

From Early Learning to Workforce

The STEM pipeline in Israel

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General Overview and Rationale

According to the World Economic Forum, the world is living its Fourth industrial revolution, which is the combination of cyber-physical systems, Big Data, the Internet of Things, and the Internet of Systems. Alongside great benefits, concerns emerge such as the fact that many jobs and disciplines will disappear and automation, computers and machines will replace workers across many industries, and the gaps between the skills learned and the skills needed is growing. Excellence and literacy in STEM (Science, Technology, Engineering and Math) are considered essential tools for students to measure up to the challenges of the 21st century.

This exponential change will require skills that weren't given enough weight, if any, in teaching programs at all levels, whether at school, university or work: excellence, innovation, creativity, entrepreneurship, world experience, critical thinking, etc. In recent years key stakeholders and experts in Israel have been warning about growing shortages:

- In skilled students in the education system, as well as in the higher education system that develops STEM tracks;
- In a skilled workforce capable of fulfilling technology-based positions in the military and in industry in the next 10 years; and
- The limited scientific literacy among the general public.

STEM education has thus recently become the focus of an intensive public discussion and debate that can be gauged from increasing government attention and cross-sector initiatives.

An inter-ministerial committee headed by Israel National Economic Council outlined unequivocally the direct link between science and technology literacy at a young age, quality of high school diplomas, the number of students studying relevant fields in higher education, and the flow of a skilled workforce in knowledge-intensive industries, as well as minimizing the socio-economic gaps.

Outstanding university graduates with degrees in computer science and technology, with work experience, are clearly in great demand. In parallel, the private sector, the Association of Manufacturers, the IDF and other stakeholders point to a similar gap that exists in the practice-tech industry, from the training of technicians and practical engineers to their employment: the demand for skilled technicians and practical engineers. In the past 20 years the technological education system was significantly cut back and stigmatized, and none withstanding some exceptional schools, made technological education a last-choice for students.

The gaps between the edge that Israel has had and its ability to meet current needs has to be bridged. Accordingly, the pipeline from kindergarten to career is surveyed in the context of the drivers of STEM education, considering students and teachers, and then employers.

Aims of Report

This report aims to provide an overview of the current status of the STEM eco-system and pipeline in Israel by mapping the main stakeholders and activities, as well each phase of the continuum:

- Kindergarten and elementary school
- Junior high- and high school
- Postsecondary training
- Army
- Higher education
- Workforce and employment

It seeks to examine the warnings of a diminishing scientific and technological reserve force in Israel, claims about the lack of skilled workforce and the generally inferior level of STEM literacy in Israeli society. Moreover, this overview is intended to provide insights into trends and challenges and identify the gaps and opportunities for change.

The Main Players on the STEM Continuum



**The report was written before the responsibility for technological education was transferred from the Ministry of Economy and Industry to the Ministry of Social Affairs and Social Service*

Insights, Gaps and Opportunities Along the STEM Pipeline

Kindergarten and Elementary Education

Current gaps: In the formal sphere, the goal of the Ministry of Education is to develop scientific and technological literacy among children, mainly through curricula, to encourage a positive attitude to the field, and to emphasize practical experience. The Ministry of Education has changed curricula in a manner reflecting their recognition of the need to start STEM education at an early age.

In the informal educational sphere, there are diverse activities in cooperation with the technological educational networks, NGOs, science museums, the Youth Science Units in the universities and academic colleges, such as science competitions and Olympics. However, by in large, informal educational organizations, industry and philanthropists, have yet to become engaged in this arena. Most of the attention remains focused on junior high school, and even more on high school, where results are already evident.

Opportunity for change: The relevant entities, from all sectors, should be made aware of the real need and potential that can begin to be tapped from kindergarten as a catalyst for long term improvement in the results at the end of the pipeline.

Secondary School

Current gaps: Over the past decade, there has been a decline in the number of secondary school students achieving the highest levels of matriculation in mathematics, physics and chemistry, which are the base of all technological and technical studies. There has also been a decline in the number of students studying in the technological tracks and schools. Accordingly, the Ministry of Education's current focus is on increasing the number of students taking high-quality matriculation examinations in these subjects, with emphasis on math. The point of departure of the Ministry of Education is that excellence is influenced mainly by motivation, perseverance, and hard work.

There is also a highly-developed informal ecosystem involving philanthropy, NGOs, and organizations that cooperate in order improve science and technology literacy and excellence.

Opportunity for change: Despite some national-level efforts, technological education at that stage hasn't received a parallel focus or budget. And while it depends on training and on close cooperation with the world of employment and with academia, in practice, only a low proportion of students receive industry training.

