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Research Article

Basic evaluation of engineering education and expectations

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Abstract

Engineers have different responsibilities in different types of business. Engineers are organising works and workplaces according to those profession requires. In certain jobs they are hired for their design and new innovative powers to create new fields to their companies in competitive businesses. Therefore, engineers should be graduated to handle their actual responsibilities. After realising some deficits in engineering education, some engineering faculties have reshaped their education and covered more design and problem solving activities. Graduating engineers in changing world in technology and population requires "engineers" who can meet technological and social rule changes. They should have deep knowledge in their subjects and creative design abilities. Educational methods aimed to reach "good engineers" in engineering faculties are given here to present importance of eternal, analytical and creative knowledge gained by engineering students.

MÜHENDİSLİK EĞİTİMİNİN VE BEKLENTİLERİNİN TEMEL AÇIDAN DEĞERLENDİRİLMESİ

Anahtar Kelimeler
Mühendislik eğitimi
Gerçek-dünyada mühendislik
Müh. eğitimi yöntemleri
Eğitim

Özet

Mühendislerin farklı iş kollarında farklı sorumlulukları vardır. Mühendisler iş-işyeri çalışmalarını ilgili işkolları için gerekli şartlara göre organize ederler. Rekabetçi işkollarındaki bazı işlerde görevli mühendisler ise şirketlere yeni açılımlar oluşturmaları için tasarım güçleri ve yaratıcı, yenilikçi, özellikleri için işe alınırlar. Bu nedenle mühendislerin bu yenilikçi gerçek mühendislik işlevleri için eğitilmeleri gereklidir. Mühendislik eğitiminde bazı aksaklıkların fark edilmesinden sonra, mühendislik eğitimi veren bazı kurumlar kendi eğitim sistemlerini değiştirmişler, eğitime daha çok tasarım ve problem çözme işlevleri katmışlardır. Teknolojik ve nüfus açısından durmadan değişen dünyada "mühendisler" değişen teknolojik ve sosyal kurallara uyumlu olmalıdırlar. Mühendisler kendi konularında derinlemesine bilgi sahibi olmalı ve yaratıcı tasarım yetenekleri olmalıdır. "İyi mühendis" mezun etmeyi hedefleyen mühendislik fakültelerinin mühendislik eğitim yöntemleri burada özetlenerek, öğrencilerin kalıcı, analitik ve yaratıcı bilgileri kazanmalarının önemi vurgulanmıştır.

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INTRODUCTION

Engineers in companies or companies which hire engineers to continue their businesses have asked to produce decisions which generally have taken together with uncertain input data. Governments put regulations to obtain safe working places, but works in most cases have to be completed in limited time with limited opportunities. That means engineers should ready and can carry responsibilities of their decisions. They must have ability to design and innovative actions under complex data environments. In general, it is expected that all decision parameters can be measured in reasonable manner in all engineering applications. However, this is not the case in most of the cases. Firstly, it should be known that all the measurements through the lab or in-situ tests are average values including variety of standard deviations. Engineering works have included numerous factors of decision parameters which cannot be fully determined and they have supplied in general through statistical analyses, values. So engineers must be ready for these kinds of (including certain degree of blindness due to nature of decision parameters and statistical evaluations) works. Engineering decisions, in most of the cases are taken in such situations, thus engineering students should be educated to handle these uncertain decision conditions.

Some engineering students expect regular working environments for their future professions. They may feel ready for reasonable engineering problems which have step by step problem solving procedures. This kind of engineering may be handled in factories where their working steps had been already designed. What about the mining engineering workplaces in different mine sides? They have to organise their works for each new day at new working locations, (new area, different location, variety of excavation conditions, etc.). Engineers are ought to be creative in their decisions, knowledgeable about safety rules, realizing human behaviours, understanding the capacity of the machines used in all mine activities. How these engineers can then be educated, this statement is mainly analysed here to present the importance of engineering education. However, it should be stressed on that, education can only be reach its peak aims if the educators and students are honestly keen on the knowledge & experiences. Constructive knowledge can only be transferrable assets if it activates long stay memory of humans and it could be acquired through personal concentrations. In some documents, in order to show the boundaries of engineering, they supply vocabulary root of "engineering" which is "*derived from the Latin ingenium, meaning "cleverness" and ingeniare, meaning "to contrive, devise"* [1, 2]. This definition was supplied also by The American Engineers' Council for Professional Development (ECPD, the predecessor of ABET) as; "*The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behaviour under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property*" [3].

