21ST CENTURY EDUCATIONAL REQUIREMENTS AND TEACHING STRATEGIES FOR COMPETING WITH THE CYBORGS

Shahbaz Pervez[1], Gasim Alandjani[2]
[1]Dr., Yanbu University College, Saudi Arabia, Email: shahbazchattha@gmail.com
[2]Dr., Yanbu University College, Saudi Arabia, Email: alandjanig@rcyci.edu.sa

Abstract

The recent innovative technologies have dramatically changed the future of humanity. There are many pros & cons of this excessive impact of technology on our lives. The main goal behind the advancement of these technologies was to increase our day to day efficiency. At a larger scale, it aimed on more productivity from the industrial zones, alleviation of poverty and improve life index of people. This era of smart society, which is a result of investing huge amount of resources on IT Infrastructure of Smart Cities to automate life of its citizens with a quest for perfection has raised the bars for competence level required in all walks of life. The students of Smart Societies of the future will be seeking state of the art knowledge platforms and teaching aids that would be interactive and effective for attaining knowledge. On the other hand, the teachers of this smart era would have to enhance their knowledge, teaching skills and expertise as per the demands and needs of these students. The educationists would have to educate these students to deal and compete with machines (e.g. in Industry 4.0 where robots will be replacing workers at different levels of industry and eventually will totally replace human workforce). This is essentially a paradigm shift that requires non trivial forms of teaching and learning methods for preparing the students to meet the needs of increasingly complex digitally driven AI based Smart Societies. We discuss these challenges of the Smart Societies and their possible solutions by positively introducing these new technologies in pedagogy, curriculum design, ICT skills, fast learning, technology oriented and outcome based educational environment, where student will not feel any change while moving from classroom to the industry.

Keywords: Actuators, OBE, IoT, Smart Society, industrial 4.0, PLO, CLO, 5G, Cyborgs, AIEd.

1 INTRODUCTION

We can call our current era as the emerging Internet of Things (IoT) era without any doubt, which is equipped with ubiquitous computing & networks of interconnected and Internet-enabled objects. We can't deny the value of understanding of digital technology in this era. Micro-controllers, sensors, actuators, and MEMS are considered as the building blocks of IoT. Cutting-edge technology leaders are mostly focusing on implementing these components in commodity objects. With these phenomenal advancements of digital technologies and ubiquitous computing, it is becoming mandatory to train our society about emerging concepts of computer science and IT skills regardless of their core areas of specializations. On the other hand, for students, who are currently enrolled in any program at educational institutes, it is of utmost importance to prepare them for these technologies. Companies will be looking for candidates, who will be equipped with knowledge of the latest state of the art technologies. Industry leaders such as: Cisco, Microsoft and many others have already added IoT,

Cloud Computing & Virtualization in their current academic curricula to train the future engineers and IT experts.

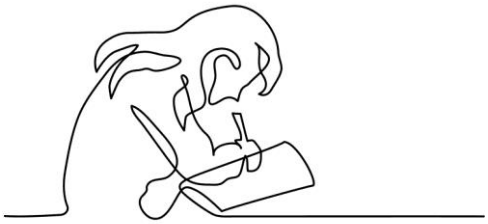

Figure 1: Student Centric Technological Teaching

Educational institutes on the other hand not only teach computer science concepts but also encourage critical thinking and innovation. The June 2017 issue of Computing Now from IEEE Computer Society [5] elaborates how technology can be effectively utilized by teachers in the IoT era. The selected articles introduce methods for integrating IoT into Science, Technology, Engineering, and Mathematics (STEM) education while simultaneously building educational environments that values problem solving and exploration. Additionally, the videos highlight how working with open-source IoT platforms can help foster creativity among the 21st-century learners. We further discuss various perspectives of Teaching and Education that must be incorporated while developing educational curricula to fulfill the requirements of Smart Society literacy requirements.

