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Education of Engineers in the 21st Century:

Paradigms, Insights

and Implication to Israel

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ABSTRACT

The rapid and exponential changes in science, technology, economy and society at the onset of the 21st century require re-evaluation of the role of engineers and their education. The drivers for the revision and upgrading of the engineering education could be a merger of two revolutions: the industry 4.0 and the information revolutions. Critical review of the state for affairs in Israel and abroad was carried out, in addition to surveys of the stake holders, academia, industry and students. On that basis a Forum for Engineering Education for the 21st Century was established, to discuss and resolve paradigm shifts and insight of steps needed in view of these shifts.

The paradigms were classified into four categories, knowledge & skills, the real world and industry, student, and faculty. A road map has been developed to establish a process for the implementation of these paradigms and insights. It involves three components: within the academia itself, academia and industry and discussions at the level of the Israeli Council of Higher Education, to develop national policies to provide guidelines, support and incentives for the process. Implementation steps were presented, ranging from evolutionary ones, which can be implemented within a short time period, to ones which require structural changes on the long run. The evolutionary steps can be harmonized with the long-term structural changes.

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1. Introduction

The rapid and exponential changes in science, technology, economy and society at the onset of the 21st century require re-evaluation of the role of engineers and their education, e.g. [Duderstadt 2008]. Various surveys in Israel [Kandel 2012, Zuk 2014, Bental and Peled 2016] have identified shortage of engineers, but, in-depth analysis of the data suggest that the issue is not just quantities but, to a large extent, the profile and quality. Similar trends were reported in the US, quoting from [Gover and Huray 2007].

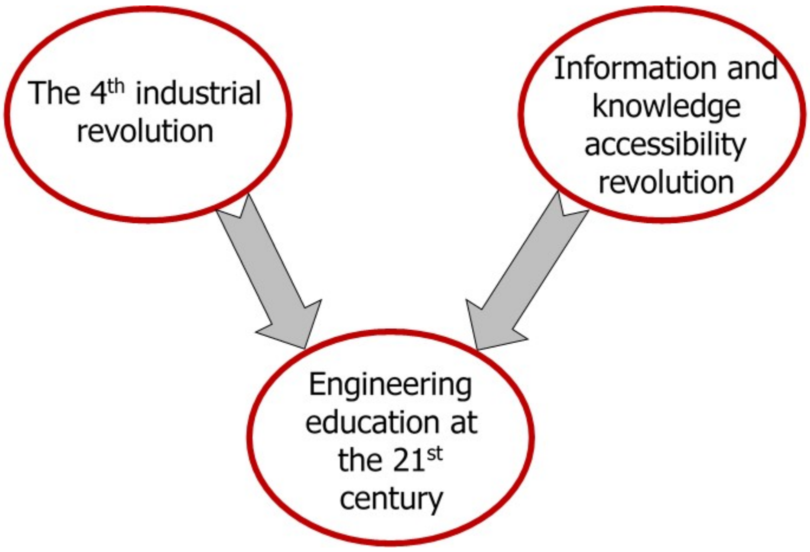
- "Industry executives and university presidents from most prestigious companies and universities in the US have been claiming for several years that there is a shortage of engineers graduating from US universities"
- "What is often meant, but usually unstated, is that the shortage is of highly innovative U.S.-born engineering graduates who are prepared to immediately enter the work force and make innovative contributions to the level U.S. companies need"

The profiles of required engineers can be deduced from the needs of the 4th industrial revolution, and a summary of those can be concluded from the report of the [World Economic Forum 2016]:

- Sophisticated and innovative industry with large requirements for experts and reduced demand for production labors
- Significant increase in the demand for engineers with high skills for development, establishment and running of advanced production systems
- Demand for engineers with interpersonal proactive skills and creativity, alongside technical and scientific abilities, to lead new processes

The drivers for the revision and upgrading of the education of engineers at the 21st century could be a merger of two revolutions: the industrial and information revolutions, as shown schematically in Figure 1.

Figure 1: Drivers for change of engineering education



Source: Samuel Neaman Institute

The need for re-evaluation of engineering education in a country like Israel, where the advanced knowledge industry is central in its economy and society, has driven the Neaman Institute to embark on a project to study the needs and the nature of changes, to lead a national effort to explore the polices required and the mechanisms for their implementation. The present paper describes the process that was carried out, which included critical review of the trends in engineering education and the establishment of a Forum where all the stakeholders are represented, to brainstorm and come up with recommendations for policies and proposals for best practices.

2. Status of engineering education worldwide

Extensive discussions of the future of engineering education are the topic of many reports, and most of them address the issue of the need to develop personal & leadership skills already during the academic study period, in addition to the core science and engineering fundamentals. There are several skills that need to be addressed, but they can be classified under the umbrella of "engineering design thinking" and "entrepreneurial thinking". These have been addressed in several reports and highlights from two of them are quoted below:

Engineering design thinking [Dym et al 2005] - a systematic, intelligent process in which designers:

- generate, evaluate, and specify concepts for devices, systems, or processes
- whose form and function achieve clients' objectives and users' needs
- while satisfying a specified set of constraints

Entrepreneurial thinking [Thorp and Goldstein 2010] – seeing the big picture of ingredients and imagining how the pieces fit together:

- in the world of complex problems, seeing the big picture is required but not enough;
- the entrepreneurial thinker must be also accomplished in one or more disciplines;
- a good team player, or team builder, and highly ethical because of the profound societal issues that are often involved.

Some insights into the current and future trends in engineering education were highlighted recently in a report by [Graham 2018] who carried out a survey to identify the current leaders in engineering education and the emerging ones and to characterize their profile.

The current leading institutes identified include:

Olin college, MIT, Stanford, Aalborg, TU Delft, University College of London-UCL (UK), Purdue University (US), NUS (Singapore), Cambridge (UK), Chalmers (Sweden)

The emerging leading institutes identified include:

Singapore University of Science & Technology-SUTD (Singapore), Olin College (US), University College of London-UCL (UK), Pontificial Catholic University of Chile-PUC (Chile), Iron Range Engineering (US), NUS (Singapore), TU Delft (Netherlands), Charles Stuart University-SCU (Australia), Tsingua University (China), Arizona State (US)

The profile of the current leading institutes:

- Public University of a high international status in international ranking, with a large number of students
- Excellence in teaching shows up in "islands" of one or several departments, many points of light, but without interconnection and with difficulty to disseminate the "light" beyond the "islands"
- Focus on external partnerships in education and best practices in the international community, such as CDIO in MIT and Stanford.