Engineering in some countries has been well regulated for last 40-50 years. Since work and workplace safety have been main influencing factors in social welfare of modern life, governments and companies feel to obey social improvements and understanding in social goodness of their members. For example, mining industry which can be assumed as harsh and dangerous working branch in past days, but now it is regulated to handle new safety standards. The questions arose here; if engineering faculty graduates are ready for these improvements. As an engineering branch for example, what is "engineering" works, action, activities, responsibilities in mining industry? Every single day in mines, new parts of natural resources are mined out. Mining operations applied at these new faces, sides, are mostly similar, but working and operational problems and easiness can also be different. That means engineers, foremen and mine workers have to be ready to cope with these obstructs with reasonable time (includes the rules following all regulations). Uncertainties are directing the underground mine design parameters and other mining operations like open pits, quarries, exploration drillings etc. Mine engineers should supply daily orders to continue mine operation in daily bases. Then, mining societies, organisations and governments should consider deeply that; how the statements in these orders can be logical to regulate mine operations. In basic thinking, those orders based on engineering evaluations and decisions directly influence mine companies' efficiencies and their successes in current mining business environments. Costa and Scoble stated that [4] mining engineers recently especially act to handle "*usage of natural resources, keeping sustainability of nature itself around the ore bodies"*. Natural Resources Canada [5] has recognised sustainable development as "*the integration of environmental, economic and social considerations, as the key to ensuring we maintain our quality of life and continue to create jobs, without compromising the integrity of the natural environment or the ability of future generations to meet their own needs"*. These statements in reality encapsulate the direction of new engineering activities and engineering education.

According to Singer and Smith [6] *"engineering education research has been on the fast track since 2004 with an exponential rise in the number of PhD's awarded*". Educational science has remarkable researches and tests especially on primary to high school education period, K12. Several educational methodologies have been proposed to obtain capable individuals for societies in modern world. Froyd et al [7] stated *"major shifts in engineering education in the past 100 years*". They implied that, engineering included *"hands-on and practical emphasis"* at the earlier times. Then it has turned out more complicated professions gradually by shifting meanings of "engineering" step by step as listed;

i) A shift to *"engineering science and analytical emphasis,*
ii) A shift to outcomes-based education and accreditation,
iii)A shift to emphasizing engineering design,
iv)A shift to applying education, learning, and social-behavioural sciences research,
v) *A shift to integrating information, computational, and communications technology in education"* [7].

Froyd et al [7] wrote also that first two shifts in this list are completed, but the last three of them are still in progress. Engineering behaviours, expectations and responsibilities for official state duties, for companies are changing gradually in the world. Engineers asked to solve or answer gradually different types of questions related with technology, safety and economic productions. People would like to live in certain limit of welfare without ruining environment and other people's rights. They are usually alertly sensitive common values and resources like human rights, ozone layers, CO_2 accumulation, forests, icecap thickness at the poles, clean water resources, animal rights etc. Therefore, engineering decisions should first consider those sensitivities and their social impacts. That means new generations who would like to be engineers have been educated with those preliminary considerations.

Students have selected engineering as carriers for their professions in different circumstances. In recent years, students who prefer to be involved in new developments in industry, health and social issues have selected engineering education to handle those subjects' technological sides. Joshua Cruz and Kellam [8] researched on students reasoning and satisfaction during their selection of engineering major education by surveying 21 undergraduate students in South-Eastern Research University, USA in 2018. This research caused to understand *"student conceptions of the engineering field when they enter; who enters the engineering* *field and why; how students' expectations are met or not in engineering programs"*. The researchers [8] pointed also that students "*entering engineering tend to have a limited understanding of what is entailed in an engineering program and benefit from interactions with advisors, teachers, and peers in the field"*.

REQUIREMENTS OF IMPROVEMENT IN ENGINEERING EDUCATION

In engineering education area of study, some universities define their education to compensate those new understandings. For example, Cambridge University in UK [9] defines its engineering education strategic aims to graduate engineers for 21st Century as; "*inspiring future generations of engineers, equipping them with the best integrated engineering education, and engaging them at the leading edge of engineering thinking, so that they can change the world"*. Cambridge University stressed on the role of engineers on new conditions appeared in the world which governments and companies should challenge. These subjects can be "*energy, climate change, ageing population, economic re-growth or a myriad of other big issues*" where engineers should produce solutions, practical and considered actions even these problems include openly known or covered uncertainties and unknowns.

