

# Opportunities and Challenges of Application of 3D Printing Technology in Teaching and Learning in Developing Countries in Africa

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**Abstract:** *The advance in technology in the world today have led to the development of innovative approaches and strategies in delivery of educational content. The use of multimedia technologies has greatly enhanced the teaching and learning process and also made learning to be interesting and hence motivating. 3D printing is one of the technologies that has currently started to infiltrate in to many academic circles. The development of 3D printing technology has a lot of potential for application in education in developing countries in Africa. This paper discusses on the opportunities challenges and prospects of application of 3D printing technology in education in developing countries in Africa.*

## 1. Introduction

The emergence of new information communication technologies (ICT's) has influenced the way human beings relate with each other and their environment. Remote communication, wireless networks and other innovative technologies have improved information flow throughout the globe. Educational systems have endeavored to adopt and apply current innovative technologies in order to improve learning content presentation and delivery pathways. One of the current decade innovative technology is the 3D printing technology. The growth of this innovation has recently received keen attention among industrialists and educators alike. Many developed countries have embraced this technology and even integrated it into their curriculum. Many studies have reported positive achievements to both teachers and students from 3D printing technology. This technology therefore has great potential for the digital age.

## 2. 3D Printing Technology

3D printing technology entails the process of creating an object using a machine that extrudes molten material layer by layer in three dimensions until the desired object is formed. It is a type of additive manufacturing technology that allows the rapid production of identical copies of the same digital model (Chaeet al., 2015, Sander et al., 2017). Before initiating a 3D printing process, one has to design the object using specialized software like OpenSCAD or other software for creating solid 3D CAD objects. An alternative is getting free pre-designed objects from online open communities and databases like Thingiverse or Smithsonian X 3D. The object is then uploaded for slicing using software such as Cura to prepare the digital 3D model settings for printing. The 3D printer is then connected and the printing process executed. Traditional printer use liquid ink or powder (toner) for printing but 3D printers use molten plastic ink. The common commercially applied being the thermoplastic polymers acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA) (Rosenzweig et al., 2015). The molten plastic is deposited in layers on a print bed and

since it dries fast, other layers are built on previous ones until the 3D object is created.

## 3. Application of 3D Printing Technology

3D printing is a revolutionary emerging technology (Campbell, et. al., 2011). The 3D printing technology has found wide application in industry and medicine. In industry 3D printing has found novel opportunities in manufacturing for production and design of prototypes. In the construction industry it has popularly been used to produce models before final production is done. Professional grade 3D printers create objects using materials like cement, bronze, glass and wood. Companies like ApisCor have developed a mobile construction 3D printer which is capable of printing whole buildings completely on site. The image below shows a commercial printer printing a structure using concrete.



**Figure 1:** An ApisCor mobile 3D printer printing a concrete structure

In medicine, some human body replacement parts in the skeletal structure are printed and used on emergencies that need the assistance of this. The prototypes are also applied as teaching learning resources in anatomy classes. According to Trelease, (2016), virtual reality and 3D printing technologies will continue to develop. This is a clear indication that there still are many complex applications that are yet to be innovated.

#### 4. Potential of 3D Printing in Education

Across the world, several institutions have engaged in learning projects based on 3D printing technology. The College of Education at a university in western Massachusetts in the year 2015-2016 organized a 3D printing project for learning where elementary students and secondary students designed old artifacts through the leadership of pre-service and in-service teachers. The students were committed to 3D modeling and printing through activities that linked required curriculum content with the use of 3D printing technology (Maloy, Trust, Kommers, LaRoche, & Malinowski, 2017; Trust, Maloy, & Kommers, 2017).