The profile of emerging leading institutes:

- Systematic approach, where two groups can be identified: New institutions such as Olin College and veteran institutions that developed a holistic reform, such as Arizona, PUC, UCL State. A holistic approach of this kind is not characteristics of most of the current leaders
- The development of the institution is affected by local needs and constraints, such as PCU in Chile, CSU in Australia and Arizona State in Arizona
- Educational approach which is different than that of the current leading institutes, in at least three of the following components:
    - Recruiting and screening requirements which are not conventional
    - Integration of work-based learning
    - Incorporation of on-line learning outside of campus and experience-based learning within the campus
    - Development of extra-curricular activities led by students
    - Emphasis on incorporation of engineering design with students' self-reflection

These components lead a way which is different from the current leading universities.

3. Forum for Engineering Education for the 21st Century

Following the analysis of the world-wide trends, a process was initiated by the Neaman Institute for National Policy Studies at the Technion, to assess the implications for Israel in view of its needs for advancing the industry in the 4th Industrial Revolution era and the special nature of its industry and its economic and societal impact.

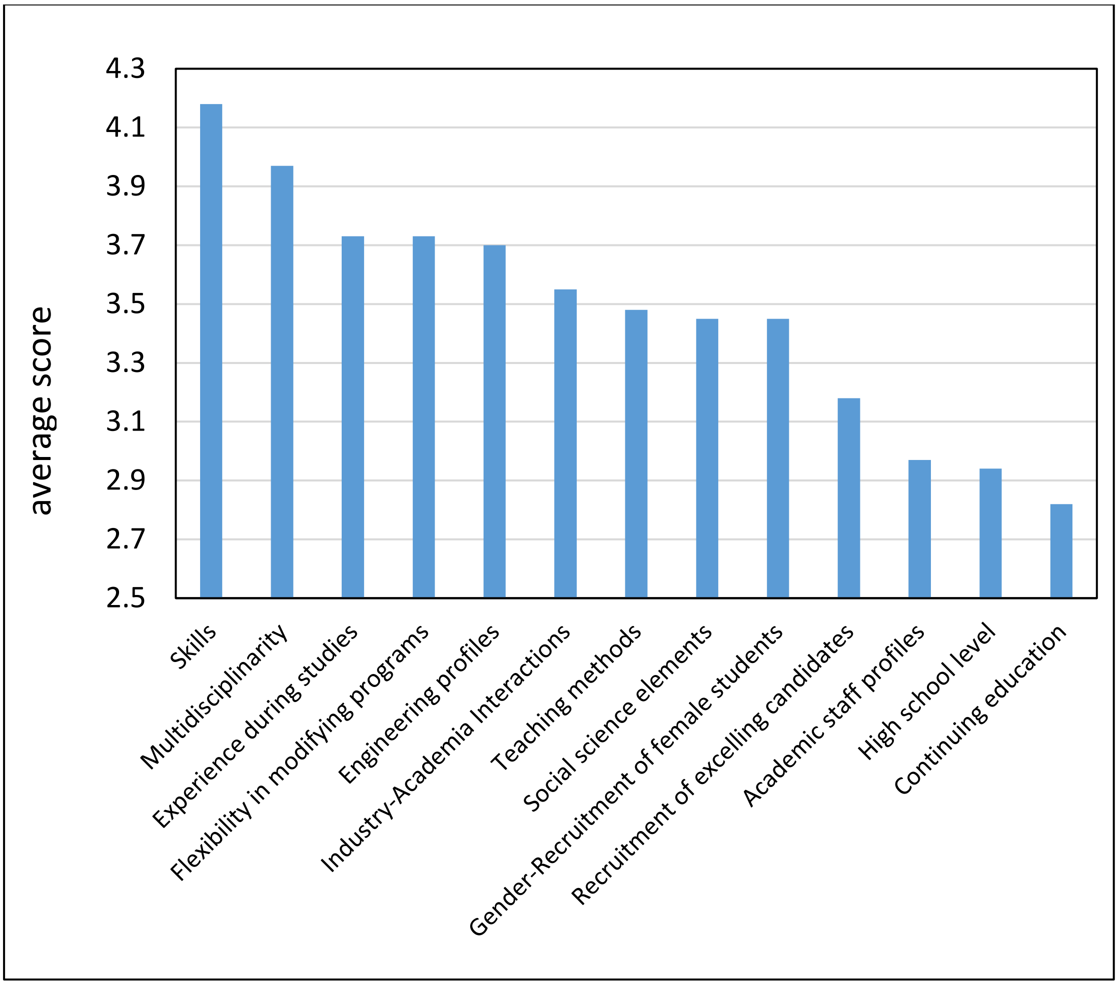
For that purpose, a Forum for Engineering Education for the 21st Century was assembled, which includes representatives from all of the stakeholders: Universities, Colleges, Government Ministries and Agencies, the Council of Higher Education, The Innovation Authority, Industry, young engineering graduates and students. The Forum activities included brainstorming sessions, roundtables meetings, surveys by internet, close and open interviews, involving about 500 people representing all the stakeholders. In addition, it assembled data on students' reflections which were obtained in surveys carried out by the National Union of Israeli Students and the Israeli Central Bureau of Statistics.

The data and insights generated through this process are presented graphically below. It served for the development of guidelines for a comprehensive approach which is presented in the section "Paradigms and Insights".

