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Disruptive Architectural Technology in Engineering Education.

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Abstract

With engineering students' attention spans diminishing and the Internet challenging the knowledge resource of faculty it is time to innovate new methods in the teaching – learning process of the Indian Engineering Education. Most of the spaces designed by Architects now called "Smart Class Rooms" have 24/7 access to the Internet and a projector that can help us access and share knowledge with students just working smartly from our laptops. This paper concentrates on high tech architectural disruptions yet sustainable solutions to be brought into traditional smart classrooms teaching and Innovation Design Lab experiences to make it more vibrant, participative and innovative. Architecture, the creative science of place making will be conceived not to just satisfy the spatial, visual and functional requirements of the students and faculties using the classroom and labs as it does now but will also be conceptualized using Architectural Technology, AR & VR technologies. While we focus on Technology driven methods we also propose to enhance the CDOI model of Curriculum development (Conceive, Design, Implement and Operate) that is currently gaining acceptance globally and seems to be the future of Engineering Education too. The paper also explores the reality of "DeSchooling" the Indian Engineering education in the 21 stCentury .

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1. Introduction

Higher education students are under stress on various aspects. Professional students, especially engineering students are into high stress level in their places of study. There are many factors responsible for them to be in stress and few are diagnosed as Borderline Personality Disorder, Acute Anxiety Depressive Disorder, Depression, Manic Depressive Disorder and Panic Disorder. Various factors and environment are instrumental in inducing these stresses in the students. Besides these students are also suffering from stress caused due to peer pressure, relationship issues due to misunderstanding or expectation, poor parental bonding, academic pressure, lack of interest, death issues in the family, lack of confidence, etc. A proper guidance to the students will help them to be confident among themselves in terms of their understanding and activities to be involved for a better academic life. In a stressed environment it is very difficult for learning to take place. It is observed in many of the developing and developed countries the higher education institutions have adopted features of a formalized, rationalized decision making and strategic action lead by more powerful and efficient facilitators. They have become more organization like than before and a parallel development is taking place regarding the wider spectrum of outreach activities commonly referred to as academic engagement and in interaction grounded in education activities. [1] Integration with the society and industries are considered to be of paramount importance to an institution of higher education. It

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is time for technical education to move from traditional chalk and talk, projectors or a video based lecture to a more innovative and participative learning environment. Augmented reality and virtual reality technologies combined with appropriate tools could bring in a huge change in learning.

1.1 Augmented reality

Learning ability could be enhanced by using experiential learning, in addition to that the superimposition of virtual objects on real environments, the features of augmented reality are usable in a variety of applications in higher education. Using these features offer very high advantages [2] in all stages of teaching learning process. If augmented reality is employed in class room and laboratory teaching the efficiency and effectiveness increases many fold. It may be noted that this technology brings down the stress level in the students thereby keeping the students engaged in learning. Augmented reality technology allows the inclusion of virtual elements on a vision of actual physical environment for the creation of mixed reality in real time[3]. This is one of the disruptive technologies that could be effectively used in class room teaching and this technology can help the students to help themselves. Augmented reality combined with cloud technology is another one that is proved to be effective in enhancing learning in engineering education. This kind of a learning environment increases the learning ability manifold as the students are involved in problem solving, fulfilling other tasks and are also motivated to solve non-standard tasks. Rapid growth of mobile devices has made it easy to implement augmented reality in the class room environment. Many researchers have pointed out that [5], augmented reality could be successfully implemented as an effective tool in teaching and it has many advantages too. Using AR in the class room enhances motivation, helps in permanent learning, increases student participation in classes, develops positive attitude, enhances various skills including spatial skills, makes it possible to have co-operative learning, makes learning a fun, and decreases cognitive load.

