Trending, 2022	Declining, 2022
Analytical thinking and innovation	Manual dexterity, endurance and precision
Active learning and learning strategies	Memory, verbal, auditory and spatial abilities
Creativity, originality and initiative	Management of financial, material resources
Technology design and programming	Technology installation and maintenance
Critical thinking and analysis	Reading, writing, math and active listening
Complex problem-solving	Management of personnel
Leadership and social influence	Quality control and safety awareness
Emotional intelligence	Coordination and time management
Reasoning, problem-solving and ideation	Visual, auditory and speech abilities
Systems analysis and evaluation	Technology use, monitoring and control

Figure 1. Trending and declining top ten trends in industries (source: World Economic Forum 2018: The Future of Jobs Report)

While there are trending skills for the 21st century employees, colleges and universities should rethink on their undergraduate curriculum to make sure that students learn those skills. Michigan State University, for instance, has adopted the attributes of what it calls the *T*-shaped professional as a cornerstone of its undergraduate education experience (Figure 2). The vertical bar of the *T* represents a person's deep understanding of one subject matter as well as one industry, for instance, logistics, health care, manufacturing, etc. The horizontal stroke of *T*-shaped people is the ability to work across a variety of complex subject areas with ease and confidence.

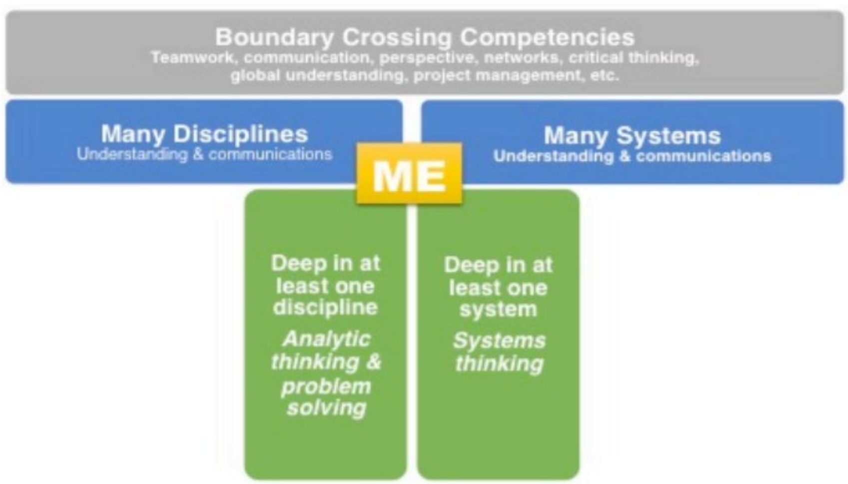

Figure 2. *T*-shaped professional (source: Gardner and Estry 2017)

Large employers like IBM, IDEO, and Cisco are tend to hire *T*-shaped professionals (https://uidp.org/webinar/essential-t-shaped-skills/). IBM in particular is experimenting with ways to scan and code an applicant's resume to assess a *T*-score (Hickman 2014). "The people we would like to work with are *T*-shaped," says James Spohrer, the head of university partnerships at IBM. He also says "We want people who can wrap their head around the whole thing and be part of teams" (Selingo 2016).

The *T*-shaped skill concept was originally proposed by Iansiti (1993). According to him, the *T*'s vertical stroke shows in what specific area the person's expertise is. The horizontal stroke shows how the person's discipline interacts with others. In addition to their specific disciplinary knowledge, they exposed to experience and knowledge of other disciplines.

To educate the future of workforce, much of the responsibility for better equipping young people for contemporary careers has fallen to higher education. By aiming to strengthen the position of the engineering profession as a competitive, cost-effective, highly respected and attractive option in the rapidly changing world of work, the curricula of engineering faculties should be changed/updated according to the industry requirements. Today, it may have to change more profoundly and rapidly than it has in the past 40 years. According to Kamp A. (2016), the 21st century engineering curricula need to be re-formed to shift the focus from "knowledge" to "capabilities". We provide a summary from his suggestions and extend his findings in the below sub-sections.