The "closed" internet survey posed 13 issues which the Forum thought to be of significance in the consideration & promotion of engineering education. The respondents were asked to provide ranking for each, between 1 and 5, with 5 being the highest importance. The average scores for each are presented in Figure 2, at a decreasing order. The six highest on the list are:

- Skills
- Multidisciplinary
- Learning by experience during studies
- Flexibility in modifying programs
- Engineering profiles
- Academia-Industry interaction

Figure 2: Quantitative presentation of the outcome of the closed internet survey, in which the respondents were asked to rank the importance (namely: attitude and significance) of the issues presented (rank between 1 and 5, with 5 representing the highest importance)

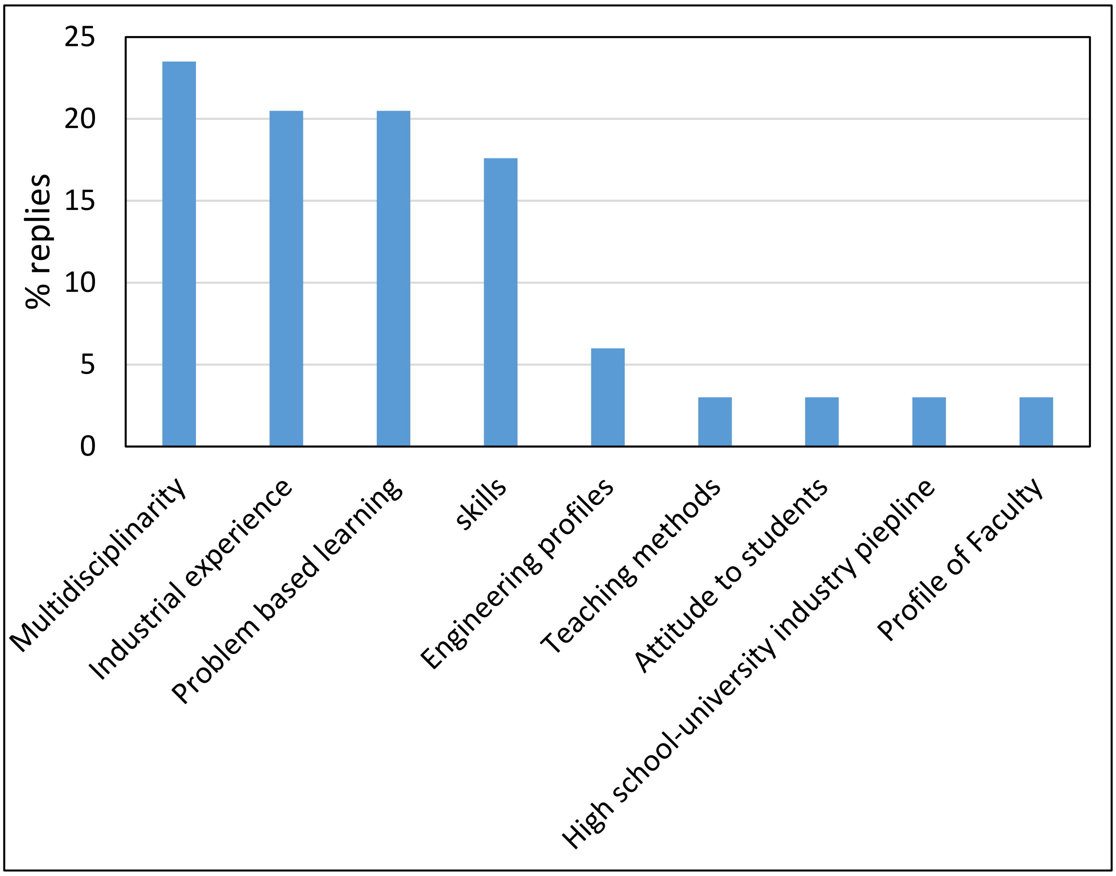


Source: Samuel Neaman Institute

Open internet survey was carried out in cooperation with Afeka College of Engineering. The survey provided "freedom" for the respondents to present the most important issues they think need to be considered in modern engineering education. The results are presented in Figure 3, with the most important ones being:

- Multidisciplinary
- Industrial Experience
- Problem based learning
- Skills

Figure 3: Quantitative presentation of the outcome of the "open" internet survey asking for the most important issues which the respondent believes should be considered in modern engineering education; the data is presented in terms of the % of replies for the various issues