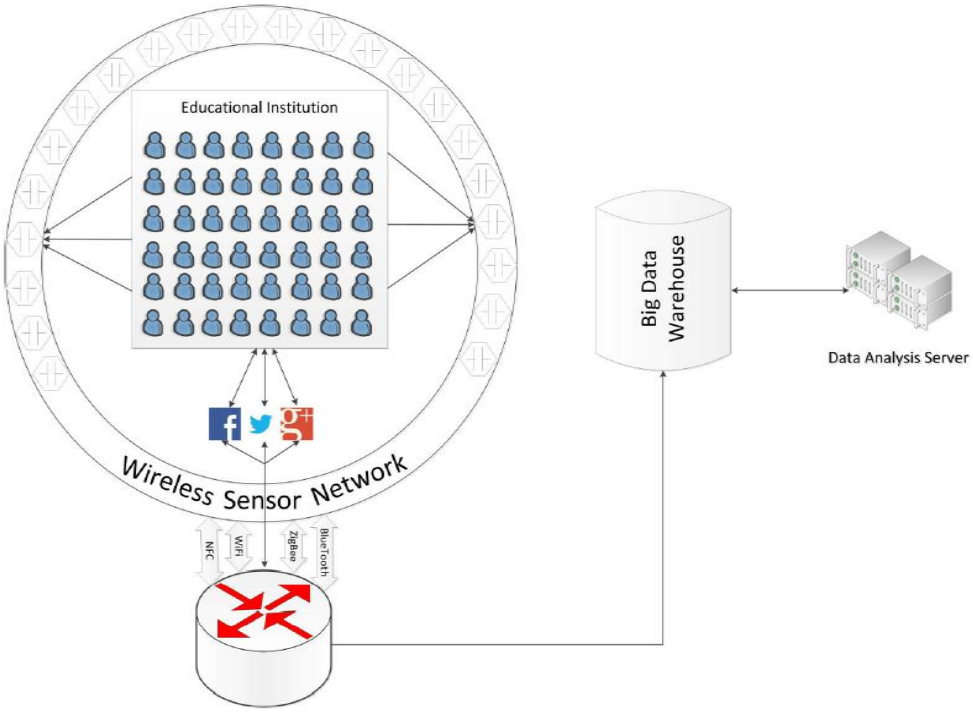

Figure 2: A model for e-learning based on crowdsourcing and Internet of Things [10]

1.1 Use of IoT Platforms and Visual Programming Languages in Teaching

According to Gartner [10] in the last year 6.4 billion connected devices were in use across the world, which is 30% more than the preceding year of 2015. By year 2020, this usage will reach up to 20.8 billion devices. IT Companies like Cisco [11], Xerox, IBM, Bosch [12], NI [13] , HP, Apple and others have envisioned IoT to be the major disruptive technology for education just as it is for all other industries. Many prominent researchers [14] [15] [16] [17] have suggested following IoT tools and technologies for teaching in the classroom:

Microcontroller development boards,Advanced embedded systems,Electronic white boards, Mobile phones, iPADs, Laptops and Tablets, Automatic Electric lighting, Smart HVAC systems, RFID enabled Student ID cards, Wireless door locks, Security cameras and video conferencing, Biometric Attendance tracking, eBooks, Augmented Reality, Virtual Reality, Additive Manufacturing Devices to create 3D objects,MOOCs

Classrooms equipped with electronic interactive white boards allow richer and consistent experience for the learners and teachers during the whole course of study making it easier to share, add, edit contents with

students while bringing online contents on the fly to support the discussions in classrooms. Students are encouraged to bring their own devices (laptops, tablets, mobile phones etc.) to the classrooms allowing them to perform their classwork and assignments on their own devices. This allows the students to take the work performed in class room when they return to their homes providing them an opportunity to revise and reinforce the concepts in their leisure time. Students can use micro-controller development boards such as: Arduino, Raspberry Pi, and STM32 Nucleo as small IoT platforms. A very prominent example of it is in British schools, where children learn to use the BBC micro:bit, a single-board computer with Bluetooth and USB connectivity, an LED display, and two programmable buttons. All of these boards offer add-ons to extend their functionality to meet the myriad requirements of IoT application development. (what happens as a result of this usage??? Elaborate in a sentence or two. The result or impact of it).

Another option is to use advanced embedded solutions, which combine micro-controllers with Field-Programmable Gate Arrays (FPGAs) The Blu5 SEcube security-oriented open platform is a good example, as it's a single-chip design that expertly integrates three main parts: a powerful microcontroller, a Common Criteria-certified smart card, and a flexible FPGA. Developers (and students) can fully control and customize Blu5 SEcube.

