



3D PRINTING - THE NEW STAR IN HUMANITARIAN TECHNOLOGY?

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Abstract

The main objective of this paper is to prove why 3D printing is a potential candidate to be the upcoming humanitarian technology and its impact on the world and on the different sectors of human welfare. The conclusions were reached by statistics, ongoing projects and a survey conducted by me asking people opinions on this agenda. As this is a topic that is quite new and fresh, I have adapted to use the style of numbers, data, and logical reasoning to back my hypothesis and also prefaced a bit on how this technology works and its astounding process.

Keywords: 3D Printing, Education, Healthcare, Housing

INTRODUCTION

Humanitarian technology can be thought of as two words. 'Humanitarian' has been defined as concerned with or seeking to promote human welfare[14]. 'Technology' is often thought of simply as a 'tool' that extends human capability for example, from hammers to the internet). So it can simply be thought of as innovations and creations that benefit human well-being. It involves projects that improve water and sanitation facilities, healthcare, education and off-grid electricity generation.

3D printing can reproduce physical objects from a geometrical representation by continuous, sequential addition of material [1]. It was first used in the commercial sector by Charles Hull in the year 1980 [2]. It is an application of additive manufacturing which can be defined as the process of producing parts through the deposition of material in a layer-by-layer fashion[15]. It uses raw materials like plastic, metal, ceramics, and resins and uses them to produce an array of three dimensional objects.

The obvious reasons for this technology to be chosen are it saves time, conserves money, and preserves the environment. These three constraints are what human life revolves around. It saves time as the internal process is quite fast. Now, if we save time, productivity increases, pressure reduces and there is time to explore more opportunities. It reduces costs as there is no need for labour at factories and less machines are needed as it can handle the entire job. By conserving money, it produces more funds to be invested in other areas of interest and research, businesses don't face losses, no loss of employment, more income generated. The environment is protected as it makes use of recycled waste materials and If the environment is not harmed, then sustainability is achieved, better air and water quality and cleaner earth and better space for us to live.



Now as we 3D printing has the ability to print anything which has its dark side as well. There are security implications with 3D printing like production of illegal weapons and loss of intellectual property. However, there have been introduction of policies and standards by the EU (European Union), China and USA. Also, high capital investment is another downside of it. However, in the long run they can cut down a huge amount of costs and be more profitable compared to traditional methods.

Theory

So how does 3D Printing work?

3D Printing is a four step process. Firstly, you have to design the digital representation object you want to 3D print in CAD software like AutoCad, TinkerCad, etc. An electronic version can also be created by 3D scanning the real world object by a specialised software which precisely scans the object and produces a digital copy of it. The second step involves converting the digitised version from design software into STL file format which has an extension of .STL. .STL stands for stereolithography which uses tessellations wherein the whole model is represented and recreated by small triangles which stores information about the model in a language which 3D printers can understand. The third step includes slicing the model where the object is chopped, segmented into numerous horizontal layers. Now, after this process a unique file format called G-code is produced which contains each and every step and instructions for the machine as to how to print the 3D model and finally the model is printed using raw materials provided. The fourth step involves post processing wherein the model is enhanced in its quality, appearance by use of special techniques like polishing.

There are various technologies used in 3D printing:

Fused Deposition Modeling (FDM)

Here a plastic filament material which has thermal properties is heated at its melting point and released out of nozzle and model is built layer by layer.

Stereolithography (SLA)

It uses ultraviolet light to produce layers of 3D model. A pool of photoreactive resin has light emitted on its surface which causes resin to turn into solid thereby producing a shape.

Selective Laser Sintering (SLS)

This technology uses a high powered laser which is struck over a layer of fine powder which causes the particles in powder to bind and fuse together to create a thin solidified layer. Then, another layer of powder is placed over the top of the previous layer and reiterates the process.