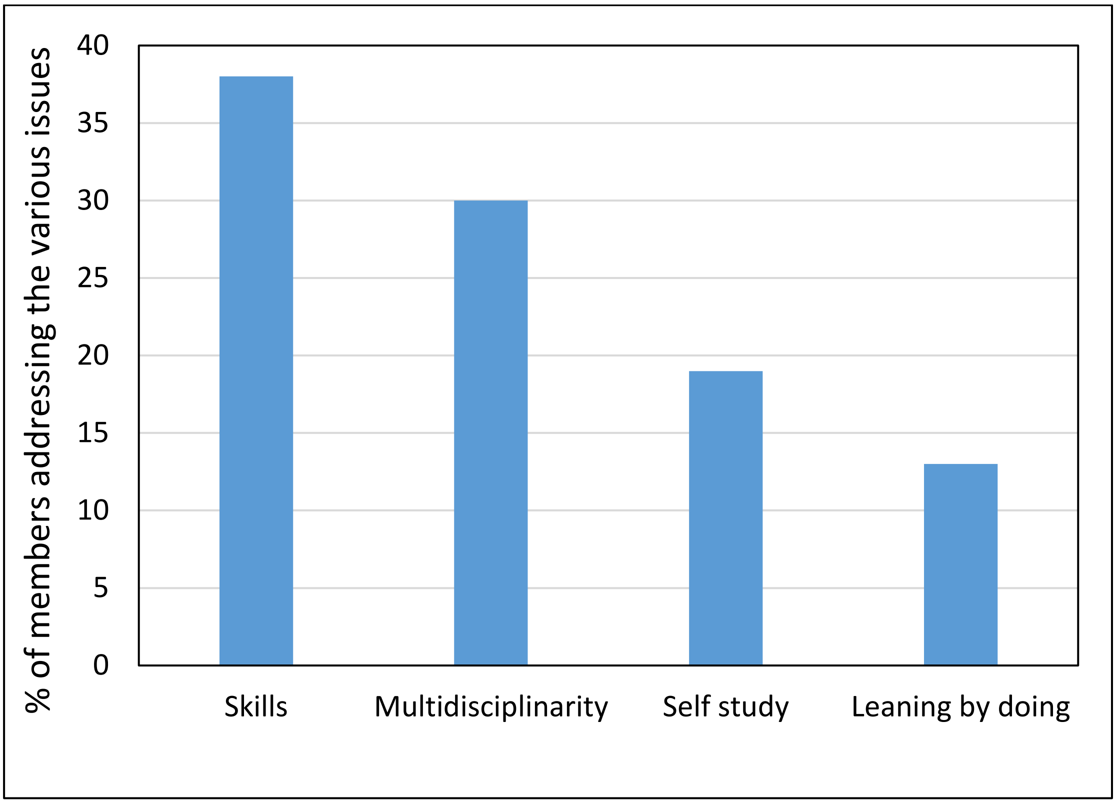
Source: Samuel Neaman Institute

The discussion in the brainstorming sessions during the meetings of the Forum were quantified by the number of members addressing the various issues, and those were presented in relative terms in Figure 4. The most important issues are presented in the Figure, while many others which received only marginal attention are not included.

The major issues are:

- Skills
- Multidisciplinary
- Self-study
- Learning by doing

Figure 4: Quantitative presentation of the issues addressed by the members of the Forum during the brainstorming sessions

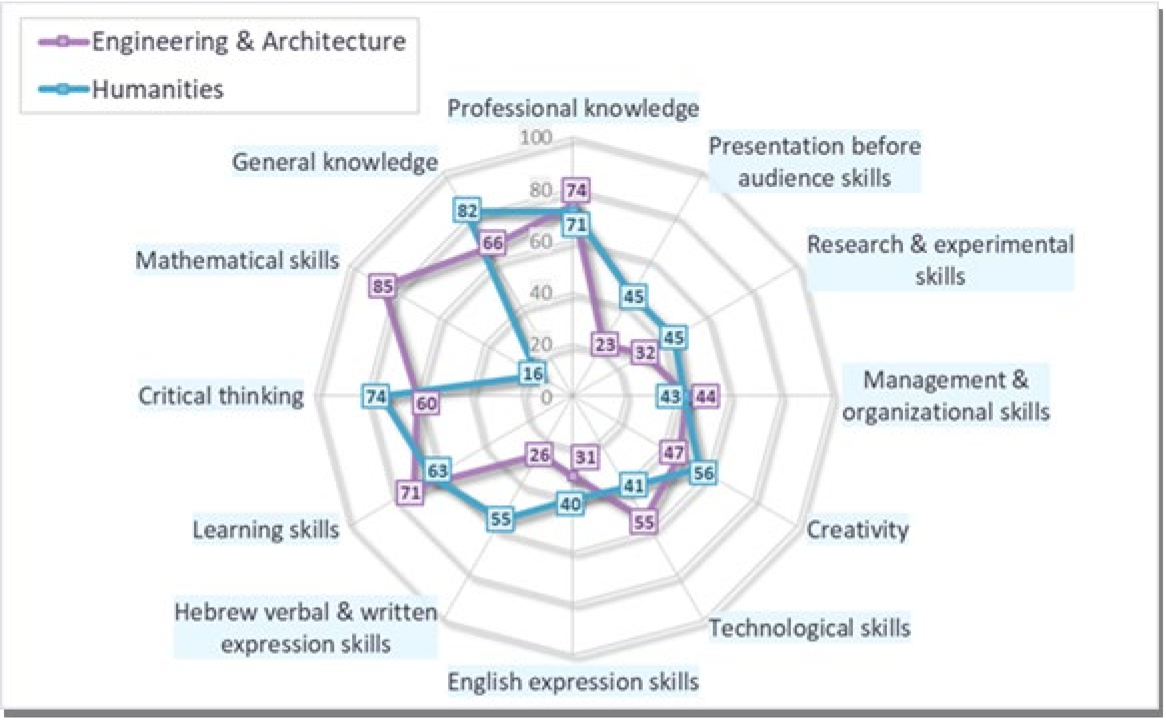


Source: Samuel Neaman Institute

Comparison between the prominent issues highlighted by the different surveys indicates considerable similarity. These reflect to a large extent the views of the academy and industry stake holders. The attitude of students to many of these issues can be resolved through surveys carried out by the Israeli National Union of Israeli Students and the Israel Central Bureau of Statistics with regards to their perception of the knowledge and skills gained during their studies.

The results of a survey carried out by the Israel Central Bureau of Statistics, to resolve the improvement in skills the students believe has occurred during their first year of study, is presented in Figure 5, comparing engineering & architecture programs with liberal arts programs.

Figure 5: Enhancement of skills after the first year of academic studies in Engineering & Architecture and in Liberal Arts, results of student's survey by the Israel Central Bureau of Statistics, 2013/14, Published 2016/17 [Central Bureau of Statistics 2018]