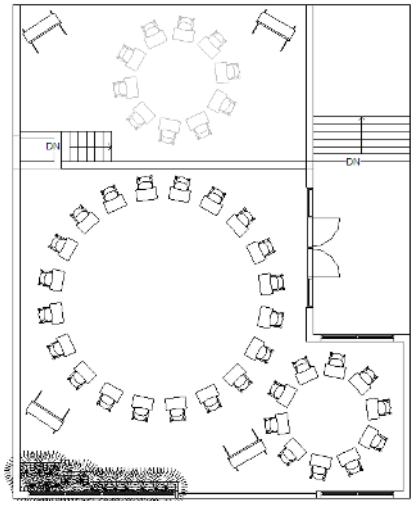

Fig 1: Class room arrangement to accommodate augmented reality tools. No black board or white board is used in this class room

1.2 Cloud based environment for effective learning in higher education institutions

Replacing the existing class room and laboratory setup with a hybrid cloud oriented environment [4], that integrates the components of university academic cloud such as e – learning courses, electronic tools and manuals, recorded visual resources, videos, virtual desktops and environment for automated assessment of tasks in programing and case analysis with academic components of internal and external cloud services helps to enhance the teaching learning environment. Using social networks, higher education students will be able to obtain new knowledge individually because they have open access to professionally oriented

information that is covered in magazines, newspapers, books, videos, blogs, etc to share the information faster with peers who are users of social networks and have common professional interests; to discuss issues on day to day learning. Resources provided in such a platform are verified unlike the unverified ones provided in social media that cannot help in any learning.

Fig 2. Cloud based learning environment

1.3 *Traditional environment to dynamic environment*

Bringing live experience into class room teaching (4 D experiences) helps the millennials to focus on the subject and get involved in learning. It helps the students to break the rote learning model and use new technologies with a modern method to bring in visualization into the teaching learning ambience. Using constructivist and constructionist concepts [6] help the students to understand better and the learning gets deeper, makes the motivation greater and creativity stronger. Using these technologies students can apply cognitive tools, such as thinking and speech, in connection with the cognitive prostheses available in their surroundings. Millennials whose minds are formed in a different way skewed towards digital technology can adapt to these technologies well to delimit and structure cognitive schemes well to have a deeper learning.

Many of the subjects in higher education are inextricably connected to real world practice. If it is not so, it may not help the students to enter into job market or to be a successful entrepreneur. It is always important to connect every aspect of teaching into the practical world outside of a class room. It is very important to select the right tools and devices and appropriate learning strategies [7] and teaching methods.

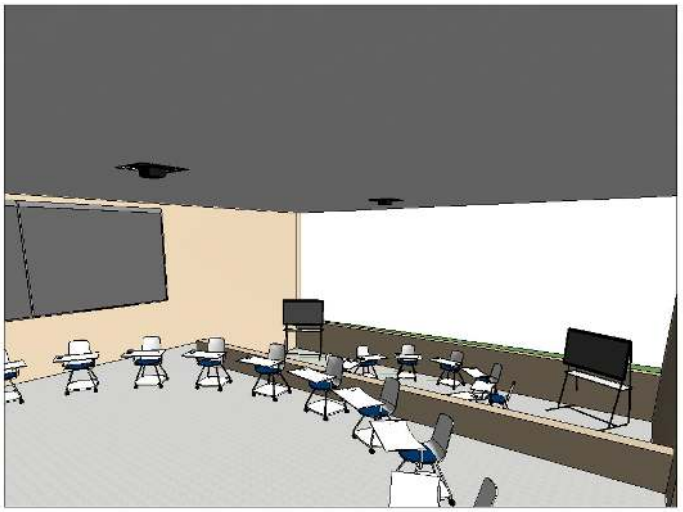

Fig. 3 Classroom with activity area

Selection of right courses and integration of academics and practice should be enhanced with roles and knowledge of instructors, engineers, computer experts is very important to implement the augmented reality technology for domain specific learning. A few years ago engineering was very broadly divided into three streams, electrical, mechanical and civil engineering. After the onset of computer and electronic sciences many other branches have evolved. Yet it is necessary for any engineering graduate to be aware of the latest technologies in every field of engineering. Departmentalization is history and engineering is moving towards inter and trans disciplinary streams.