Engineering education has its own documentations and main requirements of educational research in engineering have been outlined by realizing the problems experienced for graduates of engineering departments. Main critics concentrated on the graduates' behaviours and capacities have been gradually concentrated on their science backed education. This type of education may sometimes include detail scientific lab-test information. Actual engineering problems on the other hand are in-situ in characters, and they include several uncertain facts (surrounding the engineering activities). These features, aspects, of engineering decisions should be taught in engineering faculties to address the complexity of engineering jobs, businesses.

ENGINEERING EDUCATION AND DIFFERENT APPROACHES

New approaches in engineering education have gradually been offered to handle the concerns in ability and capacity of engineering graduates. Attitudes tried in several universities have thoroughly been considered to obtain solutions for; "how engineering students might be educated in universities to graduate them with the readiness of real engineering problems". Followings are samples of the approaches followed by several engineering faculties to obtain qualified graduates for real-world problems.

a) Tutorial approach: When we think about early years of a child, we definitely realize first tutors in her/his life, mother and father (sometimes brothers and sisters are also effective). These tutors have transferred their learning and knowledge by behaviours, expressions, directions and teachings during child's growing up years. In school years, students have obtained general education in classrooms together with their classmates. What about the profession, in certain craftsmanship, master degree can be handled after working sometimes together with earlier masters in the same working places? Tailoring, handcrafting, carpeting, carpenter, auto mechanics, fireman, etc. these job branches have masters and freshmen which education has taken place while working in their business. Engineered works in ancient civilization had been constructed by ingenious men. In somehow; Egyptian pyramids, long wall of China, earlier underground cities etc. are the results of "hands-on and practical emphasis" (transferring) of engineering knowledge human to human in time. This education methodology has been used since early times in human history. The question is already asked and replayed by Oxford University (UK) that, Tutorial education is also effective method in engineering education. Each tutor, "*who is an expert on the topic*" in this university, closely directs and coordinates two or four students during their engineering education. This university claims that students have their "*chance to talk in-depth about their subjects and to receive individual feedback on their work*" in this tutorial centred education models [10]. In regular tutorial controls, students are under "*close progress monitoring, so tutors can quickly provide additional support if necessary*" [10].

b) Lecture-content based education: Lecturing on engineering subjects has steadily been traditional in last decades but, attending engineering lectures required additional attitude in engineering in the past times. Engineering in early times was not defined clearly and talents in technological capabilities were transferred from master level superintendent to the new candidate by working together. Experiences define many practical subjects but lectures were organized to clarify important part of machines used together with key structures of their job procedures. That means lectures were handled to group of practical engineers to improve their experienced engineering knowledge in he past. In later years, engineering lectures have been more science and design related to overcome societies' new technological requirements.

Lectures and their content have deep influence on students understanding in the giving subjects. Lectures should be the key to realize the main points, students' thoughts are then stimulated, encouraged, to think creatively and critically. Learning points in lectures are depending on some educational factors which Ramsden [11] wrote for them as a factor of good teaching as well. He mainly stressed on sharing of desire to learn, stimulating learning, explaining subjects, encouraging further search for deep understanding. The success of classical lectures in engineering education depends on the lecture plans and their good presentations. "*Lectures which are based around a set text should be used to clarify, expand, or explain the content of the text rather than merely to repeat it*" [12]. Gibbs and Habeshaw [13] points three facts which can be considered to handle more effective engineering lectures. Educators should know that, students construct their own knowledge, they would like to understand whole picture of lecture giving on daily bases. Educators should also be careful for students' feelings which overburden them to quit out of the engineering education or select memorizing to fulfil the required limitation to handle pass grade from the selected lectures. Students, who select engineering in their education, are encouraged to explain concepts in their own words. Students put forward conflict and paradoxes in engineering subjects to discuss in their lectures. Their pre-ready knowledge gained in general education from kindergarten to university, sometimes includes misunderstanding and misconceptions. These are corrected by supplying engineering points of view in engineering lectures. Besides, students would like to understand the limits of lecture contents together with knowledge covers interdisciplinary connections. Supplying lecture content with "*overview of the whole subject at the beginning - a written subject outline or diagram of the subject can be helpful. Students can then link each new session back to this overview and to previous sessions*" [12]. UTS, University of Technology Sydney (Australia), pointed that "*presenting too much content too quickly can rapidly overwhelm students' ability to make sense of it*" [12]. In engineering education, any subject which is lectured without noticing students understanding causes memorisation. Thus, students repeat that statements written in books without realizing the meaning in detail (deep approaches). This type of knowledge is ready to be forgotten by students in a few week times. Thus, UTS called this type of knowledge gaining as a surface approach [12].