2.1.1 Engineering Knowledge

With recent IoT developments, systems are getting larger, more connected and more complex. To be able to solve complex problems and advance the current knowledge, it is obvious that deep knowledge in technical engineering disciplines and logical thought are required. In order to prepare engineering students to discover, analyze, conceptualize, design, develop and operate complex systems, the engineering education has to focus on the acquisition and development of core knowledge and capabilities in the domain of the engineering sciences. Future engineering curricula can keep the emphasis on discipline-based learning. However, it should also focus on a holistic view of product and system designs. The students should acquire a conceptual understanding by integrating theory with physical phenomena and engineering sciences, by modelling real-life complex problems. They should also learn how to simplify the assumptions of a real complex system so that a feasible solution can be constructed in which they can transfer their knowledge into it.

Specialization has become a significant requirement to be competitive in innovation. In the 21st century work environment, instead of technical knowledge, an ability on "learning-to-think" and "learning-to-learn" is much more critical. This is because we live in a world where the half-life of cutting-edge specialist technology information is less than, may be, five years. Hence, for future engineers no need to memorize anything they learnt at school because that it is not hard to reach any information and knowledge by using search engines. Hence, it becomes more important to shift our educational methods from cramming large amounts of expert knowledge into the heads of our students, to letting them learn how to acquire knowledge from the surging sea of data, and how to use it when it has been found.

We also live in a world in which engineering is not only a matter of applying science, or solving problems using the theories and methodologies of math and science. It is also becoming the discipline of advancing knowledge through research and experimentation. Hence, the higher education should focus on training the engineering students to let them gain some basic literacies such technological literacy, data literacy, new-media literacy, and human literacy, etc.

By 2030 it is estimated that an enormous amount of data and information as "big data" will be created by the future of 10 trillion online devices with digital sensing, computing and communication capabilities. Therefore, any engineer must have to be data literate. They will need to have a good working knowledge of and skills in algorithmic thinking and programming, statistics, data visualization techniques to deal with "data–rich" engineering environment. Also, it should be noted that, that data environment will also create a significant requirement for data analytics who are able to control and manipulate big data through algorithms, programs and scripts, cybersecurity, cloud computing and optimization techniques in engineering design.

2.1.2 Critical Thinking and Problem Solving

Engineering science can also be referred as "problem solving". With the recent connected systems environment, problems have become huge and more complex resulting with the requirement of different approaches than the traditional methods for the solution of those problems. Hence, this case should be emphasized in the new generation curricula.

For instance, while structured problems usually have a finite set of solutions, most of the real life are not that straightforward and they seldom have one unique "correct" solution. Then, sometimes formulating the right question, or knowing how to avoid a problem rather than having to solve it, may become significant. Critical thinking is about asking the right questions. Complex problems might be overcome by asking critical and intelligent questions, helping to formulate new directions and new ways to manage it successfully. By courage and imagination, critical thinking can be procurable. Especially, humanities and educational related courses or research projects collaborated with people having humanities background may be an effective way to develop these questioning and critical thinking skills. For instance, knowing who to ask, is one of the most important approaches in problem solving for engineers. Training engineering students in these simple, basic professional (communication) skills will benefit them a lot in becoming the future of problem solver engineers.

2.1.3 Interdisciplinary and Holistic Thinking

With the Industry 4.0 technological developments, future of engineers will obviously work in industries where smart machines exist. The universities have to prepare their graduates to a profile having an ability to cross the border of their specialism and communicate with other people having different backgrounds. Those can be either in other technical or non-engineering disciplines or from different cultures. Even today, individual researcher or designer concepts have come to an end. This changing paradigm means that the engineering professionals need new skills such as holistic thinking, the ability to work in interdisciplinary global teams, and ethical leadership. Collaboration across locations and disciplines is increasing. Engineers not only collaborate in teams to solve complex problems, but also have to manage people, and increasingly will have to collaborate with robots. Communication and collaboration are widely regarded as the key assets for engineers.

For instance, high-tech enterprises increasingly look for engineers who can combine and understand "the big picture" of a system, have a sense of the multidisciplinary problem point of view and a good awareness of the business side and human context. They must be able to reduce the complexity, uncertainty and ambiguity to workable concepts, and create value for the enterprise and customer.