Visual Programming Languages (VPLs) are GUI based environments that use graphical elements for programming, and one of the most well-known is a Scratch. It was developed at MIT. This programming language helped millions of trainers and learners to develop programming concepts and logical thinking. According to Gans [20], Scratch can complement IoT platforms in education: "BBC micro:bit can be seen as a simple IoT computing platform, making it easy for students to create ubiquitous computing applications using a range of computer languages (such as Scratch), perfectly matching different age or group abilities". Researchers believe that learners must not only understand underlying principles and theories but also have the creativity to produce effective solutions and physical or virtual implementations. To overcome barriers in obtaining and utilizing high-end technologies, they propose adopting a requirement engineering approach that focuses on quality-in-use employing general usability and quality models which measures specifics to pre-college engineering education.

2 COMPETITION BETWEEN TECHNOLOGY & EDUCATION

If we look at current era of technology and popularity of automation with the introduction of industrial 4.0 there are great opportunities that at first level routine jobs scenarios will be toppled by the steady rise of the robots and human interaction, which will eventually result in increased productivity of industry. With that development there will be dire increase for need of ever smarter algorithms deployed on bigger data-sets. However, the consequences of this for learning have received relatively little sustained and thoughtful attention. If we fairly look at current situation, major part of our global education system is being led by economists rather than educators. So eventually, they will be looking for economic outcomes and profits rather than quality of education. This research [24] also reflects gaps in existing quantitative research, which focus largely on job categories, rather than skills, and on the roles likely to be automated, rather than those likely to be created. The authors explained components of Artificial Intelligence based Education system which can be combined to develop an impartial smart real-world testing and evaluation platform for the students. They further discussed requirements of having more understanding which should eventually result in more productive output by use of smart machines in day to day routine at work place. This will bring a positive change and significant impacts of globalization on existing issues in education sector. They completed two things.

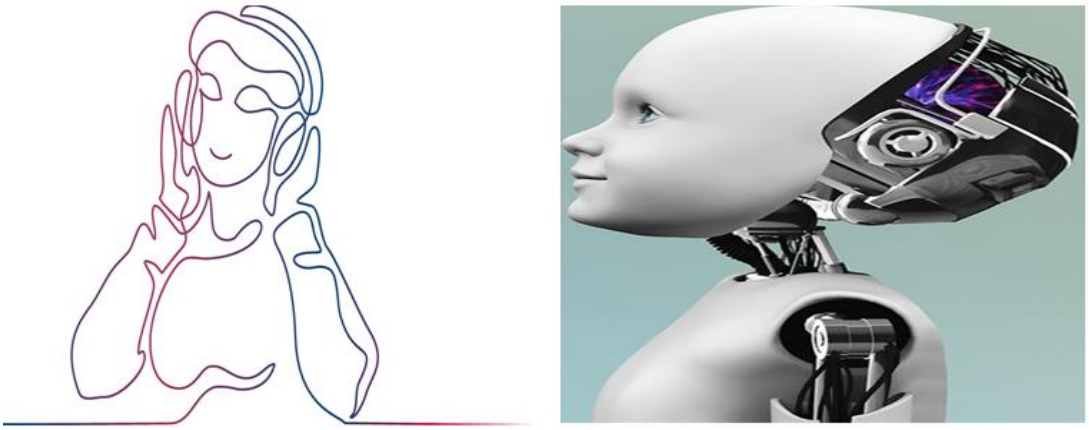

Figure 3: Learning through Cyborg

I. Mapping the catalogue of AIEd tools, which will eventually help for massive challenge by supporting the next phase of education system reform.

II. Set out the ways in which AIEd can be deployed to help for understanding and realizing this reform agenda.

There is need of timely and actionable feedback from students. We should prioritized and made affirmed that the 'purposes' of education are than getting a job. For example, a list would include discovering your passions, experiencing the flow and satisfaction of good work, and being a moral person with the capacity and desire to affect positive change in your family.