c) Problem based education: Engineering departments in some universities list their departmental lectures which have elective courses as well. Recently, design courses supplied in these institutes have planned to cover interdisciplinary knowledge and information transitions cover the earlier lectures' subjects. Trying to solve original problems after obtaining basic knowledge related with departments has leaded the students to understand actual work conditions and problem solving techniques (under supervisions of university professors). Mills & Treagust [14] wrote that problem-based learning has been used for professional training in medicine since 1960. Each patient applied to hospitals brings her/his health problem to be treated after consultations. Treatment of each patient then supply valuable opportunity for problem based education in medicine. The question was asked if similar education can be applied for engineering education. Since, "*it is clear that the profession, the industry employers and the students themselves are calling for significant changes*" [14], in engineering education style which have numbers of science related courses but limited design courses, engineering graduates in near future have suffered due to their absent capabilities; at official and unofficial communication; design on the base of actual engineering conditions; and administration and leadership. It should not be forgotten that engineers in certain branches must lead foremen and workers to complete proposed engineered assets in scheduled time. This needs additional abilities in addition to science and administration based knowledge. Why problem-based education has offered to apply in engineering education can be summarized as follows [14];

i) Engineering curriculum in certain universities "*has mainly focussed on engineering science and technical courses without providing sufficient integration of these topics or relating them to industrial practice*".
ii) Engineering programs in certain universities have no privileges and they "*do not provide sufficient design experiences to their students*".
iii) Some engineering graduates have problems in *"communication skills and teamwork experience."*
iv) Engineering students have enriched their "*awareness of the social, environmental, economic and legal issues that are part of the reality of modern engineering practice*".
v) Some of the engineering departments follow strictly about their practical experience applications, such as summer practices, working weeks in industry during normal semester times etc. However, there are also departments do not pay enough attention on practical experience, (students either do not have it or they attain practical works at inadequate companies). Engineering students who do not attain good practical working places *"are not able to adequately relate theory to practice or provide design experiences"*.
vi) *The existing teaching and learning strategies or culture in engineering programs is outdated and needs to become more student-centred.*

Problem-based engineering education aimed to relate engineering knowledge with real-world engineering problems to graduate who feel more readiness to modern engineering work-workplace conditions. As Fink [15] stated there are two major outcomes from universities and they are "researches" and "graduates". Engineering departments should consider deeply on these to arrange their education system. Main questions to be highlighted here; "*how can we optimise the usability of these outcomes to society, and to industry in particular?"*. At this point some engineering departments handle problem-based education system and modified for engineering education to integrate "*real-life engineering problems in the study programme, which has been shown to be a good way of initiating and maintaining*" properties which actual engineers required to have in their engineering behaviours. To illustrate the effects of problem-based engineering education, survey had been performed in Denmark in 1997. Aalborg University graduates found themselves very different in the following skills when they were asked about "*how important they judged several skills to be and what priority they found these skills were given in their education"* at their universities [16]. These skills were "recognised as the results of the pedagogical concept" and those had been obtained in education & training in students' group based projects works, where problem based learning had been realized. These skills are;

i) "*Communication (written and oral),*
ii) Ability to define engineering problems,
iii)Ability to carry out a total project,
iv) Carrying out technical development and research,
v) Cooperating with people from different educational and cultural backgrounds,
vi) Including social consequences of the technical solution" [16].

d) Project-led education (PLE): Engineering lectures sometimes include only lectures, explaining the subjects in classrooms through several media types. Project led education has differences; firstly, it is student, learner, centred. After assigning the projects, students follow its own research methods and search time to complete the project's requirements. Students were taken basic science related and engineering related lectures to produce meaningful projects in these departments which follow PLE system. Architecture faculties in Turkey have applied similar educational system. At the beginning of the semesters each student has informed individually about a design problem. Students have worked on their assignment and supplied related plans and graphs separately. Therefore, these students, have experiencing their profession in academic environment during these project-led lectures. Lima et al. [17] performed study on PLE and they pointed recognised differences in; "*teamwork, communication skills, connection with the professional practice, and an increased motivation for learning*". They stressed also about; *"PLE as a tool to enhance quality of learning in engineering education has proven to be useful in a sense that contents became more interrelated, student motivation has increased and teacher job satisfaction also has increased. In spite of the negative aspects that are evidently identified by students and teachers, all clearly recognize the advantages of PLE compared to more traditional approaches to teaching and learning"* [17].