Quality Skilled STEM Teacher Shortage

Current gaps: Quality teachers are a critical driver for change throughout the STEM pipeline. Currently, the educational system faces a significant shortage of quality STEM teachers at junior high and high school levels. The shortage in quality skilled teachers is the most strategic issue across the pipeline, and one of the main avenues for change and action, since teachers have

a tremendous influence over their students' educational and professional choices. Efforts are being pursued on a national level to train quality teachers and provide incentives for career changes for industry personnel. This needs to be addressed through quality training preservice for teachers, through the teachers' training colleges, and not just in service training, after being enrolled as a teacher. New training methodologies and content need to be introduced, as well as tighten the entrance criteria for STEM teachers.

Opportunity for change: Investment in all other teachers in STEM and STEM-related fields along the pipeline from junior high school to higher education is limited. The problem becomes exacerbated in technological tracks and colleges where there is sometimes a tradeoff between pedagogy and experience, as a result of which the graduates of these programs are shortchanged and less prepared than they could be for entering the labor force in STEM fields.

Post-secondary Education

Current gaps: At the post-secondary stage in the STEM pipeline, programs have been developed to allow students to continue their studies for technician and practical engineer diplomas in 13th and 14th grades. However, it is the Army who decides on the quotas for the number of students who continue to 13th and 14th grades, which are 20% of technical and practical engineering students. This track is under the supervision of the Ministry of Education and has its own qualification and accreditation system, independently of the Ministry of Economy and Industry system's (in charge of adult technician and practical engineers tracks), creating de facto two, unequal tracks. Finally, technicians and practical engineers need a strong hands-on experience, and in general, the students should be much more involved in projects, training, and internships in the industry and the army.

IDF

Current gaps: The IDF estimates its shortages in technologically skilled incoming soldiers in the thousands. The IDF (and employers) find the graduates lacking the ability to meet their needs. Accordingly, the IDF provides training for high-end, as well as practical -tech and low-tech skills needed in the course of the compulsory military service of high school graduates.

Within the STEM pipeline, the IDF has been identified as a crucial linking factor between the education system's graduates, higher education, and the labor market. The army plays a key and double-edged role in science, engineering, and technology education. On the one hand, it is a consumer of graduates of these tracks; on the other, it also trains them during the course of their service.

Opportunity for change: Despite its importance, currently, the IDF is almost considered as an obstacle on the STEM continuum. However, the IDF should be thought of as leverage, a bridge for career development, which can open the door to more in-depth and scalable cooperation with the Ministry of Education and the industry, to tackle issues of accreditation and qualifications.

Higher Education

Current gaps: The past decade has seen an increase in the number of graduates in fields that do not reflect the market needs. Clearly higher education has been unable to respond to the demands of the industry.

In order to address the need to train students in the STEM professions, particularly computer science and engineering, the Ministry of Finance and the Budget and Programs Committee amended the budget and created incentive packages for universities that manage to increase the number of students. Universities have also developed virtual courses and learning platforms.

However, some substantial gaps remain: The university's acceptance criteria in science and technology should reflect the importance of skills and knowledge, and include such criteria as project work, critical thinking, innovation and creative thinking etc.

The universities entrance bonuses do not reflect the necessity to encourage STEM studies. They give a 35% bonus for students with 5 points matriculation in mathematics, 25% for students with 5 points matriculation in sciences and only 20% for other 5 points, articulation for all other disciplines including technology and engineering studies. This difference gives those studying math and sciences a real advantage compared to those studying technology. Hence, students have less incentives to study technology. Changing the bonus difference sends a clear message that technology is as important as science in STEM education.

In some of the OECD countries, Israel included, it has been reported that there is a mismatch between the graduates of the academia and the requested work force in the labor market.

Opportunity for change: More effort and investments are required to integrate industrial practice in the engineering curricula. In addition, Practical engineers who would like to peruse their engineering studies in Israeli universities should be accredited with more academia credits, which will enable them to complete an engineering degree 2-2 1/2 years as it is in American or European universities.

Technological Secondary and Post-secondary Education

Current gaps: A number of issues interfere with gaining the most effective results from the technological education pipeline:

The duplication between the Ministries of Education and Economy and Industry, has created a political decision-making rather than a collaborative environment in terms of knowledge, skills and attitudes.

The degree of government funding is lower for teachers in the technological tracks than in academia. The budget for technological colleges is a 1/3 of the academic college's budget, per student per year. This is also the case for teachers, labs, etc.