Community, country, and the world. Having said this, getting a good job is consistent with the list above. Indeed, it is one of the central reasons why governments invest in education. The table shows our mapping of the tools of AIEd against the likely requirements of the jobs market in 15 years' time

In Engineering Programs, early exposure to IoT development frameworks can help students feel comfortable with IoT fundamentals and applications. Jing He et. al. present a case study [21] in which the authors showed how a module design method can be used to develop a course lab-ware on the basis of embedded training boards. This technique was very effective as in a fun environment; the students gained understanding of computer based automation and maybe one or two more. Teachers should motivate students to innovate, with the goal of gradually preparing the students for IoT era through smart approach of doing tiny experiments to build their hands on experience for innovation in a seamlessly manner.

3 LEARNING OUTCOMES BASED TEACHING

While adding modern educational techniques and new technological gadgets the importance of learning outcomes should not be ignored. There are chances that learning outcomes might slightly be changed but the overall learning goals would not be affected.

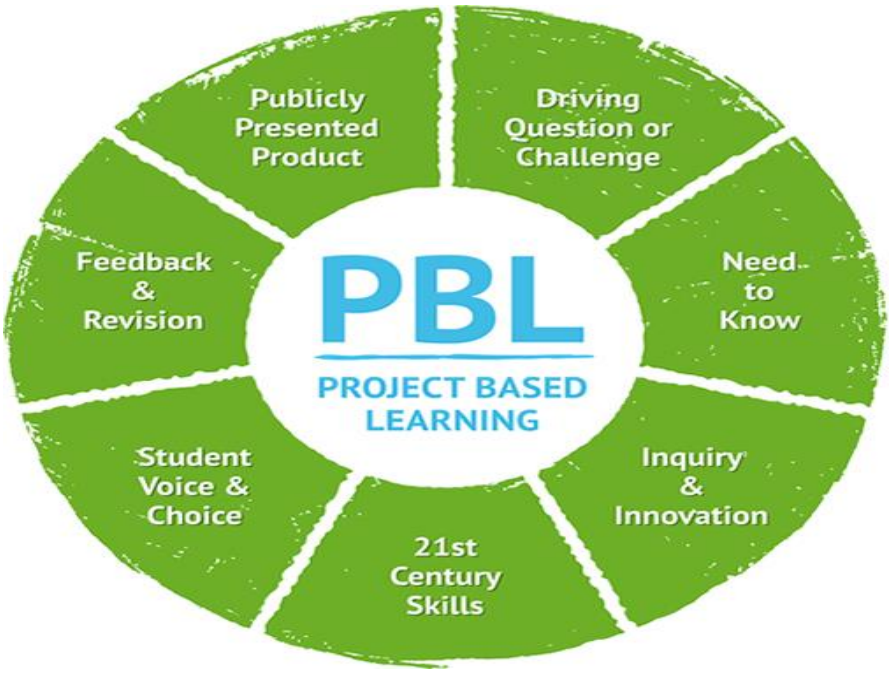

Figure 1: Students Learning Outcomes Cycle [24]

3.1 Program Learning Outcomes

Every curriculum is designed with some particular Program Learning Outcomes (PLOs), which means that students after completion of that course will have sufficient amount of knowledge, which is measurable by the standards defined by the National & International Accreditation Bodies e.g. NCAAA, ABET, ACM etc. Table -1 shows course learning outcomes for Computer Engineering Bachelor's Degree program at Yanbu University College, Kingdom of Saudi Arabia.

		Mapping of course learning outcomes (CLOs) to ABET EAC Student Outcomes (SOs)										
		ABET EAC Student Outcomes (SOs) [21]										
		a	b	c	d	e	f	g	h	i	j	k
		An ability to apply knowledge of mathematics, science, and engineering	An ability to design and conduct experiments, as well as to analyze and interpret data	Design system, components or process	An ability to function on multidisciplinary teams	An ability to identify, formulate, and solve engineering problems	An understanding of professional and ethical responsibility	An ability to communicate effectively	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	A recognition of the need for, and an ability to engage in life-long learning	A knowledge of contemporary issues	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
Course Learning Outcomes (CLOs)	CLO 1.01	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	CLO 2.01	☒	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐
	CLO 2.02	☐	☒	☒	☐	☒	☐	☐	☐	☐	☐	☐
	CLO 2.03	☐	☒	☒	☐	☐	☐	☐	☐	☐	☐	☐
	CLO 2.04	☒	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐
	CLO 3.01	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐
	CLO 3.02	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐
	CLO 4.01	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☒