Materials used in 3D printing

Plastics

This is one of the most popular materials used for 3D Printing. Mainly, because it is very affordable, provides strong flexibility, has great smoothness and firmness. In plastic there are various types like Polylactic acid (PLA) which is made from sugarcane and corn starch and therefore makes it biodegradable and environmentally friendly. Acrylonitrile butadiene styrene (ABS) is another material which is very strong in terms of strength and is often used to make toys like LEGO blocks.



Metal

Used by direct metal laser sintering or DMLS technology of 3D printing, it is often used to make parts of aeroplanes in the aviation industry, make utensils, ornaments made of gold. It is often utilised in the form of metal dust. Properties which make it quite useful are high melting point, ductility, good corrosion, oxidation resistance and high specific stiffness [4].

Impact of 3D Printing on humans

Healthcare

- ***Prosthetics:*** It is an artificial, man-made human body part made mostly from ABS, plastics, metals that is to be fitted whenever a person loses any of its body parts or when they become non functional. There are about 1.7 million people in the United States living with limb loss, and 50,000 to 100,000 new amputations occur per year[3]. 3D Printing has made great advancements in this area as it is considerably cheaper which is truly evident as reports by American Orthotics and Prosthetics Association suggest that an average traditional prosthetic costs between \$1,500 to \$8,000 while a 3D printed prosthetic is available for a price as cheap as \$50! Nevertheless, it can be customised as per the person needs which makes them more comfortable wearing it. It can be developed within a timespan of 24 hours [5] which makes them easily accessible in emergency and increases production rate. This emerging technology has allowed disabled or severely injured athletes to continue their desire to play sports in competitions like Paralympics which otherwise sports persons couldn't even play.
- ***Artificial organs and Tissues:*** The bioprinting of tissue involves the use of silicone mold where living tissues are placed on a chip. Later, a grid of living cells are printed layer by layer followed by insertion of stem cells via a specialised ink into the mesh of cells. An additional microgel involving a lot of nutrients is supplied via a single inlet and outlet. With this, patients do not have to wait for the donors and are also saved from the risk of cell rejection. They also make it possible for people to get organ transplants for which there are no compatible donors, open room for more research to be conducted and devise solutions to health problems that couldn't be solved before.
- ***Personalised and new medical equipment:*** Right from printed glasses, surgical tools to stethoscope, thermometers everything can be 3D printed. They allow the creation of personalised designed medicines as per the patient's needs. A girl born in 2011 named KaibaGionfriddo was born with tracheobronchomalacia, a disease in which windpipe collapses causing breathing and heart rate to stop often during the day. Her doctors 3D printed bioresorbable device that instantly aided Kaiba breathe. Later, after the operation her trachea rebuilt itself and she was able to breathe properly again [6]. Now, local hospitals and pharmacies can manufacture medicines as per patient's problem leading to more effective and faster treatment. This is the power of 3D Printing!

Education

- ***Virtual Training and Planning:*** Usually when CT scan is performed on a patient, a digitized version of the required body part is produced. However, much cannot be done with this digitized version of this part. So with the help of 3D Printing, we can reproduce the digital version into a three dimensional, real model. Now the doctors can train themselves for the actual, real life surgery by first rehearsing the entire process on the 3D



model. This will help acquire more precision, accuracy and lower surgery times. It can help trainee doctors to understand how each part of the body functions and appears in real life and visualize them even more effectively[7]. Real hands on practice of surgeries is no longer a dream now! Shah and Ahmed, two undergraduate medical students conducted a survey on the importance of the variation in teaching for undergraduate dental education and found that the majority of students had a preference for kinesthetic learning ie. tactile learning [8]. Those physical interactions or activities are the reasons why 3D printed models are essential in the training of medical professionals.