The technological education has a bad reputation and a positioning problem. In the current state of affairs, the biases, stereotypes, and negative attitudes towards the technological tracks will continue, unless the public sees and believes the field is taken seriously.

Insufficient commitment and involvement on the part of the private sector with respect to different methods of training - employment, mentorship, apprenticeship, etc., from the early stages of technological education – leaves unaddressed needs

Opportunity for change: High profile campaigns similar to the Math efforts, defined as high priority and backed by dedicated additional budgets, should be a possible model to duplicate. Encouraging a growing role for the private sector in STEM education should prove beneficial for students, teachers and employers.

Employment and Workforce Development

Current gaps: Whereas every year, an additional 7,000 new jobs are added to the hi-tech sector, the number of high school graduates with satisfactory math skills is 6,600 students a year, and the number of graduates in computer disciplines from universities and colleges is only 4,500 a year. The indicators of the shortage are the numerous available positions with high salaries, the insufficient high school graduate flow and industry reports of difficulties in recruiting personnel.

In parallel, the hi-tech and practic-tech industries lack thousands of technicians and practical engineers. The Ministry of Economy and Industry is very much aware that employers need to be more engaged and the Israeli background report itself assesses employer's involvement in funding, curriculum development and work-based learning as weak.

Opportunity for change: Compared to developed countries, graduates of non-academic postsecondary studies in Israel do not receive the tools needed for integrating in quality positions in the job market. Additionally, the higher education system does not manage to fully address the needs of the economy, articulated in a shortage of engineers in the hi-tech industry.

Finally, jobs of the future will add additional stress on the system, because they will require new knowledge and skills if industries want to lead economic and technologic developments. Israel has to choose the market structure and labor relations that are conducive to addressing 21st century challenges.

Untapped Populations - Providing Solutions for Women, Arab, Haredi, and the Periphery

Current gaps: Sectorial deficits are very often due to a combination of education, culture, opportunities, and budget allocation. In order to increase the quantity and quality of STEM students and workers, national efforts are being made to tap into the potential population that lag behind in general, and in STEM education in particular: Women, periphery, Arabs, and Ultra-Orthodox Jews.

Opportunity for change: Although targeted programs exist on the national and local levels, the gaps between sectors and geographical lines are still so distinct and will not disappear without external intervention, that the need to further address these gaps and be proactive through affirmative action programs is an imperative. Additionally, there are not enough efforts of coordination and synchronization between the Ministry of Education, the local municipalities and academia to increase the participation of these populations and address motivation and incentives for education and technological training.

Continuum, Synchronization and Coordination

Current gaps: The continuum along and across the STEM pipeline is fragmented and lacks continuity. Along the pipeline, the different stakeholders in each phase are not accountable and responsible to each other, as they work towards achieving their own goals, with no general overview of the entire pipeline. For example, junior high school and high school have been identified as a critical intervention point on the STEM pipeline, however, all stakeholders need to strengthen the connections between each of the continuum phases beginning with kindergarten through high school and into post-secondary.

Equally important will be the need to look and assess future needs – IDF, higher education, employment – in terms of content and skills, in order to create a second strong continuum from high school to employment through IDF and higher education.

Opportunity for change: Across the pipeline, there is a lack of synchronization and cooperation between the formal and informal education. STEM excellence and literacy, require the mobilization of concurrent circles: school, family and community. Hence, the necessity to strengthen the coordination and common activities between the education system and the diverse education NGOs, science museums, educational networks, universities, research centers that operate complementary, and sometime parallel, programs.

Final Remarks

The goal of mapping the STEM pipeline was first to highlight the current state of STEM education from kindergarten to employment in Israel. Although there is at almost any given crossroad a real understanding and action on the national level of the need to improve scientific and technological literacy and excellence, gaps remain. Implications of the mapping then provide a frame of reference within which plans of action for the future can be considered:

Despite the gaps, we are witnessing some positive trends in STEM education which are indicative of a real momentum for change. This is evident in the increasing number of students taking the 5-unit math and quality matriculation, as a direct result of the collaboration between a national cross-sector coalition (5*2) and the national plan implemented by the Ministry of Education, among other recent policy changes.

The STEM issues can only be tackled by moving from an ego-system approach, in which each stakeholder looks at the pipeline from his perspective and agenda, to an eco-system that includes all STEM stakeholders along and across the pipeline, so as to create a real, comprehensive continuum, where the strategy takes into account each phase. A concerted effort, will attract more quality women and men along the STEM pipeline to ensure sustainable change for Israel's future.

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