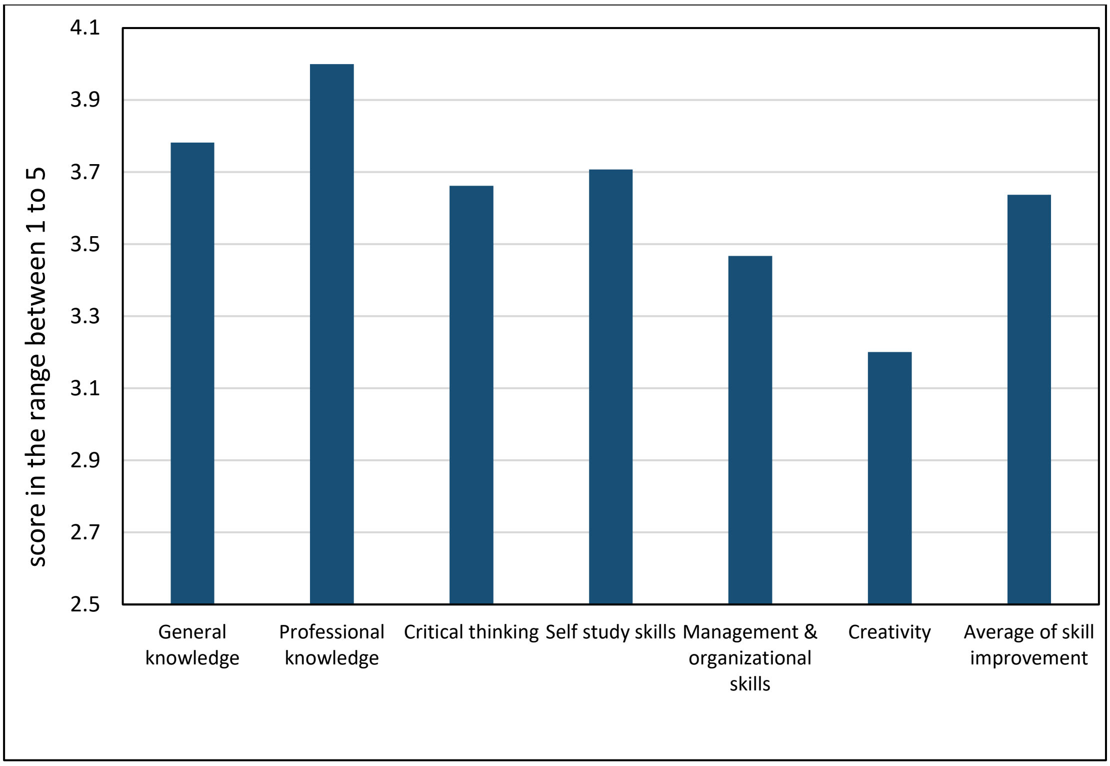


Source: Central Bureau of Statistics

It can be concluded from this data that the engineering and architecture programs are ahead in enhancement of mathematical, technological and self-study skills, but are lagging behind the liberal arts programs in enhancement of general knowledge and variety of essential skills: critical thinking, creativity, research & experimental skills, communication skills (Hebrew and English). These skills are often referred to as "soft skills", yet it is preferable to address them as "essential skills" which are needed to equip the engineer with leadership and influence capabilities.

The results of a survey by the National Union of Israeli Students [National Union of Israeli Students 2017] of the knowledge and essential skills enhanced through the studies of students in universities and engineering colleges are presented in Figure 6.

Figure 6: Results of the survey by the National Union of Israeli Students of universities and engineering colleges regarding the enhancement of skills during academic studies [National Union of Israeli Students 2017]



Source: National Union of Israeli Students 2017 data processed by Samuel Neaman Institute

The data in Figure 6 shows that the highest scores are in professional knowledge, followed by general ones. The lowest is creativity, while management, self-study and critical thinking skills are in between.

The results of the surveys for the knowledge and essential skills can provide indication of the strengths and weaknesses of the education programs in Israel, but the conclusions to be reached depend upon the objectives of the programs, whether knowledge is first and essential skills are behind, or there is a need for some other balance. In the past, it was assumed that essential skills can be gained during practicing years and it is not necessarily an objective of academic education. This issue was highlighted in the discussions of the Forum. Surveys of the kind presented here can be valuable for assessing the current status and can serve also in the future for evaluating the success of implementation of new policies and study programs.

In the discussions of the Forum the issue of balance between educating for knowledge and acquisition of essential skills was central, with the view that greater attention should be given to skills. The brain storming sessions addressed not just the outcomes required but also the educational means that need to be developed and implemented. Skill acquisition requires hands-on activities and mentoring by the faculty in small group sessions and activities.

The current mode of operation of engineering departments is, in many respects, engineering & science oriented, and the structure of programs and profile of the faculty are not favorable for essential skills acquisition. If greater attention to essential skills acquisition is to be - encouraged, there are several challenges which need to be considered:

- Acquisition of skills which will not be at the expense of core engineering science education
- Requirement for working in small groups in institutions where the ratio of students to faculty is high and unlikely to change drastically in the foreseeable future
- Profile of faculty which is scientifically oriented and adequate for engineering & science education but not adjusted to acquisition of essential skills for leadership and influence

A feasible and favorable mode of action to overcome this conflict can be based on more intimate cooperation with industry, which can be developed into a variety of practical mechanisms, provided that cultural adjustments are made in the academy and the industry:

- Understanding in the industry that it has responsibility and commitment to be a partner in the education process, based upon moral recognition and the added value for industry
- Recognition in the academia that cooperation with the industry is essential for development of students' skills and the role of industry is more than just supplying experts as adjunct teachers

In order to assess the validity of this approach, interviews were carried out with leaders of the Israeli industry. They posed criticism on lack of leadership and soft skills education but were very open to develop with the academia mechanisms for cooperation in which they will take upon themselves commitments and responsibility.