1.4 *Interdisciplinary an Trans disciplinary learning*

The dawn of 21st century has seen unpredicted changes in engineering and higher education. Latest in the list of changes is the concept of inter and Trans disciplinary learning. This inter and Trans disciplinary learning combined with augmented reality helps the students to view the inner or unapproachable devices of various fields, helps them to handle various equipment while doing their practical and provides supplementary information [8], preparing them to face the real world with confidence. There is an increasing perception of the need for graduates of engineering to be creative thinkers and innovators [19]. It is however not clear how creativity can be nurtured or fostered within the students or how it can be assessed. If the creative process can be described as preparation, generation, incubation and verification, then proper strategies for idea generation are also to be included in engineering education to help students to have creative thinking. Conceive, design, innovate and operate is one of the new strategies coming up into engineering teaching which breaks the students free from the bond of rote learning.

2. A holistic and transformative approach to Engineering Education through CDIO

In order to stop the rote and mechanical approaches employed in the transferring of knowledge in the teaching-learning process of Engineering education, we begin by giving below UNESCO s Four Pillars of Learning .

UNESCO defines the following four pillars as foundational principles for reforming education[9]We should always consider these principles even as we are developing disruptive strategies to improve ourselves and society.

1. Learning to know

2. Learning to be
3. Learning to do and
4. Learning to live together

CDIO is an initiative to reform Engineering education that was started in 2000 with the goal to produce "Engineers who can engineer". Current Engineering Education responding largely to the needs of the society and industry throughout is OBE. Engineering professional education and accreditation bodies focus on providing the set of skills and competencies that increase the employability of the graduate engineers in the global market. It is seldom viewed and deliberately practiced as a process of holistic character development such that the individual is not only equipped with the necessary job skills but also with much more valuable life skills[10]. It is anticipated that equipping future graduates would require a greater outcome than that which a more traditional engineering education approach currently can deliver.The main focus apart from building students technical and non – technical knowledge base and understanding seems to be towards communication skills, teamwork and other outcome based experiences in alignment with the Washington Accord[10] However today a global competence is required from the graduate engineers to compete in a global market place and handle global challenges of climate change, security and economic growth with sustainability as its focus. Also Engineering education needs to equip and empower stakeholders in the context of Rural development too as Urban infrastructures of cities are bursting at their seams globally. By 2050 more than 70% of global population will be living in cities of high technological advancement.

CDIO provides a more holistic education approach, by introducing the Conceive, Design, Implement and Operating skills and going beyond the existing framework of OBE. Holistic education is regarded as a paradigm, a set of basic assumptions and principles related to educating the whole person to develop into his or her fullest potential and that these principles can be applied in many diverse ways[11]Additionally students are encouraged to spend time on Fast track Initiatives and Challenges that increase their research experience, interdisciplinary curriculum, entrepreneurship, global awareness and service mindedness in learning. This becomes a transformative experience of the proposed engineering education turning the focus away from earning money to prioritizing service before self too[12]

The global, transformative and disruptive engineering initiatives in curriculum can be listed as:

A. Energy and Environment

i. Provide solar and wind energy economically
ii. Provide fusion of energies
iii. Provide access to clean water free of cost
iv. Reduce Carbon footprints and enhance embodied energy in production processes
v. Monitor and manage the Nitrogen cycle

B. Health

F. Engineer more organic medicines
G. Advance and institutionalize health informatics

C. Security

H. Eliminate Nuclear terror
I. Increase cyberspace security
J. Restore and Readapt Urban Infrastructure
K. Reduce the carbon footprint of the global built environment

D. Learning and Parametrics

L. Relearn and reverse engineer the human brain

M. Enhance Virtual reality and Artificial Intelligence
N. Expedite personal learning
O. Engineer and enhance tools of scientific innovation.

All the elements of the above list should enable global awareness while providing cutting edge knowledge and facilities for both research scholars and graduate students alike[13]

To qualify for the Fast track Initiative Research students should have the following requisites:

1. Engineering knowledge needs to be outstanding.
2. Committed to engineering of the Fast track Research Initiatives.
3. Passionate about positively contributing towards problem solving of both social and global engineering issues.