- ***Boosts Maker Culture:*** It is simply a replica of DIY(Do-It-Yourself) culture wherein people use their ideas and creativity to fabricate things. It draws and attracts people, communities into creating something unique and new. With the advent of 3D Printing, students are not limiting their imaginations as anything they want to build can be immediately available in 3D version. No need to produce presentations, pitch to manufacturers, spend time travelling and waiting. All you need is a 3D printer. It will increase the number of freelancing designers as they manufacture designs easily with open source community softwares. The students can experience hands-on, practical learning which will help them further deepen the level of interest with the touch and feel of objects. Innovation will reach new heights as ideas are transformed to reality with this amazing invention.
- ***STEM Education and R&D:*** 3D Printing has helped students especially in field science and technology to improve their skills like spatial, problem solving skills. They can foster their creativity and imagination by building prototypes. Learners make designs in software, test their designs, encounter issues, solve them and they keep trying which helps them build problem solving. With 3D printing, there are a plethora of avenues that are unexplored like they can be used to print laptops, furniture, gadgets, so these areas need research which young enthusiasts would be willing to perform.

Disaster Relief

Whenever natural disasters hit us, they come with massive amounts of destruction and economic loss. They destroy homes, buildings, transport systems, shops and literally anything that comes their way. After the storm of demolition passes away, there is an urgent need for reconstruction of damaged infrastructure. There are things that need quick fixes and 3D printers have the ability to produce objects instaneously and with a limited amount of resources. They provide immediate solutions like production of medical equipments, newly built homes. What we need after a disaster is shelter which is facilitated by use of 3D printers as they build small, sturdy houses from eco-friendly materials. Another immediate requirement is electricity which can be attained by printing new wires to replace damaged ones , solar panels to generate electricity and even fabricate generators.

In 2015, an earthquake of magnitude 7.8 hit Nepal and tore the whole nation into pieces. An organization named Field Ready went to a place in Nepal, named Bahrabise, where a huge number of families were affected by the natural phenomenon. Later, when they viewed and inspected the area they found out that there were multiple pipe breakages, leaks coupled with missing bath fittings. The designer, immediately within a small span of time designed a CAD drawing of a water fitting model and fabricated a three dimensional model of it. They fixed it in



the pipe and it worked perfectly alright. This was the first time that bath fitting for pipes had ever been 3D printed [9]. Now, if the process was done traditionally, firstly, it would have taken a couple of days to import materials required from different countries, then manufacturing it. It would have taken a great ordeal of time and money. With 3D printing, both of these assets are saved as well as people are able to restore water supply immediately for their use. Enormous volumes of water were conserved, people continued their household chores and so many things improved in such a small matter of time.

Another amazing project by Field Ready was implemented by the local manufacturing of rescue airbags and medical equipment in Syria. As it is known, Syria has been a country that has been severely affected by war and conflict. Rubble, collapsed buildings, gigantic rocks have covered the entire country. These bags produced from recycled materials are a cheap effective solution that has allowed lifting of debris, ruins that weigh up to tons. Due to constant bombings, people often get stuck under the rubble and can face severe injuries due to the heavy amount of pressure. With this new invention people can easily be rescued and so many lives are saved. If there were no 3D printed airbags, so many people would have died by now [10].

Housing and Shelter

- In today's world, 29.245 percent of urban population live in slums [11]. This huge number shows the global housing crisis the world is facing right now. This calls for an immediate solution to produce cost effective houses to accommodate these people. 3D Printing with its amazing innovation is able to build homes from concrete and recycled materials. The quality of homes is excellent and provides protection against natural disasters like floods, earthquakes. As natural disasters occur, there are millions of people who are left homeless and there is an urgent need for cheap and sustainable homes like these which makes the implementation of this technology even more significant.

Projects

- New Story, a non-profitable housing organisation in collaboration with ICON are constructing the world's first ever 3D printed community in a remote location in Mexico. Their aim is to create 50 homes with an area of 500 sq.ft for families that live on less than \$3 per day. Providing 2 bedrooms, bathrooms, kitchen and protection against seismic activity this community will take just a couple of days to be ready. This shows that the world is moving towards this technology. Here are some pictures of the project.



