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Innovation in Education - Inclusion of 3D-Printing Technology in Modern Education System of Pakistan: Case from Pakistani Educational Institutes

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Abstract
On this research, the traditional education system of Pakistan has been analyzed in comparison to international modern education system with 3D printing technology. Also how this technology results in revolutionizing current education system and its future aspects. The study adopted semi-structured interviews to solicit an understanding of teachers, students and 3D printing service providers on the inclusion of this prototyping technology in Pakistani education system. Content analysis technique was used to analyze the data and verbatim texts were applied in discussing the emergent themes. The findings indicate that teachers and students are really motivated and convinced that prototyping technology will bring another revolution in education system of Pakistan near future, just like computers. They rely so much on modern learning techniques to present innovative ideas in tangible forms. They were influenced by this technology in their current practices and mentioned that primary and basic education should adapt this technology to create better understanding to innovative minds. The paper identifies key contribution of 3D printing technology as a factor in state development. This study will be significant and gainful for educationist, understudies and individual working in the field of prototype development and customization who wish to see how the field has developed and evolved as well as the individuals who are occupied with way for future research.
Keywords: 3D printing technology, prototyping, traditional education system, Pakistan.

1. Introduction

3-Dimensional printing – the virtual designs to Additive manufacturing; turns digital 3D models to solid objects. However, in last decade, 3D printing has additionally started to evolve into educational system around the globe, but in developments of 3D printing technology continue to accrue most of the STEM (Science, Technology, and Engineering & Math) institutes especially in developing countries (Brown &Hurst, 2011) like Pakistan. The focus of this study is to explore the current and futuristic range of applications of 3D printing technology in revolutionary educational era.

In recent past years, inception of 3D printing has reached to reality and growing fast with pace to develop new technologies for almost all fields (Anderson, Reder & Simon 1998). In Pakistan growth of 3D printing technology and its application in multiple areas for the benefit of society is often limited by various users. Globally, 3D printing on larger scale is used to empower educators and learners in order to create more effective ways of learning and to perform better with 3D printed models in classrooms (Bhatia 2015). This study presents an overview of current 3D printing technology uses in Pakistani educational environment and also discuss numerous examples of the same field (especially in the field of Engineering & Medical Sciences).

This research describes the importance and applications of 3D printing process and technologies currently in use worldwide and in Pakistan. Further this study explores the implication of 3D print prosthetic and models in current educational system. A number of research centers and groups in United Kingdom is currently exploring higher education sector that actively exploiting 3D printing technologies in Design and Art contexts (Walter & Devies, 2010). These research centers include the Autonomatic, Falmouth, RCA Rapidform, the Jewelry Industries Innovation Centre and the 3D Printing Laboratory university of West England; Centre for Fine Print Research.

Problem Statement:

Educational institutes are considered as backbone in country development and played important sole factor that is responsible for innovation throughout the world. Problem has been identified in current educational cycle of Pakistan regarding graduates produced by the help of traditional teaching methods (with no interactive class learning) is considered inefficient outcome in the context of state development. This study explores the use of modern tools in 3D printing education system to get useful products out of universities (Liebert, 2014) in terms of graduates.

Objectives:

- To identify the importance of emerging field of 3D printing & prototyping in educational system of Pakistan.

- To conduct critical analysis of obtained data in order to facilitate society, economy, business and education system of Pakistan.
- To study Additive Manufacturing/3D printing's important attribute and their significance that can be best utilize in learning patterns.
- To assess influences of factor in inclusion of 3D printing in traditional to modern educational world.

Significance of Study:

Additive manufacturing sets new paradigms for manufacturing and engineering designs that has to be profound in economical, geographical, geopolitical, environmental, demographic and security (Williams, 2011) implications. Keeping an eye on the technology of computers, worldwide web and internet, we can predict the future of additive manufacturing that it will create an impact in global economy (Campbell, 2011). Extending above the prototyping applications of 3D printing in engineering, science, technology and math design (Brown, 2014), fields of most commonly technologies employed. It has a vast application in education sector in terms of providing support to teachers with 3D models that they can use in classroom particularly in illustrating a hard to grasp concept, to seize student's interests by showing pictorials of objects, allowing them hands-on learning via mini-models (Engineering, architectural and medical students) and by providing bigger room for interactive approach in class activities (Kharbach, 2015).