e) CDIO-based study programs in engineering education: Gradual changes in engineering education have been related with differentiation in engineering, changes in production and requirements of engineers, number of students attending to engineering departments, decreasing supply of practical experience opportunities, etc. To implement engineering activities, rather than just supplying science related deep knowledge, engineering students have been educated in some universities (in different countries) by following Conceive-Design-Implement and Operate, CDIO, concept which were considered first at the Massachusetts Institute of Technology (MIT), US, in the late 1990s. Then, MIT worked together with Swedish universities (Chalmers University of Technology, Linköping University, The Royal Institute of Technology) to form CDIO Initiatives in 2000 [18]. CDIO system requires curriculum transformation in engineering education. It has active learning procedures which concentrates projects, problem based learning, group/team working, communication to improve students' capabilities to be ready for engineering work environments. At this point Krogsboll et al's [19] words need to be mentioned for CDIO approach in engineering education. The aim here is graduating "*engineers who can engineer".*

f) The School of Engineering and Applied Science (SEAS) system in engineering education: After recognition of handicap in engineering graduates, Princeton university, US, *"set a new standard for excellence in engineering education and research",* [20]. This university put forwarded a statement that, *"as the pace of innovation accelerates and technology grows ever more complex, science and technology are becoming increasingly interdisciplinary, demanding an approach that spans multiple academic disciplines and includes a broader,* *non-technical perspective"* [20]. SEAS education in engineering aimed to reach "*a greater understanding of the impact of technology on society". "Society needs leaders who are capable of incorporating both technical and non-technical considerations, whether in academia, business, government or the not-for-profit sector"*. There are sectors in human societies where engineering approaches are essential. In SEAS approach, students are aimed to equip with fundamental principles and ability to solve real-world problems. SEAS offers to supply new education system which impact on societies especially on these emerging technology areas:

i) Engineering and the life sciences,
ii) Materials and nanotechnology,
iii) Information science and engineering,
iv) Computational and mathematical approaches to understand systems.

Princeton University presented SEAS education approach because different issues have been expected to influence societies in near future. Expected problems related with following issues should be handled by science and engineering methodologies;

i) Urban environment,
ii) Energy and a sustainable future,
iii) Engineering for the developing world,
iv) Privacy and security,
v) Engineering and culture.

g) Evidence-based approach in engineering education: Universities sometimes expects certain type of honouring for their efforts in graduating engineers after confined and lecture-insensitive education. However, in last 2-3 decades, "engineering" levels of engineering faculty graduates push questions to universities instead. Readiness of graduates to real-world engineering jobs requires more effort than the lecturing. Engineering education researches and reports, (especially; US-The National Research Council's *Discipline-Based Education Research (DBER)* reports), outline the engineering education conditions and "*state-of-art advances in our understanding of engineering and science learning*" [21]. Researches on engineering education have been escalated after 2004 and DBER is concentrating on "applying education, learning, and social-behavioural science research" [21], which was described as 4th shift in major five shifts occurred in engineering education [7]. DBER works have caused to "*generate insights with the potential to improve undergraduate education in science and engineering*". Many studies concluded that evidence-based education approach is more effective on students with respect to traditional ones. Therefore, DBER report recommends that institutions, disciplinary societies, and professional societies support faculty efforts to use evidence-based teaching strategies in their classrooms [21]. Evidence based teaching have its base at; clinical fields of medicine, dentistry, nursing, psychology, social works, agriculture, education and other fields [22]. In this methodology, educators approach teaching in organised way and implanting evidence-results examples to open students' imagination to transfer required engineering knowledge. Bubou et al [23] suggested that "*engineering education adopt the evidence-based teaching, as part of the bouquet of solutions to the problems*". During application of this method, educator have advised to improve their teaching practices to enhance engineering students' imaginations, thinking, analytical skills together with students' motivation to being good engineer. It is important to notice that supplying evidences of problems in an engineering branch together with ready-to-use solutions encapsulate students' creativity. Thus supplying evidence and related solution options should involve students' efforts and wonders as much as possible. Thus experiences obtained through searching activities on the base of evidences results engineering graduates more ready to real world problem with respect to traditional ones.

