent of sixty cents on the dollar. 3D printing of the parts resulted in a reduction in the risk of neonatal umbilical sepsis. In Nepal, while visiting the International Hospital in Kathmandu, members of the organization found a lot of out-of-use or broken equipment. Among these, five heated cribs, three had the same defect. The clamps holding the sides of the crib were broken. As it was an old piece of equipment, there was no possibility of purchasing spare parts. So, a Field Ready engineer designed a new part, improving the broken area. This part has been printed, tested, and redesigned. When evaluating the new clamp, the hospital's chief engineer said it fit better than the original part. The organization was able to print the supplies needed to repair all the heated cribs (James & James, 2016).

Design for Social Sustainability and Digital Fabrication in a Humanitarian Context

Corsini and Moultrie (2019) used the Design for Social Sustainability (DfSS) approach to study projects using digital fabrication in the humanitarian and development sector. The authors developed a DfSS framework to assist designers using digital fabrication in the humanitarian sector. The framework should support professionals in guiding decision-making at the beginning of the project and help to assess, at the end of the design process, the social sustainability of the products developed. Initially, to develop the framework, the authors carried out a literature review to identify the main themes and factors contributing to DfSS. After analysis and systematization, thirty-six sub-themes were organized into fifteen themes. To verify the relevance of the themes organized for the projects in this context, the authors used three case studies. The selected studies should use digital fabrication to develop products for the humanitarian and development sector and work in low-middle-income and low-income countries. In addition to having a duration that would allow for the establishment of live and detailed data, the projects should also serve the health area. One of the case studies was conducted by Field Ready organization. Then, for eight months, interviews were carried out with members of the selected projects to build knowledge about the studies. Initially, the authors interviewed designers and project managers to identify the main themes of DfSS for design in a humanitarian context. That was used to develop the framework. The elaborate framework identifies sixteen factors, divided into three sets: product, process, and paradigm. The development of the framework took place iteratively. The interviews were coded and the fifteen themes and thirty-six sub-themes, based on the literature review, were refined into sixteen. These themes were grouped into three categories. The first set corresponds to the factors related to the product: need, suitability, access, usability, quality, inclusive, adjustability, and complementarity. The second set presents the factors related to the design process such as local manufacture, local control and repair, collaborative, transparent and scalable. In the third set, the authors gathered the factors related to the paradigms: advancement, systemic, and empowerment. After the initial interviews, the authors collected real information about the projects. This collection took place through field observations and interviews with various stakeholders, end users, partners, and beneficiaries; which was later used to evaluate the projects using the developed framework.

Participatory Design, Co-design, and Service Design Approaches to Humanitarian Aid Context

One possibility for the development of work in the context of humanitarian aid is the use of a participatory approach. For Sanders (2006) the participatory mentality consists of designing with people. Participatory researchers and designers see people as co-creators in the process and respect their experience. The origins of participatory design can be traced back to unions in Scandinavian countries during the 1960s and 1970s. Participatory design is a design approach that attempts to actively include people who are served through design in the process. This inclusion is intended to help ensure that the product or service designed meets the needs of these people. In co-design, the researcher, who can be a designer, must act as a facilitator of this process, leading, guiding and providing the instruments (Sanders & Stappers, 2008).

Service design is a practical approach that helps organizations improve and create service offerings. It has many aspects in common with experience design, design thinking, and user experience design. It is a human-centered, iterative, interdisciplinary, and collaborative approach (Stickdorn et al., 2020). For Fountaine (2018a), service design addresses both creation and re-design. In order to do that, research is carried out on what people need and elements are developed and iterated until they are effective. The final phase is implementation and working with stakeholders to ensure that the service works.

Médecins Sans Frontières (MSF) translates to “Doctors without Borders” is an international, independent medical humanitarian organization that brings healthcare to people affected by humanitarian crises (MSF, 2023). Following the service design approach, Charlotte Fountaine (2018a), a designer, developed a project on the transfer of old and new members in Doctors Without Borders (MSF) missions. MSF's fieldwork, due to its extreme nature, operates with high turnover. After working in hospital administration on an MSF project, international staff return to their homes. There is often a gap between the departure of one staff member and the arrival of another, due to the fact that old staff may not have time to teach new staff the operating procedures of the hospital. This affects the quality of patient care and the overall hospital strategy. Fountaine worked with the organization to improve their transfer procedures. In the first stage of development, the problem was defined and then an advisory group is created. The group is composed of IT professionals, data analysis, hospital management, human resources, doctors, and employees of logistics departments. According to Fountaine (2018a), thirty international officials and five national officials contributed their knowledge and opinions during the

development of the project. The workshops created with the field teams (Figure 2) allowed the elaboration of ideas for the transfer process, based on initial research.

Figure 2. MSF professionals participating in Workshop activity. (Fountaine, 2018b)

The team evaluate their ideas considering whether they would be implementable or not and what would be the impact of this implementation. The ideas that had the greatest impact and were capable of implementation were prototyped so that they could receive feedback. A member's journey was developed and divided into three stages. From the moment the new member is preparing for the mission, during their participation, and when leave fieldwork. The project depicts the breadth of possibilities of the service design approach. Among the resolutions developed, there is a live organizational chart template, which allows employees to easily know who the members in the field are and what their roles are. The solution consists of a form, with space for a photo and member data so that members can easily update the organizational chart on a wall. Other solutions consist of a guide of comrades of the national team so that members of the organization that works in the country receive and assist the new international members. In addition to a flexible transfer model, a report on findings and a best practices guide. Another action is to motivate members to write their transfer reports from three months to three weeks from the end of the mission; to avoid a lack of motivation to write the report due to stress and demands with their exit procedures. Designed to be as fast and efficient as possible, the new transfer process provides for the intermittence of the connection structure and access to electricity, in addition to the limited amount of telephones and computers (Fountaine, 2018a).

Final Considerations

Thousands of people are already displaced from their places of origin due to droughts, floods, storms, and other natural disasters. Climate change should increase the occurrence of these situations. Thus, organizations working in the humanitarian sector have been looking for innovative solutions to assist victims of these disasters and other situations that demand the assistance of the humanitarian sector.

The literature and projects presented indicate both the capacity of projects that have already been put into effect or are under development, as well as the potential of design approaches that can enhance the use of 3D technologies and the development of new resources for the humanitarian aid sector.

Challenges in the humanitarian aid field can involve cultural differences or the need to understand different languages. Design can assist in adapting transmitted information to accessible formats. The development of these adaptations can be benefited by the integration of the communities served by the projects in the planning of activities and by the maintenance of the knowledge acquired during the execution of the projects.

However, the planning of activities must consider structural limitations. Strategies and tools must be adapted considering the possible absence of resources such as energy and connection, and the unavailability of computers and other devices. The efforts needed to perform these tasks must also respect possible emotional overloads of the people involved.

Using the participatory design, service and co-design approaches, consultative groups could be established to organize demands and possibilities for actions using 3D technologies and other technologies for digital fabrication. One possibility would be to establish a procedure for assembling and maintaining simplified makerspaces or fab labs in the field.

An essential issue is to understand and attend to the sustainability social aspect during the development of these projects. Therefore, studies such as the one by Corsini and Moultrie (2019) are essential to assist professionals who design and develop actions in the sector.

Future research can explore the challenges of adapting resources that facilitate the quick visualization of information in accessible formats, considering the use by people with disabilities and the limitations of resources in this context.

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