2. Related Literature

a. Education: in context of Innovation

Educational Institution plays a vital role in country's development through their innovations, but there is a gap between regional innovation system and the approach and process followed by universities on innovation (Kitagawa, 2010). In European countries, Triple Helix Formula; university-industry-government is been followed to build the relation and synchronize the activities for future success and development on one state. Educational institutes produced graduates to fulfill the demand of dominated labor market, not for innovation/invention (Simon, 1968). Most of the agencies considered educational institutes as a main source of regional and local development of state but these academies exploiting the benefit for their interest. In order to meet the development criteria within the region (Simon, 1968) universities have to create a mechanism to construct innovation system between universities anointer-organizations. Lipson and Kurman (2013) found that innovation burst has happened with the removal of emerging technology due to cost, time and duration barrier. 3D printing technology has removed the cost barrier as it transformed traditional fixed machines with portable devices and reduces the distance barrier at the same time (Luna, 2013).

b. Innovation in engineering schools

Education should be kept alive as the modern world of civilization. It must be relevant to the modern world as newspapers. Engineering schools plays a key role in building creative minds, they needs to be striving for the discovery, Mastery, stimulating experiences and creativity. These schools should encourage students that they can build impossible, generating a sense of responsible-ness to renewal of society and continued advancement, but without sacrificing human values (Simone, 1996, P. 83). Technological change as invention and innovation concerns properly to the field of engineering. Also, as Inventions plays a vital role in the economic growth of any state, Engineers supposed as a medium of development in any country. Today's world is technologically transforming but socially fragmented, virtual world has got power to bring people in touch, as virtual world has a power to convey information, reduce the cost of learning and offers the change that might have been requires to fulfill futuristic approach of entrepreneurs and innovators. Technology making second life education is most common with the shorter time span (Ondrejka, 2008). The idea leads to the concept of Amateur to Amateur Education; People spend too much time in this world to educate directly or indirectly to each other, as well as on learning. Resident learning is also a tactic to clear the reason and motivation of learning rather than "Skill & Drill "assignment. It offers social pattern of learning, peer-to-peer learning. Unlike other pattern, if one resident want to know to make a car or how to drive a car, another resident will teach him to do that (Lee & Busch, 2005).

c. 3-Dimensional Printing – Tool to bring Innovative Ideas

Technology – a major effect on human life in previous decades in all fields. It is disruptive but made lives better in many ways by exploring new opportunities. 3D printing technology or Additive Manufacturing (AM) is one of these technologies (Bhatia, 2015). Some societies claim that it refers to the traditional manufacturing but in reality 3D technology revolutionizes designs to fulfill social, geopolitical, demographic and economic environment (Baumol, 2004).

3D printing allows industrialists in the mainstream to create customized products and affordable prices. In today's modernization, people do not want the products to be same; industrialist focused to meet individual needs by paying no extra cost. 3D printed products has different cost standards perceptively, this is why it generally more expensive. Mass manufacturing is cost effective in any economy but don't offer customization,

complexity, personalization, demand and designing, hence it is dominant in many industries because it provides whole new powerful product category. 3D printing will help in self reliant, rural based, decentralized economical boom that leads to the edge of industrial revolution (Schofer, 2016).

3D printing and additive manufacturing; both are inflated expectations on the peak. Reduction in the prices of 3D printers and devices, increase in variety of supporting materials and their accuracy, the expiration of devices critical patents (Hamza, 2015) leads to a new context for booming innovation and application of this emergent technology with various sectors using 3D printing (Rehfeld, 2015).

d. Drastic change in Education Sector and 3D Printing

3D printing technology is fascinating opportunity for innovators, inventors and visionaries to fabricate their proposed designs. This technology creates huge impact in multiple fields as well as in maker spaces, universities and elementary schools (Kraseentien, 2014), but the development is slow because of less knowledge and understanding of practioners.3D printing in education is a matter of bringing objects out in the hands of students from computer screens for inspections and practical exposure. It can be used in multiple education areas like, Engineering, Architecture, History, Graphic, Geography, Automotive, Cooking, Biology, Chemistry, Math ("10 ways 3D printing used in education", 2013). The common perception around the globe is higher secondary education provides higher salaried job opportunities (Butterworth, 2011). Implication of 3D printing technology in higher secondary education becomes a popular medium of tactile learning aid (Buehlor and Hurst, 2015). This emerging technology allows tangible learning patterns for students to facilitate them in free expression of interest, flexible method of engagement and presentation (Meyer, 2002; Kane, 2015).