Table 1: Program Learning Outcomes for Bachelor of Computer Engineering Degree Program

3.2 Course Learning Outcomes

Every course is designed by keeping in view some Course Learning Outcomes (CLOs) from any particular course, which are bench marked against some international bodies like ABET, ACM etc. Table-2 shows the example of Computer Network Course with its Expected Outcomes, Assessment Methods and Teaching Strategies, which is being offered at Yanbu University College under B.Sc. Computer Engineering program.

Expected Outcomes of the Course		
At the end of this course, the students will have the capabilities to: • Know switching concepts & switching technologies • Understand types of routing and routing protocols • Design, calculate, and apply subnets masks and IP addresses • Design, configure, and troubleshoot a medium sized network by implementing switching and routing technologies. • Upgrade some hardware of communication devices (Switch, Router)		
Knowledge and Understanding		
Course Learning Outcomes	**Teaching Strategies and Activities**	**Assessment Methods**
Describe Computer Networks, topologies, OSI Layers, basic switching concepts, operations, and technologies, static and dynamic routing, and purpose of ACL.	Lecture followed by discussion	Quizzes and exams
Cognative Skills		
Course Learning Outcomes	**Teaching Strategies**	**Assessment Methods**
Configure, implement and troubleshoot Layer 1 and layer 2.	Lab work	Assignments, exams, and project
Design, calculate and apply subnet masks and addresses to fulfil given requirement.	Lecture followed by example case-studies.	Assignments, exams, and project.
Configure, implement, and troubleshoot Layer 3.	Lab work	Assignments, exams, and project
Configure, implement, and troubleshoot ACL, NAT, FHRP, and NTP.	Lab work	Assignments, exams, and project
Configure, implement, and troubleshoot basic security features.	Lab work	Assignments, exams, and project
Interpersonal Skills and Responsibility		
Course Learning Outcomes	**Teaching Strategies**	**Assessment Methods**
Show effective participation in group and exercise leadership when appropriate.	Group project	Project rubric
Act ethically and responsibly in a professional environment.	Clear policy about academic integrity and firm deadlines for all work submission.	Penalty on plagiarism and late submission.
Communication, Information Technology and Numerical Skills		
Course Learning Outcomes	**Teaching Strategies**	**Assessment Methods**
Demonstrate good use of lab hardware and software.	Lab work and group project	Project rubric
Psychomotor Skills		
Course Learning Outcomes	**Teaching Strategies**	**Assessment Methods**
Upgrade hardware chases of a router	Lecture followed by experiment	Lab Exam

Table 2: Course Learning Outcomes (CLOs)

To evaluate the performance of students and to ascertain the effectiveness of teaching strategies mapping is done between the CLOs and PLOs as shown in Table-3

Mapping Matrix Course Objectives and Learning Outcomes

Course's Contribution to Program and College/Institute Goals

The contribution of the course is analyzed through CLOs to PLOs mapping.

Mapping Matrix (Curriculum Matrix)

		Computer Engineering PLOs							
		PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8
		To apply knowledge of mathematics, statistics, computer science, and engineering.	To design and construct experiments	To interpret, analyze and organize data.	To identify, formulate, and solve hardware and software problems to meet specific needs within realistic	To create multidisciplinary teams working cooperatively, respectfully, creatively, and responsibly.	To demonstrate efficient communication by oral, written, and graphical means.	To identify the impact computer engineering solutions in a global, economic, environmental, and societal context.	To recognize the need to engage in lifelong learning, mainly in the field of computer engineering.
Course Learning Outcomes (CLOs)	CLO 2.01	☒	☐	☐	☐	☐	☐	☐	☐
	CLO 2.02	☐	☐	☐	☒	☐	☐	☐	☐
	CLO 2.03	☐	☐	☐	☒	☐	☐	☐	☐
	CLO 2.04	☒	☐	☐	☐	☐	☐	☐	☐
	CLO 3.01	☐	☐	☐	☐	☒	☐	☐	☐
	CLO 3.02	☐	☐	☐	☐	☒	☐	☐	☐