h) DSMI approaches in engineering education: Engineering education which evaluated to cover new requirements results in new educational approach also at University of Southern Denmark. The engineering education model of the University of Southern Denmark, (*Den Syddanske Model for Ingeniøruddannelser,* DSMI), aimed to graduate engineers who "*are qualified and prepared to actively participate in and share responsibility for the development of a company to which they are attached"* [22]. DSMI stressed on economic growth of Denmark which depends on engineers who actively maintain and continue further development of their companies. This university has seen opportunities of development also when their graduates set up new companies. In this point, DSMI put a statement that has been the aim of all engineering faculties since at the beginnings. That is; *"an important criterion for success in engineering study programme is, then, that its graduate engineers"* [22]. In order to reach the planned aims in this university engineers have been trained to have following abilities, capacities; to *"work independently and be able to:*

i) Plan strategies for their own learning process,
ii) Evaluate their own learning process,
iii)Focus in-depth on technical disciplines,
iv) Formulate and analyse a problem in a structured manner".

Engineering education in this university has also following targets to be reached. They require from their graduates; *"Cooperate and be able to:*

i) Work in an interdisciplinary context,
ii Work with people from other academic and cultural backgrounds,
iii)Document and communicate their knowledge and results verbally and in writing to different target groups,
iv) Evaluate the work of others and give them feedback,
v) Work in a project-oriented context and in teams".

These graduates have also been asked to *"Apply their knowledge, skills and competencies in practice and be:*

i) Receptive towards new problems and solutions,
ii) Innovative and creative,
iii)Solution-oriented" [22].

DISCUSSION

Engineering covers different jobs in modern world. Firstly, it is required to organise work and workplaces according to applied legislations. Secondly, engineers control situation of production or circumstances of work at workplaces and they are responsible to have safe working environments together with controlling harmful side of work on environments. Thirdly, they have designed, planned, all human, human-machine, workplace etc. activities to sustain harmonised workplace & living conditions for related working powers including their behaviour at home, workplaces or any other places. Societies and companies in the world need engineers who perform engineering to handle works in different design options. Their designs, results of work & workplace controls, planning the human activities in countryside and urban areas are cover around us. Design of; machines, devices, operation procedures, roads, tunnels, mines, computers, software, satellites etc., they all prerequisite ingenious ideas, thinking and creative engineering works. As a customer and member of a society, observing original or similar design of commercial products including house and city plans influence our everyday life. New ideas in engineering bring usually with new investments. Some companies or state offices may not be ready for these differences. So they may not implement that ideas in to practices. However, any new development which accepted by people as a useful and new opportunity to handle, that engineering asset definitely proves their high level in this business. Engineering or technology depended firms should definitely always ready for competition in their market place. In any type of engineering works, competition in industry has been continued on costs and supplying new opportunities to customers. Therefore, companies should ask themselves if they have engineers who think creatively to support their market competition. That is the main reason why universities should graduate engineers accordingly to suit required industry conditions which have been gradually differentiate.

Universities should in reality have self-questions before graduating engineers who are going to work for real engineering problems, if their graduates are really ready for competitive world industries. Companies servicing to different industries and households through spare-part supply, technical services for maintenance or organising on-time delivery of engineering products are somehow the works of engineers seem near organisation type of works. Working in production factories, controlling assemble lines, controlling agricultural land if something required, controlling the infrastructure of cities if any renovation is necessary, checking the civil buildings if they are stable and safe, controlling the roads, railway for safe transportation, reporting any additional steps to be done to sustain supplied services etc. These are controlling sides of engineering job. There are also planning and designing sides of engineering which includes all industry products and their production related plans. Regional or local area plans, urban & countryside plans, and plans for constructions including for industry and civil purposes, underground excavation designs (mine galleries, mine stopes, tunnels, underground machine openings, underground spaces for civil purposes, shelters etc.) are all required detail planning to decease resource usages with increasing satisfactions for individuals in different societies. That’s why engineering graduate should have capacity to think more enhanced way, including social and humanitarian aspects of engineered problems [24]. Engineers who have extra courses on humanity, art, art culture, sociology, theology, physiology, nature life, environmental pollutions, energy sources etc. in addition to major degree lectures may cover the real world problems more comprehensively. Capacity deficit in engineering graduate from universities had been realized in USA after World War II. Discrepancy of imagination or creativity in fellow engineers might be the main reason of shortages in design companies’ handling number of projects. Because of similar reasons, directors try to escalate “engineering facts” in their engineering firms by organising extra courses for their fellow engineers to open their mind to ignite their creative capacity, (if that capacity had not been totally burned out during school times by compulsory instructions, lecture-intensive engineering education). When prominence of “engineering” has been perceived by engineering companies, time might be too late for them to stay in high design businesses. New methodologies offered in engineering education for real world problems have targeted to eliminate those feelings of dilemma.