2.1.4 Imagination, Creativity, Innovation

"Creativity" is the most important leadership attribute for the tomorrow's engineers. Creativity involves the ability to bring together the methods, devices, approaches, words and concepts, etc. in novel ways. It mostly involves collaborative work, divergent thinking and depends on connecting disparate dots of knowledge. Given the speed of change and the resulting complexity, students have to learn to go beyond knowledge, expertise and logical analysis, and develop a courageous attitude towards being creative and addressing different ideas.

Critical thinking, creativity and imagination, are key for the success of innovation. Education policies need to consider developing these skills as a matter of key importance. Entrepreneurship education may be a good setting for such skills fostering and nurturing. The physical labs and makerspaces may also play significant roles for key motivators of "how to" engineers, and more importantly, may be a place for idea incubation, innovation and experimental play.

2.1.5 Communication and Collaboration

In today's workplace, social interactions have become an important practice in engineering. An engineer spends at least sixty percent of his time interacting with other engineers, clients, supervisors, specialists, and many other people who are different specialists having different experiences (Trevelyan 2014). In workplaces, engineers are usually involved in several team-based and cross-disciplinary projects. In today's globally connected world, engineers require to work with international and multicultural collaborative teams taking place with different continents in different cultural settings, with different time horizons, with different incentives and conflicting interests. Also, by the recent technological developments, that collaboration may require to use complex communication techniques such as social networking, virtual and face-to-face communications, Skype virtual meetings, etc.

At university or college, students have to learn how to choose the suitable communication tools to interact. To let them learn how to communicate as an engineer, it is essential that we create an environment in which students can learn to work with diverse groups and to collaborate by using techniques. When graduates obtain those communication skills, they will find it easier to persuade, influence and lead in the work environment.

2.1.6 Life-long Learning

When students leave the university and enter the world of work, they can no longer count on teachers, textbooks, and lectures to tell them what they need to know to solve the problems. The only resources they have access to are themselves and their colleagues. If university education can help them to become independent learners, developing and relying on their own reasoning ability rather than accepting information, we will be equipping them with the lifelong learning skills they will need for success throughout their post-graduate careers.

There is a strong consensus for the future employability is that life-long learning is the most important skill an engineering graduate should have. However, to be able to gain this skill successfully, the engineer should also have a deep academic and working knowledge of the fundamentals of science, technology, engineering and mathematics, as well as an analytical mind and a good mastery of both systems and algorithmic thinking. Rapid developments in teaching and learning methods such as online and mobile learning, knowledge sharing, virtual reality, predictive learning analytics, etc., have created the environment of flexible education "at any time and any place".

2.2 Technology-based and Student-oriented Education

According to the 2016 Chronicle of Higher Education report (2016), 2026 The Decade Ahead: The Seismic Shifts Transforming the Future of Higher Education, the new "learning economy" is defined well by some technological trends. In this section, we mainly provide our understandings from that report as well as enhance it by editing our new ideas.

2.2.1 Match.com for College Admission:

According to the Chronicle of Higher Education report (2016), the future of college admissions would be based on the massive amounts of data and information collected on students from an early age. Namely, instead of waiting for applications each year and an application done in deadline, colleges could conduct searches of data on the students and parents that are available. For instance, except the high school activities and courses, the colleges could also search for prospective students among those who take free massive open online courses (MOOCs). Those MOOCs could enable colleges and universities to discover talented students fitting well for their classes and programs. It would be an easier and cheaper way to find the suitable students. And, it would create a safer belief that those students ultimately would succeed given that they were already doing the related work.

For instance, Arizona State University launched Global Freshman Academy with edX in 2015 (https://www.edx.org/gfa) offering a dozen MOOCs free of charge. The students are allowed to pay and transfer credits if they successfully complete the class. This approach turns the current admissions system on its head. Instead of students applying to college, getting accepted, paying tuition, and only then taking classes that they might end up failing, students get to try out college first with very little risk.