Table 3: Mapping of CLOs with PLOs

Although, Outcome Based Education concept provides a more systematic and measurable way of inculcating knowledge but it has also increased reliance on thorough documentation for every step in the academic calendar , which results in producing large amount of data and clerical work for each individual student. With the maturity of Artificial Intelligence and Analytics we are now capable of analyzing the data in more meaningful way for customizing the teaching strategies for further improving the accuracy of education for achieving its goals.

4 FUTURE LEARNING TRENDS WITH TECHNOLOGY

IT is shaping the way how higher education is evolving with internationalization. Researchers at Pearson and UCL Knowledge Lab [19] proposed use of Artificial Intelligence based system to improve the learning and teaching in education. Figure 3 shows their envisioned concept. The Horizon Report [25] portrays how higher education will evolve with the improvement of technology. It highlights different aspects along which teaching and education will evolve.

4.1 Long-term evolution (in half decade or more duration)

Cultural evolution towards innovative education: Universities will be required to inculcate education and skills which promote self-employment, startups, curiosity and hands-on experience.

More in-depth practical knowledge: Higher Education institutes will have to customize their training methodology to become student centric as opposed to traditional teacher centric approach that will allow project oriented teaching to enhance the psycho-motor skills of the students, while challenging the logical thinking abilities of the pupils.

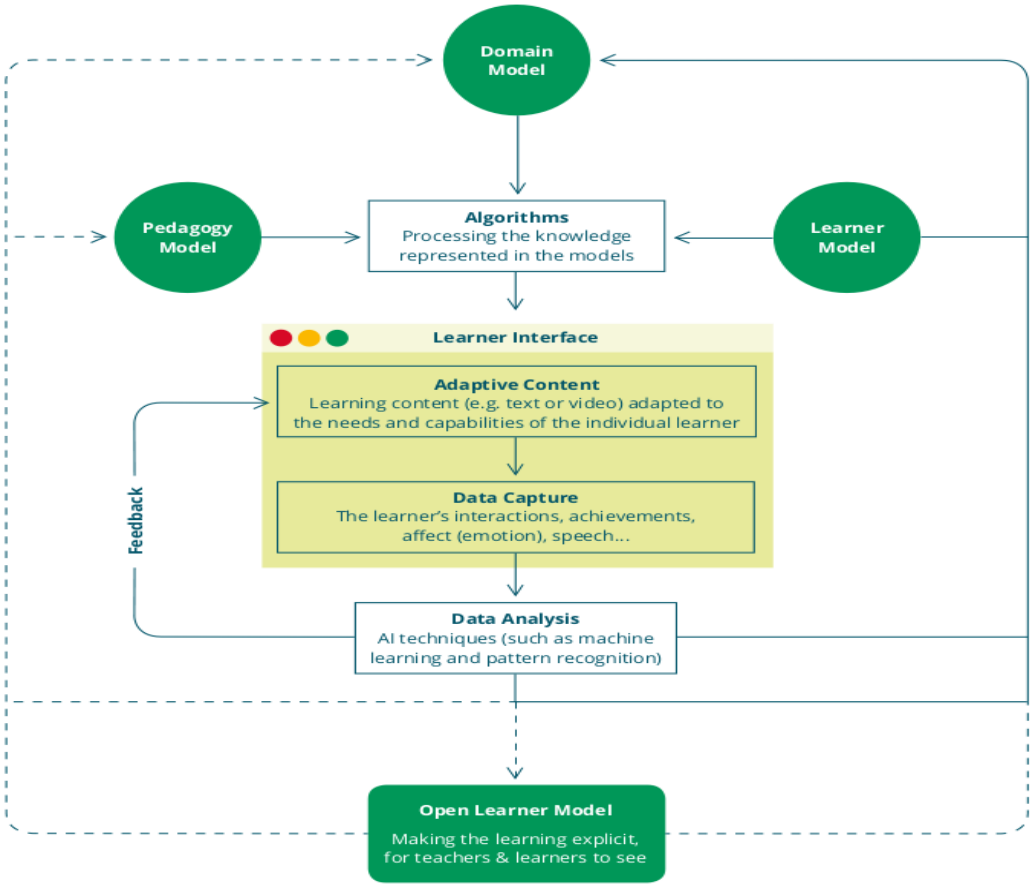

Figure3: Pearson and UCL proposed AIEd system showing a simplified picture of a typical model-based adaptive tutor [22]