Some universities today pay advance attitude to their engineering education system and they might already follow one the methodologies mentioned earlier. However, students' attitudes have directed the level of "engineering" in graduates. It has been observed for 25 years in engineering education in Konya (Turkey) for example that, mining engineering students have followed their lectures in different manners. Even the same students might pay more attention to different lectures. The levels of student interests have commonly been observed in relation with lecturers' behaviours and students' interests. If students like the lecturing methods of professors, in addition if the subjects are the types he&she interested in, then these students have more potential to obtain good grades and better levels of learning. If the lecturers present the lecture subjects with real world examples, showing slides, explaining facts related, assigning homework to force students in advance learning etc., students learning in these lectures have become deep knowledge for their engineering life. Experiences show definitely that lecture subjects learned by students just to obtain good mark from the exams are stay as shallow knowledge and these students cannot remember some of the information supplied even when they are upper Grade students in the same engineering department. This is the point, (shallow knowledge levels at some students), which the engineering faculties should try to find out and offer methods to exchange with deep knowledge. It should be bear in mind that, shallow knowledge of students causes (in some cases) to obtain even higher marks in lectures' examinations if the exam questions should not be asked to control, get, deep knowledge.

After realizing the importance of practices and obtaining experiences of real world engineering problems. Some engineering departments have recently included them in their curriculum to increase the features of their graduates. Some departments on the other hand have already applied similar educational plan to increase their graduate readiness for engineering businesses. Jonassen, et al [25], stated, in contradict that, "*workplace engineering problems are substantively different from the kinds of problems that engineering students most often solve in the classroom; therefore, learning to solve classroom problems does not necessarily prepare engineering students to solve workplace problems".* These researchers focused the real world problems' complex situations. These problematic cases might include; intense human relations, undefined rules, *"conflicting goals, multiple solution methods, non-engineering success standards, non-engineering constraints, unanticipated problems*" [25]. So, the question should here be asked by engineering faculties that if their lectures include all these possibilities which their students obtain experiences. Since engineering world is competitive and conditions have changed with improvements in technology and societies, engineering faculties should follow engineering applications closely to select their examples for their students to graduate them in ready-state form. Basic or engineering lecture contents or engineering education curriculum have reshaped for around two decades. These improvement actions in engineering education have started at industrialized countries when a "ready to act as an engineer" dilemma observed in engineering graduates. Sparso, et al [26], warned about the situation arose during reshaping engineering education system in particular faculties. In order to get advantage on graduates' level of "engineering", system changing in engineering education might be applied but it may cause undesirable turmoil as well. These researchers wrote that "*transition between the systems should be well evaluated otherwise certain lost in educational experience of the departments is inevitable* [26].

There are always constructive and undesirable sides of each provided education systems in engineering. However, it is obvious that each new approach has aimed to graduate engineers for real world "engineering" jobs. In Tutorial education, Tutors' approaches define the students' engineering understanding. Therefore, faculties should have ready to apply procedures for any personal handicaps appeared in semesters between student and his&her tutor. In lecture content based engineering education; students sometimes might have been lectured in more scientific purposes rather than the engineering. Engineering faculties have generally research projects which may be extended deep into subjects' facts and their scientific roots. However, in real world, engineering faculty graduates must understand engineering workplaces and find an occupation in engineering companies (sustain their occupation status, or obtaining promotions in their engineering offices). This real world is generally different than some research environments. Therefore, faculty lectures should always be updated for real engineering work environments. Lectures must be arranged to cover laboratory and site applications as well. In this approach, lecturers are very important, if most of them have academic background and they have academic project experiences, their lectures might be more academic and enhanced than required. Thus students might have then difficulties to follow the information transferred. They then might prefer shallow learning instead of deep learning procedures to obtain "good" grades. Problem based, project led, and evidence based approaches are aimed to graduate more ready to work engineering faculty graduates. These approaches have positive achievements in medicine and law faculties. Since the source of lecture's "problems, projects or evidences" is human depended, therefore lectures can be flourished with numerous examples. However, engineering problems, projects or evidences are case depended, so they cannot be sampled in numerous way. In other words, examples put forwarded in classroom might have limitations in scenarios. Moreover, in problem based approach, tutors must evaluate each student team member carefully, (if students are working in teams), to decide about each student's contribution in group workings. If tutors do not have enough time to make this evaluation, team members' learning levels cannot be well defined individually.