2.2.2 Competency-based Education:

Competency-based education (CBE) is an approach suggesting learning, based on developing and demonstrating competence. Instead of simply sitting in a classroom for a specific time period, students are allowed to show what they know by moving at their own pace. Although the competency-based education differ by institution, the general concept, demonstration of mastery of a subject through a series of assessment tests, assignments, instead of following a prescribed set of courses is same. In that approach, faculty mentors work closely with students throughout a degree program and design a schedule to let them access the learning materials required to demonstrate mastery. Mostly, another group of course evaluators grades those exams, research papers, or related performance assessments.

For instance, University of Wisconsin, Northern Arizona University, and Southern New Hampshire University, have introduced their own self-paced degree programs in recent years based on CBE.

2.2.3 Digital Transformation in Education:

The wealth of digital technological developments have also created digital educational resources. By these resources, new demands on higher education systems and institutions, including developing innovative curricula, study programs and alternative learning pathways, and routes to higher learning, facilitated by online, distance, open education, blended learning delivery models and short skills-based courses such as Massive Online Open Courses (MOOCs) and Open Education Resources (OERs), have emerged. Online learning such as in the form of MOOCs builds new paths to higher education as well as expanding lifelong learning opportunities. It also provides flexibility in education alternatives for students and cost efficiency for institutional education.

MOOCs and other digital tools provide self-learning environments by connecting students to global learning platforms and making learning more dynamic. Coursera, EdX, Udacity, Udemy, Carnegie Mellon and Stanford Open Learning Initiative are some of current popular MOOCs. However, MIT's Open CourseWare initiative that was launched over a decade ago is also another significant implementation in digital transformation of universities. MIT decided to put all their course materials online, and as of 2012, there are over 2150 courses posted online with topics ranging from Business, Engineering, Fine Arts, Health and Medicine, Humanities, and Social Sciences.

Due to the lack of interactivity in MOOCs, one of the recommendations for improving the effectiveness of learning in MOOCs is to enhance the interaction between the teacher and the students (Hollands and Tirthali 2014). Starting from 2015s, Georgia Institute of Technology in USA for instance has constructed virtual Teaching Assistants (TAs) for some of its online courses called 'Jill Watson' developed by using IBM Watson APIs for that purpose (Goel and Polepeddi 2016). Those virtual TAs can respond to student questions without informing the students that they were AI agents.

2.2.4 Data Analytics in Education:

By integrating in the digital teaching resources, it has become possible to measure and trace the student learning levels in real time and allow students and professors to adapt their behavior based on the outcomes. This method is usually referred to as data analytics or predictive analytics powered by the information bites being created in classrooms every minute of the day.

By collecting and analyzing data about student performances, more personalized advising and course delivery could be managed. The science behind these advising systems is the same one that drives the algorithms developed for customers to better appeal to their buying habits recommending music on Spotify and movies on Netflix. For example, by this approach colleges will know that a student who does not do well in statistics during his or her freshman year is not likely to finish a degree in economics. For instance, Stanford University's, the Open Learning Initiative's (OLI) offers innovative online blended courses to anyone who wants to learn or teach (http://oli.stanford.edu). Their goal is to create high-quality courses and contribute original research to improve learning and transform higher education. The OLI involves data analytics in it as well.

In a recent trend, new generation of students tend to create their online learning paths by ignoring passive lecture classes following the "sage on the stage. Instead, the future is unfolding on campuses such as the University of Michigan and Case Western Reserve University where professors already track how often and for how long students watch videos in "flipped classrooms". They also track which parts of the lecture might be causing them difficulty.

Conclusion

In this work, we aim to provide a study to address how the future of higher education should be towards the recent Industry 4.0 developments. Although we aim this work to be specifically focusing on engineering faculties, the content provided would also be valid for any faculties of higher education. We present the future of higher education from two perspectives by considering, the skills that the students should gain during their higher education, and the new methods and technologies to be utilized in a student-oriented education. We present what the technological trends in education as well as how the universities are required to integrate the new, innovative and multidisciplinary approaches in teaching and, how to stimulate entrepreneurial and digital skills in higher education, and boost curricula adjustments.

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