e. Emergent Era of 3D printing in Education

Today, Educational system around globe follows the DIY approach, it allows student to follow Do-It-Yourself phenomenon in order to explore their innovative extinct. DIY types of learning indulge 3D printing technology into educational system to built children interest, interaction and involvement into fabrication technologies. Encourage engagements of recent modern technology in STEM field by providing customization in designs in reduced cost (Brown & Hurst, 2011). Student from STEM fields might have to print their own tool kit or pieces to add into current commercial kits and also they might have to print customized gifts, souvenirs, jewelry, museum and other creative things (Eisenberg, 2013). 3D printing also made assistive technology easier but raises challenges for children's those adopt these technologies without teach (Hurst, 2011).

f. The Way Forward

The technology becomes basic building block of education for almost every age group in developed nations. The transformation was not easy because of educational institutes and community culture was fail to embrace the change and marked as outdated and left the mastering community (Ondrejka, 2008) cost of learning has to generate change in multicultural process.

Nations, Communities and businesses need to be a part and fall above the world's accelerating exponential curves to catch up the progress. Continual development of easy-to-use technology has emerged the international market for marketers, managers and businesses (Hoy,2013), making beneficial differences in general lives as turning the world into solitary, personalized, introvert and quiet work (Eisenberg, 2013).

3. Research Method

This study based on qualitative research method to explore the innovative-ness in education system via 3 Dimensional printing technologies. This approach has been widely used and accepted around multiple countries to explore the findings of research hypotheses (Mohamed and Perry, 2015); Fifield & power, 2009. Sample population consisted of Pakistani universities who opt to use 3D printing technology. Data had been collected through the faculty members; previous researcher, students using 3D printing service and 3D printing service Provider Company; Viscous.co & location selected as it contain number of STEM institutes using 3D printing services. For data collection, formal invitation letters has been sent to the respondents to invite them for interviews on their convenient day and time and on communicated time researcher visited the interviewees (Guest, Bunce & Johnson, 2006). This research used semi-structured interview technique. According to Malterud, Siersmaand Guassora (2015), purposive technique requires around five to eight (5-8) interviewees possess diverse experiences and can provide sufficient information in interviews. This is interview based study and conducted 7 interviews in between November and December 2016. Recruited interviewees recruited from University faculty & student, previous researcher (who worked in this domain) and CEO Viscous Corporation, Bioniks Pakistan and professionals from Robotic Lab. The semi-structured interview consisted of six guided questions. Designed set of questions has been asked from every research participant in which interviewer remained silent after asking each question. All of the interviewees assured that their provided information will remain strictly confidential in future. After interview conduction, the audio-recordings will be listened to generate research findings and put on using a web application called "oTranscribe". Content analysis technique has been analyzing the data obtained through interviews. This

was done by comparing the responses, and then summarized each question with each respondent's points of view. Summarized data will present in bellow subsequent section (Haron, 2016).

4. Analysis and Findings

Seven respondents were interviewed about the 3D technology in education system of Pakistan; 3D printers and printing service provider, PhD and Masters Faculty and Prototyping Lab in-change. Complete background and their profiles are presented in Table I. Of these respondents, everyone has got expertise and hands on experience in technical field of 3D printing. All respondents are males; three respondents were Karachi based two from Islamabad and Gujrat respectively and other two representing their companies operating over all in Pakistan. This has been made sure earlier that all the respondents should have meet standard and have to have enough knowledge to present their opinion over this topic.

Table I

Interviewee	Name	Field and Qualification	Designation	City
1	Mr. Ovais Hussain Qureshi	BE in Mechatronic Engineering	CEO, Viscous.co	Pakistan based company
2	Dr. Ali Muhammad	PhD in Nano Particle Technology	Assistant Professor at NUST – Islamabad	Islamabad, Pakistam
3	Dr. Fahad	PhD in Industrial Manufacturing	Lab In charge of Project Development lab at NED University	Karachi, Pakistan
4	Mr. Anas Niaz	BE in Mechatronic Engineering	Head Bioniks Pakistan	Pakistan based company
5	Dr.Mazhar Abbas	PhD in prototype engineering	Assistant Professor at University of Gujrat	Gujrat, Pakistan
6	Mr. Amin Islam	STEM Engineer	Robotic Lab	Karachi, Pakistan
7	Mr. Mohsin Yousufi	Masters in Petroleum Engineering	Lecturer and Virtual Lab Incharge in NED University	Karachi, Pakistan

Regarding the interviewees' interest and experiences, their perspectives are pretty much comparable, yet communicated in various courses according to their encounters over the timeframe. The accompanying reactions outline their sentiments as change creator:

We are working to revive education, industry and imagination of people, if you have any imagination we can convert it into tangible form. (Interviewee No. 1)

It is a Revolutionary technique in education. (Interviewee No. 3)

However, one has elaborated this change in futuristic manner & still looking forward for further enhancement.