General education strategies have gradually been differentiating in certain countries even for secondary and high school levels due to requirement of real world living conditions. Students have asked to follow STEAM (Science, Technology, Engineering, Art and Mathematics [27]) based curriculums to be away from context based information transferring solely. Current engineering conditions which include bigger excavation machine with automated control systems, computerised plant control for many manufacturing industries etc. have keen on engineers who can think critically and creatively. Educating and graduating mining engineers for example with the covers of mining subjects may not be accepted as enough level in near future. Graduates should also have capacity to understand environmental and social influences of any engineering projects and they should feel responsibilities to produce design products accordingly. Producing energy for example from coal should include climate concerns and environmentally friendly technologies. Engineers are asked in different projects to supply innovative ideas and technologies to reach similar aims to coincide the societies' demands with their logical acceptances. Influence of Covid-19 pandemic quarantine conditions all over the world have demonstrated that engineering firms which supply solutions for medical treatments and computer communications, play important roles since early days of 2020. In this new era, living within quarantined societies, work & workplace environments have re-organised by companies by handling different approaches. This unexpected but unavoidable new-life order is a bitter example which has been experienced by many companies. Employees, (directors, officials, workers and most importantly engineers), of engineering companies who have good reputations on definite engineering products have had certain decisions in these quarantine days. If their decisions are not suitable for this new era, their companies may have started to feel difficulties in their businesses due to lock of creative and critical engineering. That is, we may define engineering act carefully to graduate engineers from faculties to solve problems of future generations which might come across many problematic, extraordinary, cases like current Covid-19 quarantine situations. Therefore, graduated new engineers in different branches should be well informed, knowledgeable and creative enough to put forwarded suitable solutions for their customers like an artist who start artistic masterpieces from blank plain canvas.

CONCLUSION

Engineering education has gradually been changed in times to graduate more comprehensive and ready-to-work state engineers. Education history presents that, early individuals who work as engineers in their work sides had spared limited time for themselves to learn theoretical background of their industrial job applications. They were in actual industry sides to finish works (supervise the works done). They were usually ingenious master-workers, foremen, who had obtained enough experiences about the works. In other words, they knew, "how engineering works had been realized". They were engineers but works most likely like other workers because there were no employment categories in the name of "engineering". Technological developments had forced some of these foremen who knew and organised "engineering works" aside for different occupational job performances like planning, designs and new developments in later years. Especially, after institutions & universities have been established for wider range of population; engineering education has been supplied for more students after World War II. Technologies and its new products push people into new era of industrialization every couple of years which require more comprehensive factories, mines, urban areas, machines, computers etc., consequently people demand more differentiated raw materials, connection roads & railways, constructions, ports, modern cities etc. Demands for engineering faculty graduates who organised and superintended industrial businesses were rather reasonable at the beginning those early industrialisation periods. Since, there were limited numbers of engineering faculty graduates around in those years. Therefore, companies had compensated new engineers' minor handicaps (at practical work sides) and those companies had put internal training activities for new engineers to give responsibilities in their actual works, shifts. Due to deep technological developments in recent years, competitive work environments have gradually driven companies to hire more ready-to-work state engineering graduates. Lately, graduating engineers who have required capacities then facilitates new understanding and education methodologies. In these methods, faculties have concentrated more in engineering activities rather than scientific knowledge transferring type education. Universities alone or as group have been in this evaluation to coup the requirements. Engineering education has become more project, evidence or problem based knowledge transfer. Recently, engineering students are learning how to use knowledge to solve real-world problem in new computerized methodologies instead of just learning the knowledge without experiencing how to use them. Engineering students' attitudes, critical thinking capacity, creativity, independent decision ability, organising and leader capacities are also most effecting factors in "good engineering". At the beginning, engineering students should be honest, good talented, ingenious and creative. They should also have hunger for new ideas like and artists.

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