4.2 Medium-term evolution (3 years to a period of half decade)

Education with measurable learning goals: Newer techniques to examine and assess the learning quotient will be emphasized. Graphical representations of students' progress will provide more accurate and focused feedback on the outcomes of student learning.

Futuristic Classrooms: For more immersive and interactive teaching the classrooms will transform into Smart Spaces that foster thorough understanding of concepts and knowledge.

4.3 Short-term evolution (In a couple of years)

Multi-source Multimedia learning environments: Novel Internet enabled teaching approach with greater participation of students in explaining the concepts discussed in the classrooms will be adopted.

Online interactive teaching methodologies: Collaborative teaching and learning where teachers and students concentrate to find answers of practical problems some of which will require specialized skills and technological advances that the pupil must learn in order to succeed.

Incremental difficulty level enhancement: Students will begin with easier concepts and tasks while progressing with their learning abilities, more complex problems will be offered to them to challenge them to apply their knowledge yet requiring further research of unknown concepts.

Grand Challenge Problems: Eventually, the students will have to apply their understanding of fundamental concepts, interpolate their skills and evolve their understanding to devise novel approaches in solving problems that were otherwise considered unsolvable by traditional approaches. By attempting to solve such complex problems, the students will evolve into next generation scholars of the future.

5 TECHNOLOGY TRENDS (IN A COUPLE OF YEARS)

Dynamically self-tuning learning technologies: Modular Hardware and Application Software will adapt itself according to the learning progress and teaching goals set by the instructor.

Portable learning technologies: New cloud-based smart platforms and services will be introduced in educational sector that will allow students to use their own mobile devices such as laptops, tablets, Smart-phones etc. through learning apps that will augment or disrupt the conventional teaching methodologies.

5.1 Technology trends (In a period of 2 to 3 years)

IoT enabled everything: The learning spaces, classrooms, labs and the environment will always be connected to the Internet through processors, effectors, actuators and sensors.

Newer immersive teaching and learning: Conventional classrooms will be entirely replaced by online software and web based platforms that allow creation of dynamic learner-centered social networking communities for teaching, discussions and learner's interaction.

5.2 Technology trends (In longer periods up to half a decade)

AI based technologies: Highly effective, human like interaction with Chat-bots and AI based expert systems will provide customized teaching sessions for all students tailored to their individual needs while maintaining synchronization at class level for all students.

Intuitive and Natural Language based Interaction with Machines: The students and instructors will have more natural human computer interaction then ever by utilizing gestures, expressions and audio visual interactions with technology thus focusing more on the concept and subject matter as opposed to spending time on learning the use of digital technology devices to achieve the following two goals.

I. To identify the best possible pedagogical techniques for effective outcome based learning requires thorough knowledge of teaching and learning scenarios.

II. To develop authentic, impartial and fine grained mechanisms to ascertain the learning progression of students in all areas of competency that are required to excel in the future practical fields at global level.

6 CONCLUSION

Today, we have various ways to teach skills that students will need in a global IoT world, which has totally changed our perception for different services [23], but we don't always implement them effectively in the classroom. To fulfill the requirements of future-proof education, the educators and institutions need to integrate IoT platforms into science and engineering curricula to help students develop digital literacy and innovation skills. Moreover, AI based data analysis and adaptation strategies will be required to provide student centric progress driven contents that enhance level of understanding while boosting the receptivity of the students through multimedia contents. We also discussed the short term, medium term and long term trends in education and use of supporting technologies to prepare the future students of Smart Societies.

REFERENCE LIST

1. Anca Mustea, Mirela Murean, Cosmin Herman (2014), Integrating E-learning into the trans-disciplinary methodology as a solution to the challenges of 21st century society. Procedia - Social and Behavioral Sciences 366 – 372.