- Tvasta Manufacturing Solutions, a startup by three IIT alumni has built India's first ever 3D printed house with area of approximately 600 sq.ft in Chennai and 1BHK style home. The house can adjust itself according to climatic conditions. Built within 5 days, it is supported by the Ministry of Housing and Urban Affairs. Finance minister feels this would be an important step to complete the mission of 'Housing for All by 2022'.
- Dubai has built the world's largest 3D printed building with help of ApisCor, a construction firm based in the US. It possesses an immense height of 6900 square feet with an astounding height of 31 Feet. Built from recycled and waste materials mixed with concrete, this building was just built from a single 3D printer. Check out some amazing photographs here.



Experimental

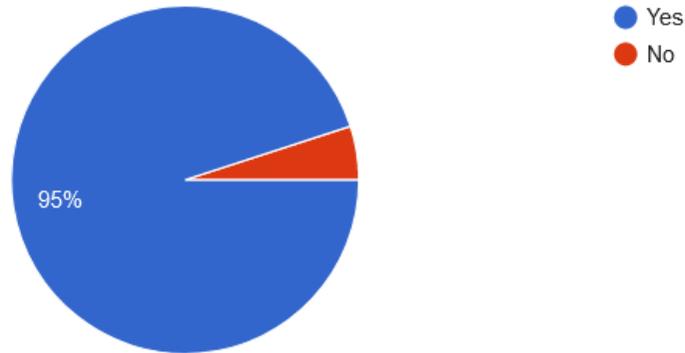
I conducted a survey to test my hypothesis of whether 3D printing will be the next face of humanitarian technology. For this, I made use of google forms to get people's opinions on whether they think that this technology will create an impact on human welfare and which sector it would affect the most. It was a multiple choice based questionnaire to make sure results can be easily quantified and inputs can be collected accurately. 60 respondents participated in the survey conducted online and here are the results.



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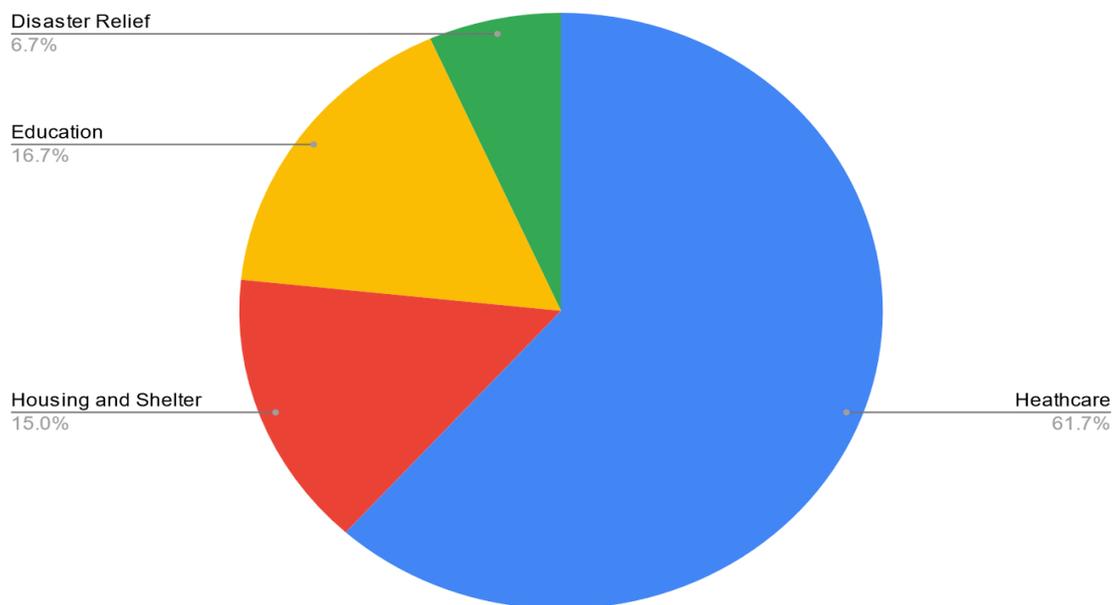
Do you think 3D Printing will improve human welfare and quality of life?