Time and again I have seen that in an ever changing and evolving society, we as scientists and engineers have to keep a step ahead of what is there now and what we plan for the future. (Interviewee No. 6)

Respondents showed mixed feelings; they are hopeful, positive and satisfied to work in this field as change maker in current education system of Pakistan. According to respondents 3D printing in the field of education prototyping and models used a lot to visualize ideas is the cheapest and effective solution among all.

It took 5 years me to reach here, first barrier I got lack of availability of sources in market. But now things are changed, we can get things easily, but challenges are there as lack of knowledge. (Interviewee No.3)

Based on the recorded responses, respondent number 3 has shared his journey in this field that how he suffered due to the lack of resources and still the challenge is prior knowledge about the transformation of this technology in education sector.

Majority of respondents noted that greatest challenge to revolutionize education system is lack of teaching expertise in this particular field. They have opinionated that system should promote young and motivated personnel in this field. Prior to the experiences of these professionals, they have shared some of the solutions to meet these challenges in near future.

[….] the facility needs to be funded by an external contributing source such as the alumni so the students can easily use the equipment without worry about the expenses in designing. (Interviewee No. 7)

It was found during interviews that respondents relate this technology a lot with modernizes education system and they are very positive when making their examples in this way. Below are quotations from the interviews.

[….] Our class rooms are not smart; we used black boards and white boards. Recently we've started using projectors in class rooms to make class rooms smart. (Interviewee No 2)

However, one respondent seeks an example to make better understanding of what 3D printing

prototypes can bring in primary, secondary and then to high secondary education.

[….] Remember the time when your teachers taken you to museum just to observe those things that you have seen in your books only, in 2D form. With 3D technology we can provide real things that have studied in books in tangible form to see and feel in order to transform their learning into conventional to modern educational way. (Interviewee No 1)

This is truly a game changer in almost all fields and same goes for education [….] (Interviewee No. 7)

The lack of teaching expertise in this field can steady the revolutionary progress in education sector. Research and development is attributable in this context of revolutionary educational breakthrough since it is in the hands on educational contributes (Waldo, 2012).

[….] With regard to lack of teaching expertise, this technology is even rare globally. Schools and colleges are not adapting it easily and that is why transformation in education system is coming to Pakistan lately in coming years. (Interviewee No 3)

These reactions introduce relative approach of respondents with global norms. Respondents have adjusted this prototyping innovation in their domains to meet international standards of education and mentioned teaching inadequacy as major debilitating variable in this field.

This is a serious matter of concern, world is moving towards 3D printed education but we don't have experts here. (Interviewee No. 4)

Another respondent compared Pakistani education system with international standard that how other countries are step ahead from our traditional system. They have the experts, resources and capabilities there. On the other hand, people who already working with this technology in their institutes has mentioned that teachers in technical institutes are gradually taking interest in this technology to bring change in coming years.

[….]Teachers in STEM institutes are working hard to bring change in. (Interviewee No. 5)

Interviewees expressions over this technology after 5 year and regarded it as important factor when making investment decision in this technology today. Hence, it enabled them to discuss the future of this technology in more comprehensive manner.

I can see this technology after 8-9 years in textbooks as another subject and schools and colleges will opt 3D printing labs just as they have opted computer labs. (Interviewee No. 3)

I can see children will have their own 3D printers after 5 years just like they have their PC's today. (Interviewee No. 4)

This highlights the importance and scope of this technology specific to education sector in near coming future. Respondents are hopeful as they can see the need of modification in current education system and increased general awareness programs in this regard.

Generally, reactions indicate blended responses and this review confirm that teachers and other people related to this field has pretty much comparable experiences yet utilized distinctive methods for expression. Among above responses, this has been said in multiple ways that field is emerging globally and still need years and years to develop and grow further. Preceding their association in this field, challenges have been confronted by them talked about divergently than each other. They recognized disappointment of customary instructive frameworks in present day world in coming years and viewed 3D printing as upheaval to resuscitate current training arrangement of Pakistan. A few interviewees talked about the urgent utilization and desperate use of technology in Pakistan and gestured that this innovation will likewise be utilized with same franticness however on flip side it will be advantageous for the progress in numerous segments in this country.

