Committee for the Evaluation of Electrical and Communication System Engineering Study Programs

General Report

November 2016

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Chapter 1: Background

The Council for Higher Education (CHE) decided to evaluate study programs in the field of Education and Science Education during the academic year of 2015-2016.

Following the decision of the CHE, the Minister of Education, who serves ex officio as Chairperson of the CHE, appointed a Committee consisting of:

- ***Prof. Alan Oppenheim***- Department of Electrical Engineering and Computer Science – MIT, USA. Committee Chair.
- ***Prof. Susan Conry*** –Wallace H. Coulter School of Engineering Electrical & Computer Engineering - Clarkson University, USA
- ***Prof. Roch Guerin***- Department Chair and Professor of Computer Science & engineering Department- Washington University in St. Louis, USA
- ***Prof. Ehud Heyman***- School of Electrical Engineering - Department of Physical Electronics- Tel Aviv University, Israel
- ***Prof. Eby G. Friedman***-Electrical and Computer Engineering, Department of Electrical and Computer Engineering- University of Rochester, USA
- ***Prof. Mathukumalli Vidyasagar*** - Chair in Systems Biology Science Erik Jonsson School of Engineering & Computer Science - The University of Texas at Dallas, USA
- ***Dr. Orly Yadid-Pecht***- iCORE/ AITF Chair of Integrated Sensors Intelligent Systems, Department of Electrical and Computer Engineering-University of Calgary, Canada.
- ***Prof. Dr.-Ing. Walter Kellermann-*** Chair of Multimedia Communications and Signal Processing- University Erlangen-Nuremberg, Germany.

Ms. Daniella Sandler and Ms. Inbal Haskell-Gordon served as the Coordinators of the Committee on behalf of the CHE.

Within the framework of its activity, the Committee was requested to:[1]

1. Examine the self-evaluation reports, submitted by the institutions that provide study programs in Electrical and Communication System Engineering, and to conduct on-site visits at those institutions.
2. Submit to the CHE an individual report on each of the evaluated academic units and study programs, including the Committee's findings and recommendations.
3. Submit to the CHE a general report regarding the examined field of study within the Israeli system of higher education including recommendations for standards in the evaluated field of study.

The entire process was conducted in accordance with the CHE's Guidelines for Self-Evaluation (of September 2013).

[1] The Committee's letter of appointment is attached as **Appendix 1.**

Chapter 2: Committee Procedures

The Committee held its first meeting on January 6, 2016, during which it discussed fundamental issues concerning higher education in Israel, the quality assessment activity, as well as Electrical and Communication System Engineering Study programs in Israel.

In January 2016, the Committee held its visits of evaluation to 12 programs: Tel-Aviv University, the Technion, Bar-Ilan University, Ben-Gurion University, Shamoon College of Engineering, Ruppin Academic Center, Azrieli - College of Engineering Jerusalem, Lev Academic center, Ort Barude College, Holon Institute of Technology, Ariel University and Afeka College of Engineering. During the visits, the Committee met with various stakeholders at the institutions, including management, faculty, staff, and students.

This report deals with the general issues facing Israeli Electrical and Communication System Engineering programs determined by the committee after visiting and evaluating all 12 programs.

Chapter 3: Evaluation of Electrical and Electronic Engineering Study Programs in Israel

In 2007, a committee chaired by Prof. Jacob Ziv under the auspices of the CHE evaluated the study programs in Electrical Engineering at the Israeli Universities and Colleges. The 2016 committee was charged with carrying out a similar evaluation, and in the process had the benefit of the work, reports, and counsel of the 2007 committee.

In carrying out the 2016 review of the various institutions (universities and colleges), the committee was particularly mindful of the comments and recommendations made in the 2007 reports with a focus on whether the underlying issues raised were addressed, and on progress that has been made since that report. A detailed individual report is provided for each of the universities and colleges visited. Our reports on the individual institutions are more specific about the 2007 recommendations, the progress made at each institution since, and recommended paths for future initiatives and developments than this General Report.

In this General Report, we focus on issues raised in the 2007 General report as well as other issues that appear to us to be pervasive in the higher education system in Electrical Engineering among many or all of the institutions visited. This General Report also considers how the various institutions are performing in the context of their mission as they articulated it to us and as stated by the Council for Higher Education. This General Report is meant as an overview of our evaluations and a general commentary about important overall issues and observations, particularly as they relate to Electrical Engineering at the universities and colleges. As a starting point, we explicitly refer to the 2007 General Report and issues raised in that report and comment on which of those issues seem to have been addressed in whole or in part.