60 responses



According to the respondents, they definitely think 3D Printing will be the next upcoming humanitarian technology. As the results state, out of 60 respondents, 57 believe it has the potential accounting for 95 percent and only 3 feel it is a creation that will not benefit humans. As this technology is dependent solely on human well being so if we ourselves feel it might create a change then there's no stronger evidence needed.

Which avenue do you think it will impact the most?

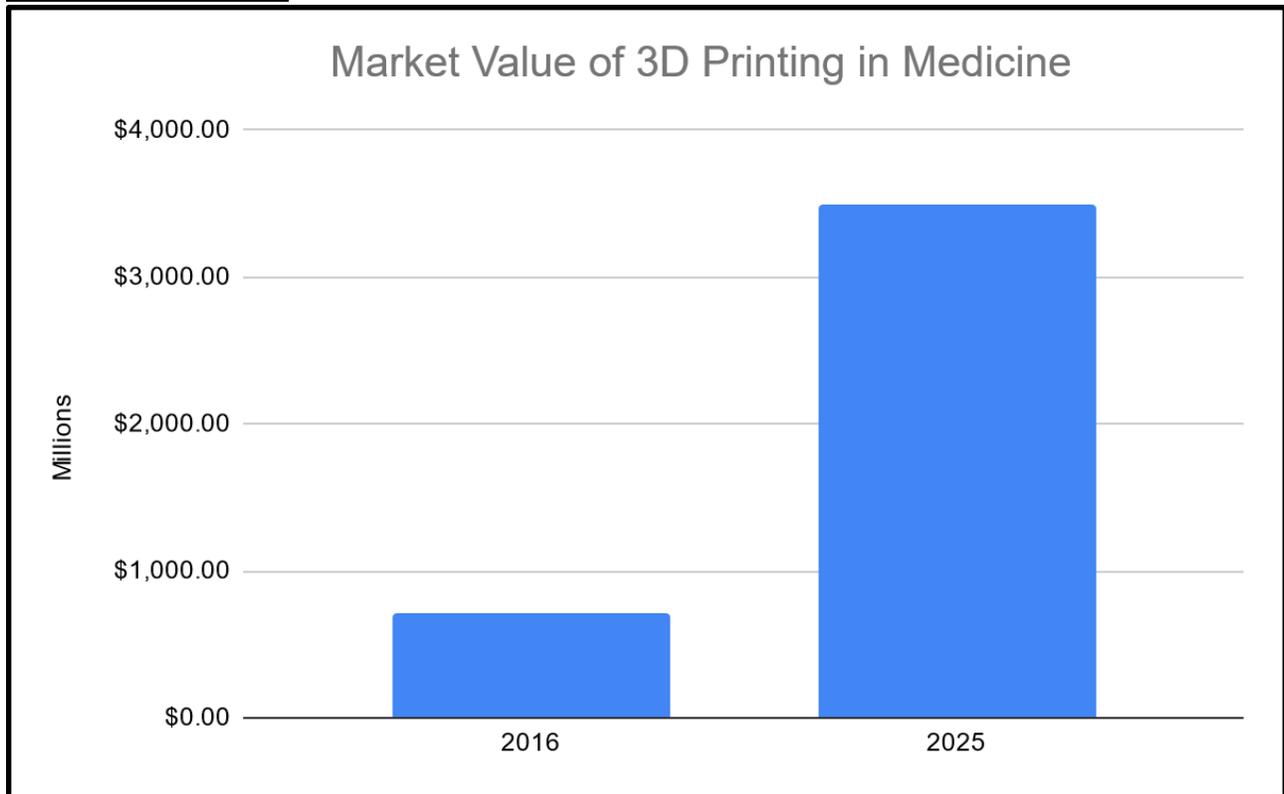




Discussion/Result

Out of 60 surveyors, about a majority 37 candidates felt 3D Printing might affect healthcare the most, followed by 10 respondents in favour of education, 9 in housing and sector and disaster relief being the avenue being least impacted according to them. This is true as maximum research findings have been developed in the medical sector and these healthcare projects are noticeable in people's eyes and spreading in the news.