With respect to the needs of respondents as change maker in educational pattern of Pakistan depends on specific components; rises above to fundamental information about their field and experiences, clear goal and motivation to bring advance revolution in minds the end goal to get insurgency training framework. The review sets up encounters of educators and prototyping service providers and trainers are very comparable as of global market, yet each of them has communicated them in numerous ways. Notwithstanding their assorted encounters the respondents still propelled to proceed with their cooperation in this developing field. This helps me to remember Ondrejka (2008), Anderson (2012), Baumol(2004) and Schofer (2016) thoughts of multicultural process, lessens the cost of learning and to change the elusive condition of accessible sources in writing audit segment. In the start of my meetings, respondents present different reactions. They have shown their "energy" in numerous ways and considered absence of assets, data and educated workforce in Pakistan. With regards to meet international standards in training cycle, respondent recommends neighborhood schools and universities to approach worldwide subsidizing organizations with appropriate proposition to bolster them in adjusting this progressive innovation in classrooms. Additionally, absence of showing aptitude and their charge over utilizing 3D printers is the greatest deterrent is meant by respondents. Proceeding with the contention encourage, Hurst (2001) said that 3D printing additionally raised prototyping trouble free yet brings up difficulties for kids' those embrace these advances without instruct.

Maxey (2013) has relates the modernization of various enterprises with 3D printing and model improvement. Specified above in writing, since 2010 till now, 3D printing prototyping is developing in different fields around world. A respondent relates this wonder with innovation as they have talked about the defects of customary framework and presents the answer for future. Keen work can be accomplished by presenting brilliant classrooms in our instructive framework. 3D innovation is upheld by test learning. It requires association of understudies with a specific end goal to better take in the ideas, as 'contribution upgrades learning'.

Proceeding with further on the construct portrays absence of aptitude of workforce, teachers & trainers would be the greatest obstacle in coming years. In addition, it is presently being revealed and acknowledged by respondents that Pakistan is path behind in contrast with global advanced training framework and it is impractical to bring contemporary instruction display without workforce improvement in education sector. The kind of mental methodologies workforce express in Pakistan is uncommon and not versatile to change. These conclusions are excessively fixed with Lee and Busch (2005) and Liebert (2014) that conventional educating is currently viewed as wasteful result with regards to state advancement.

Developed eventual fate of this technology (in coming five years) in educationist setting is countered as brilliant and snappy for each learner, as they have specified it a piece of learning diagram and course work. A finding appears to be intrigued when respondents gestured that each school, college and university will have their 3D printing lab in not so distant future. These reactions respected comprehension of the financial improvement of Pakistan as advancement because innovations relates with development. In last proposition, my examination uncovers current status and cutting edge utilization of this advanced innovation in developing instruction arrangement of Pakistan.

My entire research exploration is discussing the basic methodologies of educators and instruction establishments over this advanced 3D printing and added substance producing innovation. By a similar token nonattendance of coaches, trainers and teachers in this field is another enormous challenge to overcome. Since the future for understudies, educationist and industry is brilliant in this field if carry forward in composed way.

5. Conclusion & Future work

The objective of this research was to examined and shed the light over current education system of Pakistan without opting modern 3 dimensional printing in class room learning and how it can be beneficial for educationist. Qualitative research was carried for this purpose on a sample of teachers and 3D printing service providers' from Pakistan. The findings presented in previous part and the conclusions have drawn are only based on my personal interpretation of interviewees and hence not be conceptualize to all educationist. However it can be applicable in same context on national level. Research has also unveil that respondents are motivated and hopeful for future in this revolutionary field and satisfied as people and institutes are getting aware of this technology. The implication of the finding of this research on education institute will be beneficial anyhow. As far as educational institutes support this technology, none of the student will face insufficiency to meet their ambitions. Additive manufacturing and prototyping is offering personal involvement in any field, and in education sector it will bring greater understanding as it will convert concepts into tangible form. To cut it short, the engineering universities having 3D printers in their premises are transforming innovative ideas into reality, with expert faculty and train their specialist further more to built 3D labs in their institutes. The findings will be of useful and enormous for educational institutes, students, researchers and for society as whole. Above all else, discoveries will permit education and training foundations to concoct more imaginative thought with the assistance of this speculation to enhance their aptitude set on the best way to engage their students and teachers. Besides, it proposes the urgent part of learning and common sense in customary training framework keeping in mind the end goal to acquire ordinary approach in accounts. Moreover, individuals related to this field are exposed to the specific challenges that can bring down the development of this technology in education sector and talks about the diverse method to overcome these obstacles. Finally, futuristic approach to bring revolution in education system, it application and pro and cons has been reliable to consider. Relying on these findings, educationist and trainers can design genuine policies for this growing field. Future studies should use more samples (preferably mixed methods) for generalization purpose because this study used a small sample and therefore, generalizing its findings will be limited.

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