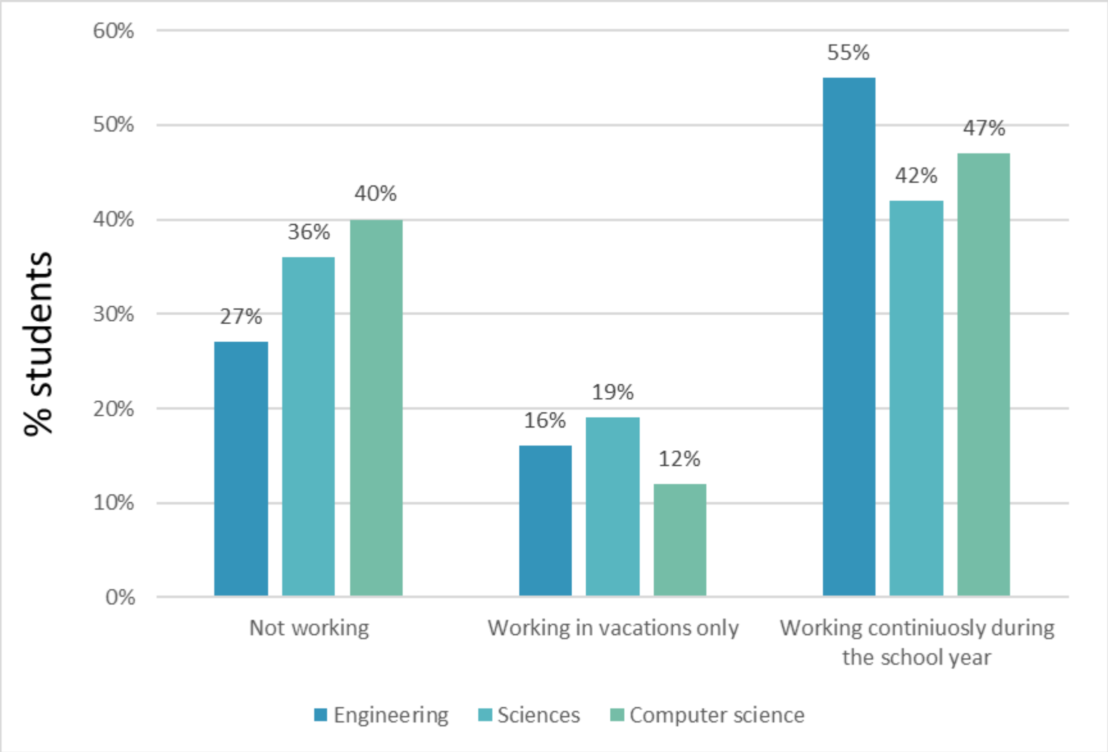
The respondents supported the need for multidisciplinary education that broadens the engineers' technological skills. They were, mostly, open to discuss the industry involvement in hands-on training of the students, primarily in projects that may be performed in the industry as well as internships.

Some expressed concern that the Academia presents conservatism and self-confidence, leading to lack of openness or willingness to adjust the education process to the needs expressed by the industry.

There was a desire to extend the model of 'students work in the industry in parallel to studies', which is common in undergraduate studies, as outlined below, also to graduate studies.

Students' employment in the industry during undergraduate studies is very typical to Israeli students: many of them seek partially paid jobs during their senior years or even before. This is motivated by personal aspiration to acquire some experience before graduation which will make them more employable, as well as the need for additional income, since they are typically older than students in other countries and some have already family to support. Survey by the National Union of Israeli Students presented in Figure 7 indicated that about 70% of engineering and science students work during their academic study years. The survey resolved that more than 50% of those who work are employed by industry in their profession.

Figure 7: Employment of engineering and science students during their academic study years, results of a survey [National Union of Israeli Students 2017]



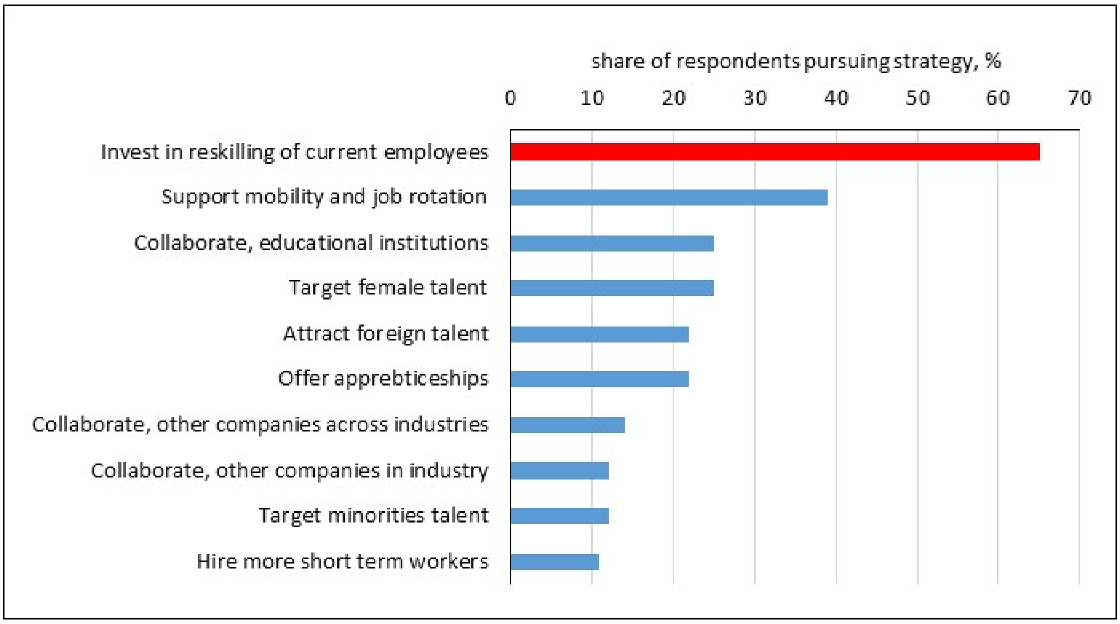
Source: National Union of Israeli Students 2017 data processed by Samuel Neaman Institute

The fact that over a 1/3 of the students are working professionally during their study years suggests that this situation could be a basis for cooperation between academia and industry to structure the work periods of the students in a way that will enhance their essential & professional skills, by a mechanism of internship.

An additional issue which was brought up during the discussions of the Forum is the need of the academic institution to be involved in life-long learning. This is an emerging field of activity, of high added value and benefits, which the academia needs to consider to become part of its educational commitments. In the new era of the Fourth Industrial Revolution the required knowledge base is changing exponentially.

Here too, there is room for cooperation between academia and industry in view of the significance of life-long learning perceived by industry, requiring its action and commitments as seen, for example, from the results of a survey reported by the World Economic Forum, presented in Figure 8.

Figure 8: Industry view of major challenges to the development of human resources, result of a survey reported by [World Economic Forum 2016]



Source: World Economic Forum 2016

4. Paradigm shifts and insights

The discussions in the Forum resulted in insights of changes and developments in engineering education which need to be addressed. These were formulated into two levels of recommendations, a more general one, of paradigms which need to be changed or incorporated in engineering education, and a more specific one, of insights of the nature of steps that can be taken to implement the paradigm shifts.