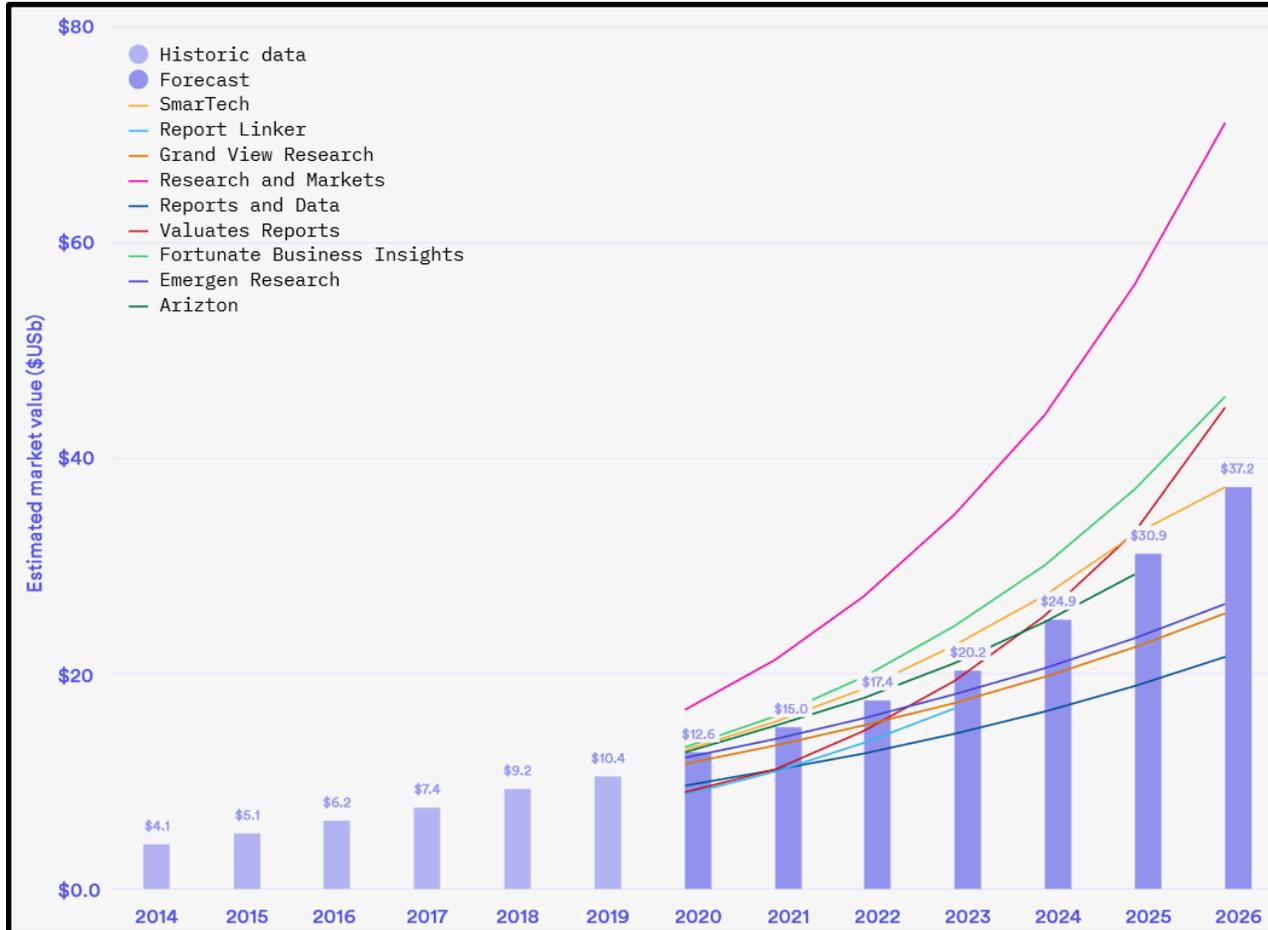
Medical & Healthcare



It has been forecast that 3D printing in the medical field will be worth \$3.5bn by 2025, compared to \$713.3m in 2016. The industry's compound annual growth rate is supposed to reach 17.7% between 2017 and 2025. 3D printing has a strong future in the market and the supply chain is about to boost to great extent as this creation has created a strong impact in every small area in the medical field. A survey conducted by the WHO states that 40 million people require prosthetic and orthotic devices. Still out of those large numbers, only 5 to 15 percent of those have access to these equipment. This is an awakening call for humans to implement large scale 3D printing and manufacturing of prosthetics to produce large quantities of these devices to help the pain in agony and suffering. The demand is so huge in the market and it's time supply gets the upper hand. The reason why 3D printing is the best fit solution here is as its less production time, less processing overall costs and environmental friendly. Around 600000 implants have been performed in 2019 by the use of 3D printing and it is estimated that number might reach 4 million.[12] which again emphasizes on the wide scale adoption of the technology.



Economic use and Implementation



As the report as per data collected by Wohler Associates [11], it shows the market value of 3D printing is constantly rising and is expected to grow exponentially in the future. This is clearly an indication that the world has started accepting the importance of this technology and is being used all over the world. In 2014, the market value stood at \$4.1 billion and from experts prediction it may scale up to \$37.2 billion. Of course, as this technology is now mainly utilized in the medical and housing sector, it will indirectly affect human welfare and aid humans.

Other Sectors

An approximate 3 billion people will require adequate and affordable housing by 2030. The prime minister of Dubai has aimed to achieve the goal of 3D printing 25% of all buildings by 2030 in Dubai. This shows the level of trust and faith the government and nations have in this innovation and large sums of money they are ready to invest to ensure homes for everyone. There are 100+ projects working under the branch of construction 3D printing all with the same aim to provide housing to all and make houses affordable and sustainable. A survey conducted by Dimensional research in November 2016 on 3D printing in Education showed that 77 percent