2. Pacific Policy Research Center. 2010. *21st Century Skills for Students and Teachers.* Honolulu: Kamehameha Schools, Research & Evaluation Division.

3. Towards defining 21st Century Competencies for Ontario, 21st century foundation document for discussion. Winter (2006).

4. Cynthia Luna Scott. THE FUTURES of LEARNING 1: Why must learning content and methods change in the 21st century? UNESCO Education Research and Foresight, Paris. [ERF Working Papers Series, No. 13]

5. https://www.computer.org/web/computingnow/archive/iot-for-21st-century-learners-june-2017-introduction

6. N. Park and Y. Ko, "Computer Education's Teaching-Learning Methods Using Educational Programming Language Based on STEAM Education," *IFIP Int'l Conf. on Network and Parallel Computing*, 2012.

7. M. Resnick et al., "Scratch: Programming for All," *Comm. ACM,* vol. 52, no. 11, 2009, pp. 60-67.

8. E.R. Halverson and K. Sheridan, "The Maker Movement in Education," *Harvard Educational Rev.*, 84.4, 2014, pp. 495-504.

9. SEcube information video: http://www.secube.eu/media/video.html

10. https://www.gartner.com/newsroom/id/3165317

11. https://www.cisco.com/c/dam/en_us/solutions/industries/docs/education/education_internet.pdf

12. Cynthia Luna Scott, (2015), Redefining learning content and methods in the 21st century

13. https://blog.bosch-si.com/building/iot-in-education-by-designing-smart-learning-environments/

14. https://learn.ni.com/teach/resources/333/ni-iot-education-beta

15. Veeramanickam et. al, (2014), IOT enabled Futurus Smart Campus with effective E-Learning: i-Campus

16. Daniel Palma at. al. (2016), An Internet of Things Example: Classrooms Access Control over Near Field Communication

17. Jai W. Kang, (2017), Teaching IoT (Internet of Things) Analytics.

18. Shahbaz Pervez, Malik Misbah, Humaira Yaqub, Mahjabeena, "PROTECTIVE MEASURES FOR SECURITY & PRIVACY IN CYBER ERA OF CLOUD COMPUTING", "IEEE International Conference on Electrical, Electronics, Computers, Communication, Mechanical and Computing (EECCMC)" 28-29 January 2018, Villore district Tamil Nado India

19. Yuqiao Yang, (2016). Construction of Distance Education Classroom in Architecture Specialty Based on Internet of Things Technology Luckin, R., Holmes, W., Griffiths, M. & Forcier, L. B. (2016). Intelligence Unleashed. An argument for AI in Education. London: Pearson.

20. Patrice Gans The Fraser-Woods School, Newtown, CT, "The benefits of using scratch to introduce basic programming concepts in the elementary classroom", Journal of Computing Sciences in Colleges archive, Volume 25 Issue 6, June 2010

21. Jing He et. Al "Integrating Internet of Things (IoT) into STEM undergraduate education: Case Study of a Modern Technology Infused Courseware for Embedded System Course."

22. http://www.abet.org/wp-content/uploads/2015/10/E001-16-17-EAC-Criteria-10-20-15.pdf

23. Luckin, R., Holmes, W., Griffiths, M. & Forcier, L. B. (2016). *Intelligence Unleashed. An argument for AI in Education.* London: Pearson.

24. Shahbaz Pervez, Nasser Abosaq, Gasim Alandjani, "IoT Services Impact as a Driving Force on Future Technologies by Addressing Missing Dots" , 16th International Conference on Applied Computer Science (ACS '16), Istanbul, Turkey, 15-17 April 2016.

25. https://santarosa.edu/course-slo/assessment

26. http://cdn.nmc.org/media/2017-nmc-horizon-report-he-EN.pdf

27. Shahbaz Pervez, Nasser Abosaq, Gasim Alandjani, Adeel Akram, "Internet of Things (IoT) as beginning for Jail-Less Community in Smart Society ", "IEEE International Conference on Electrical, Electronics, Computers, Communication, Mechanical and Computing (EECCMC)" 28-29 January 2018 at priyadarshini engineering college, Villore district Tamil Nado India.