The paradigms are classified into four categories, knowledge & skills, the real world and industry, student, and faculty. They are concisely presented in section 4.1, and in greater detail with the insights of each in section 4.2. The report of the Neaman Institute [Bentur et al 2019] outlining these paradigms and insights includes also appendices of description of courses and activities based on experiences as well as new proposals by members of the Forum. They are intended to be further developed into a database of "good practices" which could serve institutions which consider to take steps to modify engineering education.

1.1 Paradigm Shifts

1.1.1 Knowledge and Skills

1. Moving away from the notion of knowledge being the main value to be acquired in academic studies
2. Moving away from the notion that a professional must be of narrow specialization
3. In addition to core science and engineering there is a need to educate for leadership and impact skills (essential skills/soft skills)

1.1.2 The Real World and Industry

4. Acquire toolbox to operate in the "real world" with the understanding that there is not always only one solution to a problem or challenge
5. Education of engineers should not take place only in the academia classrooms and there is a need for cooperation with the industry for innovative models
6. Development of self-study skills for life-long learning with mechanisms of cooperation between academia and industry

1.1.3 Students

7. Creation of learning experience which will develop students' excitement & motivation for engineering as a leading profession

8. Evaluation based on the quality of students output and its presentation in front of the lecturers and students
9. Screening of candidates based on evaluation of their potential skills and not just their scholarly achievements in high school

1.1.4 Faculty

10. The role of academic faculty should be transformed from a mindset of "lecturer" to "mentor/coordinator of course content"
11. Investment in faculty development and upgrading as well as their evaluation
12. Incorporation of appointments from industry in a range of mechanisms, including professor of practice

1.2 Insights

1.2.1 Knowledge and Skills

Paradigm 1*: Breaking the paradigm of knowledge being the main value to be acquired in academic studies*

Insights:

- The significance of information and knowledge is dropping down (can be acquired independently and is accessible by various electronic means in the modern era), while the significance of interpersonal skills is becoming more important (see also paradigms 3 and 9)
- The role of the lecturer is becoming more of a mentor (see paradigm 10) and he/she must move away from the goal of "must cover topics and study matters"
- Move away from "cover topics" and start educating how it can be found
- Presentation of topics in class by students with the guidance of the faculty can serve for making this change

Paradigm 2: *Moving away from the notion that a professional must be of narrow specialization*

Insights:

- Modern engineer is required to have systems understanding, multidisciplinary and ability to act and understand adjacent areas; all these are required for establishing an engineer with effectiveness and professionalism for advancing new products and innovation
- Moving away from focus on a narrow area by forming connections & interrelationships

- Study in small multidisciplinary groups for executing complex and common missions is an example
- Initiating this mode of study already during the first academic year

Paradigm 3: *In addition to core science and engineering there is a need to educate for leadership and impact skills (essential skills/soft skills)*

Insights:

- Essential skills: entrepreneurship, innovation, creativity, independent and critical thinking, self-study, leadership, communication, teamwork, multiculturalism and internationalism
- Exposure to entrepreneurship and innovation is of significance for enhancing creativity and effectiveness; it is important to expose the students to the real world outside the classroom

1.2.2 The Real World and Industry

Paradigm 4: *Acquire toolbox to operate in the "real world" and insight that there is not always only one solution to a problem or challenge*

Insights:

- Acquiring tools which take into consideration issues and challengers which are not technological, such as economic, social and environmental
- Education based on problem-based learning

Paradigm 5: *Education of engineers should not take place only in the academia classroom and there is a need for cooperation with the industry for innovative models*

Insights:

- Holistic study program, with contribution of organizations and engineers acting as mentors throughout the professional life
- Incorporation of experts from industry in various mechanisms already during the academic study period: cooperation with industrial companies that employ engineers, to assure the relevance of the study programs for the development of essential skills required for the professional career, as well as enlisting the experts from the industry for project guidance and mentoring of students
- Intensify project-based learning
- Develop mechanisms for internships in industry, as part of study requirements

Paradigm 6: *Development of self-study skills for life-long learning with mechanisms of cooperation between academia and industry*

Insights:

- Development of self-study skills as a basis for enhancing the ability for life-long learning
- Cooperation with industry for life-long learning in structured programs

1.2.3 Students

Paradigm 7: *Creation of learning experience which will develop student's excitement & motivation for engineering as a leading profession*

Insights:

- Break away from the paradigm that students are not capable to deal with projects during their first year of study – incorporate projects already during the first year, not just as a component of knowledge gain, but also as a component that enhances excitement, experience & motivation
- Study process in which the students are part of the process, learning from themselves and teaching their peers; providing feedback to their peers and together with the faculty inspire knowledge creation
- Presentation of the topics in the class by the students, under the supervision of the faculty, can create the change
- Reduce requirements for memorizing the information/knowledge for tests, especially in topics which are less common in the industry; instead, focus on problem solving using engineering methods, with problems characteristic of the real challenges of engineers in the industry
- In the process of development of problem-solving skills, enhance the ability to pose questions, and additional questions which arise due to answers obtained, rather than asking for answers to standard questions in tests

Paradigm 8: *Evaluation based on the quality of students' output and its presentation in front of the lecturers and students*

Insights:

- Break away from evaluation based, largely, on tests and resort to incorporation of qualitative evaluations
- The student, during his/her study years, following the model in paradigm 10, should be able to develop products and present them in various ways
- There should be personal and group tasks which will serve for evaluation in a course
- Course coordinators could require, depending on the nature of the course, flexibility for implementation of an optimal mode for evaluation
- There is room to consider that part of the evaluation will be provided by the students themselves

Paradigm 9: *Screening of candidates based on evaluation of their potential for skills and not just on their scholarly achievements in high school*

Insights:

- The basic assumption is that for the "production" of engineers with special profile there is a need to focus on all components of the "production pipe-line": screening, education, specialization and supervision

- The link between the stages is not additive, but interactive, and there is room for screening which will take into consideration the personality in addition to scholastic profile

1.2.4 Faculty

Paradigm 10: *The role of academic faculty should be transformed from a mindset of "lecturer" to that of "mentor/coordinator of course content"*

Insights:

- The role of the lecturer as a leader and guide for group learning
- Reduce frontal teaching in favor of other mechanisms, such as flip class, project and research-based learning, problem-based learning
- Use teaching through electronic media, such as MOOCs