of educators were interested in buying these printers for teaching. 45% of survey respondents said that they let their students utilize the technology in other areas as well. Also 23% of educators surveyed said they do introduce the technology in elementary schools [13]. Well, this clearly proves that teachers are ready to teach students the new and effective way of learning-active and hands-on learning. 3D printers itself is a huge subject that can be explored, learnt and its applications in education are just a bonus.

Life-Saver

The air rescuer built by the Field Ready organisation has saved 5 precious lives in its first implementation. Now, as we know the enormous amount of medical equipment, organs and tissues that have been already fabricated and implemented coupled with so many disaster relief solutions that were designed using this innovation would have definitely saved at least millions of lives by now.

CONCLUSION

As human welfare consists of three major sectors- education, healthcare and shelter and with 3D printing it has produced a profound impact on all avenues as we have seen throughout the entire paper. Hence, this qualifies as the perfect humanitarian technology. With this invention being novel and possessing a strong prospect, it needs support from society in forms of capital, time, resources to perform more research and experimentation to enhance its impact on all possible sectors. We being youth of the community are responsible to make sure technologies reach out to maximum people out there by raising necessary awareness and helping people out. Since 3D printing can lead to a lot of dangerous activities, governments need to introduce stricter policies and standards to ensure safe usage of it. As humans, it's important for us. Also, it is crucial for human beings to be sensible enough to use this technology as every coin has two sides and it's upon us to focus on the bright side and harness the maximum potential out of it.

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