In the United States, schools are purchasing 3D printers and asking teachers to embed 3D projects into the academic curriculum so that students at every grade level can design and print objects as part of classroom learning activities. Advocates believe 3D printers can foster innovative new learning experiences for students (Torrey & Robert, 2017)

Traditional teaching methods have become irrelevant in the world of technology today. Schools in the 20<sup>th</sup> century focused on preparing working class and students for roles as workers in an industrial society, emphasizing the skills and knowledge of vocational education and domestic work (Cremin, 1988). The 21<sup>st</sup> century workers require diverse skills that will assist them fit into the technological work environment that exists today. Constructionist learning experiences can be inspired by use of 3D printers in the school (Harel & Papert, 1991). Learners want to construct their own knowledge and wish to learn in interesting motivating environments. According to Fleming (2015), the process of designing 3D models make learning an active process of making and constructing knowledge rather than a passive process of listening to information. For students to live and work in today's information-based technologically driven society, they require 21<sup>st</sup> century skills. These are a broad set of knowledge, skills, work habits, and character traits that are believed—by educators, school reformers, college professors, employers, and others—to be critically important to success in today's world, particularly in collegiate programs and contemporary careers and workplaces" (Torrey & Robert, 2017)

#### 5. Opportunities for Developing Countries in Africa

The following are some of the potential application areas of 3D printing technology in education in Africa:

- 1) Development of teaching and learning models for use in instruction in the classroom. This will be helpful since different learning styles of the learners will be catered for

and there will be increased motivation and participation in the classroom.

- 2) Teaching of 3D design in engineering education. This will help the young engineers get more skilled and readily see the outcome of their design process through the sample 3D prints.
- 3) Simple laboratory equipment can be designed and printed instead of being procured expensively. This can be very useful in science and technology fields where some equipment are not easily available and are very expensive.

#### Challenges in Application of 3D Technology in Africa

The following are some of the challenges facing Africa in the quest to apply 3D printing technology in academia:

- 1) Lack of awareness of the existence of 3D printing technology and hence its academic potential in Africa
- 2) Lack of skill on the 3D printing technology
- 3) Low filtration of the technology in Africa due to the slow change and rigid education systems
- 4) Non-availability of reliable power in all parts of Africa hence inhibiting the application of the technology in some academic institutions in remote areas.
- 5) Low innovation levels in academic institutions due to lack of exposure of teachers and students to the current multimedia educational technologies that can be used to enhance teaching and learning.
- 6) Lack of finances to invest in the current educational technologies. Most African countries are poor and hence struggling to meet the low level needs of their citizens before they can invest in the current technologies.
- 7) 3D printers are slow and printing a complex model in the classroom can take a very long time hence affecting the teaching schedules

#### 6. Future Prospects

Application of 3D printing innovative technology in academia in Africa has great potential and academic institutions in Africa need to embrace this new technology. Organizations like TReND in Africa have organized for trainings in 3D printing Technology in Africa and research and academic staff from training institutions in Africa should endeavor to learn the skill of using 3D technology in their institutions. TReND in Africa through funding from Volkswagen Stiftung has been able to organize 3D printing workshops in collaboration with universities in Africa and German participants and facilitators. The first such workshop was held in Ethiopia in 2016 while the second was held at Ibadan in Nigeria. The two workshops had participants from Africa and Germany. The images below show participants working on their 3D projects during the workshop at Ibadan University in Nigeria in 2017.



**Figure 2:** Participants working on their 3D projects during the workshop at Ibadan

This are good indicators that organizations in Africa are ready to support the 3D printing technology integration through sponsoring trainings and offering resources. African educators should seeking avenues for inclusion of 3D printing in the academic curriculum as a tool for teaching and learning. The teachers can capitalize on the technology for use in models development and design training while students can use it to enhance their design skills.

African countries should strive to invest in distribution of power in all academic institutions to enable the teachers and learners access and exploit the applications of current innovative technologies like 3D printing in their curriculum. Where power lines are not available the governments should invest on solar energy which is readily available in Africa in order not to have the African academic institutions lagging behind their counterparts in developed countries.

To exploit the use of the 3D printing technologies in African education systems, the following can be done;

1) Academic institutions in Africa can set up collaborations with similar institutions in developed countries. This can

help them share resources and also exchange staff and students which will lead to raised awareness of current educational technologies. Donations to Africa can also be one of the benefits that could accrue.

- 2) Students can be engaged in 3D printing learning projects to help them acquire the 21<sup>st</sup> century skills.
- 3) 3D educational research and training centers should be established in teacher training institutions to equip the teachers with the skills of application of this technology in the teaching learning process.

## 7. Conclusion

Integration of 3D printing technology into education systems in Africa will greatly enhance the teaching learning process. The policy makers, curriculum developers and other educational stakeholders should fast track the inclusion of this novel technology into the varied education systems in Africa.

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