Paradigm 11: *Investment in faculty development and upgrading as well as in their evaluation*

Insights:

- Since the content can be found in the media or in books the function of the lecturer should be changed
- Faculty who will move from their zone of comfort could become agents for change for the system of engineering education
- The function of "lecturer" should change to become "coordinator of course content" (see paradigm 5), to coordinate the activities of instructors who support group studies as well as set the course outline and the tasks in the various projects of the groups

Paradigm 12: *Incorporation of appointments from industry in a range of mechanisms, including professor of practice*

Insights:

- Effort to incorporate leading experts from industry, partial or full time, to take part, not only in guidance and mentoring, but also in setting education path
- Appointments of Professors of Practice to lead steps for education involving the industry, whose number will amount to 10%-20% of the faculty

5. Road Map

A road map has been developed to establish a process for the implementation of the paradigms and insights. It involves three components: within the academia itself, academia and industry and discussions at the level of the Israeli Council of Higher Education, to develop national policies to provide guidelines, support and incentives for the process.

1.3 Academia

The paradigms and insights, including the best practices can serve already at this stage institutions which are willing to take actions. Those could be actions at the particular levels of individual paradigms, to establish pilot actions, which upon success could be disseminated, thereby moving along an evolutionary process.

An alternative to consider is a more drastic approach, of revolutionary process or "radical evolution", which is comprehensive in nature and will involve significant structural changes at the institution level. An approach along that line has been discussed in the Forum and a task group of Engineering Deans was established to look into various models. One option which has been brought up for discussion is to reform the current 4 years engineering program into a combined Bachelor + Mater program, as is common in some European countries, which moved into a 3 years Bachelor + 2 years Master program. A model for the body of knowledge to be developed in such a combined program is presented in terms of a matrix of outcome of skills and level of achievements, Figure 9, based on concepts in [ASCE 2007], which could serve as a template for such steps.

The scheme in Figure 9 includes two options, one leading to technological expertise and the other is geared towards research career, and the split into each of these two takes place at the Master level.

The challenge at the institution level would be not just resolving the goals and means of the change but also systematic planning of the process of change. Comprehensive discussion of such a process, based on experience in academic institutions, was presented by [Graham 2012], identifying the major stages that should be planned and carried out, including preparation, planning, implementation and preservation.

Figure 9: Body of knowledge in engineering education, after [Bentur et al 2018] following concepts of [ASCE 2007]

		Know-ledge	Compre-hension	Application	Analysis	Synthesis	Evaluation	Creativity & critical thinkng
Foundational	Mathematics	B	B	B				
	Natural sciences	B	B	B				
	Humanities	B	B	B				
	Social sciences	B	B	B				
Technical	Materials Science	B	B	B				
	Mechanics	B	B	B	B			
	Experiments	B	B	B	B	M		
	Problem recognition and solving	B	B	B	M			
	Design	B	B	B	B	B	E	
	Sustainability	B	B	B	E			
	Contemp. Issues & his. perspective	B	B	B	E			
	Risk & uncertainty	B	B	B	E			
	Project management	B	B	B	E			
	Breadth in engineering discipline	B	B	B	B			
Specialization	Techno-logical	B	M	M	M	M	E	
	Engineering research	B	M	M	M	M	E	M
	Research	B	D	D	D	D	D	D
Professional	Comm-unication	B	B	B	E			
	Public policy	B	B	E				
	Business & public admi-nistration	B	B	E				
	Globalization	B	B	B	E			
	Leadreship	B	B	B	E			
	Teamwork	B	B	B	E			
	Attitudes	B	B	E				
	Life long Learning	B	B	B	E	E		
	Professional and ethical responsibility	B	B	B	B	E	E	

B	Portion of the BOK fulfilled in the Batchlor degree
M	Portion of the BOK fulfilled in the Master degree or equivalent
D	Portion of the BOK fulfilled in the Doctoral degree
E	Portion of the BOK fulfilled in the pre-licensure experience

Source: Body of knowledge in engineering education [Bentur et al 2018]

1.4 Industry

A special brain-storming session of the Forum took place with industry experts and leaders to develop the mutual understanding of the needs and values of cooperation and set steps for establishing best practices for the cooperation.

1.5 Council of Higher Education

The outcomes of the discussions with the industry and the conclusions of the Forum meetings, with regards to changes in engineering education, served as a basis for a brainstorm meeting session with the leaders of the Israeli Council of Higher Education and the Planning and Budgeting Committee of the Council. Mutual understanding on the steps that need and can be taken were resolved, either in the “evolutionary” mode or "radical evolution" mode. The Council leaders expressed the understanding of the need to support such steps with a spirit of flexibility, to provide each institute to develop along its vision. The Council input would be required for accreditation of changes as well as budget, moral and material support.

1.6 The Next Steps

The evolutionary steps will be of the kind that can be taken within a relatively short time and be incorporated later on with the more far reaching structural changes that will be implemented over medium or long-term time periods.

The evolutionary steps will be based on pilot activities that will be encouraged by the institutions’ managements and the Council of Higher Education/Planning and Budgeting Committee. The Forum of Engineering Education will continue its activities within the Neaman Institute to follow-up on these pilots, to serve as a forum whereby exchange of information and insights will take place, to discuss and resolve best practices. The Neaman Institute will set a Data Center where the insights obtained from the pilot activities and their discussions in the Forum will be made available to all the academia. Priority will be given to pilot activities in the following areas:

- Modules for education towards the challenges of industry 4.0
- Modules for acquiring essential skills
- Models for experiential learning and internships
- Models for cooperation with industry in engineering education
- Life-long learning

Long term steps involving structural changes are suggested to be the topic for a joint committee of the Council of Higher Education and the Forum, looking into the contents, structure and flexibility to provide individual institutes to develop within their own vision. The committee will take into consideration the developments in engineering sciences as well as the need of the industry and look into the structure of the Bachelor degree and models of its harmonization with the Master degree, as becoming common in the European higher education system. It will suggest action items to be considered on a national level as well as institution level.

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