Proposed development of Engineering Education:
Right from the first semester of the Engineering programme, students take a minimum of two major modules - "Engineering Design & Communication" which is a core module with subjects specific to knowledge building taken by all the engineering students and a second module of "Fast track Engineering Initiatives for Research & real life Challenges" which is program specific[14]The objective of this pedagogy of holistic and transformative education is to develop understanding and awareness along with a fast track research initiative focus. All the students need to be involved in a variety of engagements like talks, workshops, design and build activities, team building and discussion sessions related to real life challenges. Students are inspired to develop personal vision and mission goals and self-evaluate personal Strengths, Weaknesses, Opportunities and Challenges (SWOC) analysis and maintain a portfolio to track the development of their achievements. For the design activity, the students can be required to work in a group to design and build prototypes. Working within the design requirements and limitations, the students develop prototypes for real life problems. Thus all efforts are concentrated to ensure that the Engineering Education programme has its own identity andcharacter[15]

Deschooling engineering education :

All initiatives of quality higher education should be inclusive and students from socially disadvantaged groups should be part of it all too. Globally nations recognize the Right to Education as a Fundamental Right and it makes it incumbent upon the State to provide free and compulsory education to children of the age of 6 to 14 years. Higher Education is equally essential to develop the scientific temper, humanism, the spirit of inquiry and reform which are the fundamental for sustainable development globally[16]We are in the midst of the 4 th Industrial revolution. As technology changes exponentially, new age technologies like Blockchain, Artificial Intelligence, 3D printing and The Internet of Things are changing the way we educate , the way we work and the way we live too. We are on the threshold of vast unchartered territory too and as we chalk out our future course "Deschooling" seems to be an attractive option for radical creativity and innovation. The stakeholders need be in a " Deschooled society" that give them the widest and freest possible choice to learn whatever one wants to learn in some altogether different way[17]Deschooling students learn through their natural life experiences which include play, home responsibilities, personal interests, with self directed education in a natural environment. This develops curiosity that is innate rather than forced. Hands on learning experiences are precious as deschoolers do depend on parents and professors to help them set goals and figure out what they need to do to meet their goals too. There is again a paradigm shift since we cannot know what knowledge will be most needed in future, it is senseless to try to teach it in advance. De schooling turns out people who love learning so much and learn so well that they will be able to learn whatever must be learned. Deschoolers can meet newly emerging needs, interests and goals and can relearn as easily as to make a better path for themselves almost always. Can we think of Deschooling Engineering Education too ? Informal settings and conversations best promote learning and innovation. Institutionalized instruction will soon be a thing of the past as "life learning" and narrative research will be the study of stories so richly woven with real life challenges and

opportunities. Deschoolers oftentimes figured out what they need to learn themselves[18] The great Bernard Shaw said "What we want to see is the child in pursuit of knowledge, not knowledge in pursuit of the child". Thus De schooling is a revolutionary approach of learning unconventionally where children have the freedom to develop their own interests in their own ways and who are accountable to no one but themselves.

In the last few years the number of applicants for engineering courses in particular to core engineering is coming down. Some institutions face the challenging endeavour of motivating and engaging school students in pursuing professional careers in engineering. Moreover the recent financial and economic crisis and its impact [20] on the Architecture, Engineering, Construction and Operations sector, may have contributed to the paucity of candidates. So De-schooling will help immensely in making the students learn by themselves. It is suggested that with AR and VR if gaming scenarios are introduced it would be beneficial to the students to learn faster and better.

Conclusion

With engineering students' attention spans diminishing and the Internet challenging the knowledge resource of faculty it is time to innovate new methods in the teaching – learning process of the Engineering Education. Most of the spaces designed by Architects now called "Smart Class Rooms" have 24/7 access to the Internet and a projector that can help us access and share knowledge with students just working smartly from our laptops. This paper has projected six disruptions yet sustainable solutions to be brought into traditional smart classrooms teaching and Innovation Design Lab experiences to make it more vibrant, participative and innovative. Removing black board, white board and projector to break the concept of chalk and talk method and to make the teachers as facilitators. Bringing in AR and VR with two or three levels of class rooms, incorporating activity based learning and 4D experience. Cloud based Inter and Trans disciplinary learning with smart digital boards. CDIO curriculum model with fast track research initiatives and challenges into the andragogy.De schooling to make the learning more interesting and responsive. Radical Creativity of the learners that can be written, drawn or scribbled on the walls made of glass.

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