This General Report has two sections. The first provides a summary of the important recommendations of the 2007 report as well as historical context

relevant to the current evaluation. The second section contains the comments and recommendations concerning the issues noted by the committee during this review. The following issues are addressed in the second section of the report:

- Budgets and The Effect of the CHE Budget Model
- The Nature and Role of Research in the different Institutions
- The Importance of Clearly and Crisply Articulated Mission Statements
- The Need for Branding and Marketing of the Colleges
- The Teaching Mission at the Colleges
- The Second Degree
- Third and Fourth Year Full-time Students Working in Industry
- The Value and Importance of Internationalization
- Student-Faculty Ratios
- Teaching Models and Incorporation of Modern Teaching Technology
- Consolidation of Programs
- Handling, Incentivizing and Promoting the Development of Intellectual Property

I. OVERVIEW

Summary of the 2007 General Report:

In the 2007 report, the fable of the golden goose was invoked as a metaphor to underscore the significance of the committee's finding that fiscal support for the educational institutions and, in particular, the faculty salaries in relation to salaries in industry was a strong impediment in the hiring and retention of well-qualified faculty. Another issue raised in the 2007 report was the impact of policies related to intellectual property rights of the faculty, and a third was the very high student-faculty ratios at the various institutions. In our report, we comment both directly and indirectly on these issues. Overall, it is clear that there has been substantial change and progress since the 2007 report, but it is also clear that some of the important issues raised in that report persist.

As part of the 2007 evaluation process a separate committee was formed to evaluate the teaching laboratories. While the 2016 committee did visit various teaching laboratories at all of the institutions, this committee was not well equipped to thoroughly assess the adequacy and effectiveness of the laboratory infrastructure other than superficially, both because of its collective lack of expertise in that domain and the limited time allocated to each visit. As mentioned in the individual visit reports, the committee's impression was that at some institutions the teaching laboratories were well equipped and up to date, while at others they were in need of significant upgrading.

Some Historical and Social Context

Prior to the mid 90's, the Electrical Engineering education system in Israel consisted essentially of three universities (Technion, TAU, and BGU), and the Holon Institute of Technology (HIT) which initially had a different name and granted a degree of Bachelor of Science in Technical Education. At that time, the overall number of Electrical Engineering graduates was around 500 graduates per year. The potential student population was limited to a relatively small group of high school graduates. In addition, there were many non-academic institutes granting a Practical Engineering Degree. A problem with the Practical Engineering Degree was that it was terminal in the sense that it did not lead to a higher degree. In order to get a B.Sc. degree, the students had to enroll in a university program and complete a substantial part of an additional 4-year program of study. This transition was almost impossible to accomplish because the candidates had to compete with others for a limited number of positions at the universities. At the same time, there was an understanding that an education providing more depth and breadth of coverage is required in order to prepare a well-qualified engineering work force for the ever-changing needs of the high tech industry.

Today, the overall number of Electrical Engineering graduates per year in Israel approaches 1,700 students with almost 900 of them graduates of four universities (These numbers include graduates of The Technion, TAU, BGU and BIU and do not

include the first HUJI graduates who will join the system in two years). The system is now intended to serve a much broader student population with larger diversity in their high school record. The large diversity of Electrical Engineering graduates from various institutions can also more broadly address the needs of industry which is now much more mature and which has increasingly diverse needs ranging from basic research and development to design, production, and service.

Overall, it seems that the Electrical Engineering educational system in Israel is now sufficiently broad to accommodate all of the candidates who wish to and are qualified to study the discipline. The system also admits some students with weaker backgrounds who require additional work to improve their basic skills in areas that are needed to study Electrical Engineering at a B.Sc. level. Furthermore, there is an enhanced mandate for inclusion of a broader segment of the Israeli population and for attracting high tech industry to various population centers.

The committee heard from multiple constituencies that there is a need in industry for more Electrical Engineers and that programs of study at the universities and colleges in this discipline prepare students for what is perceived as a rewarding and promising profession. This creates a win-win situation that opens the opportunity for new initiatives to increase the number of Electrical Engineering graduates. Increasing emphasis on admission of students with a broader range of academic preparation is necessary. Those students from traditionally under represented sectors of the population that have traditionally not been well represented in the discipline may require access to preparatory programs of up to a year's duration so that they may be fully prepared to engage in their Electrical Engineering studies.

The Universities

As was noted in the 2007 report, "Israel's universities have been blessed with outstanding Electrical Engineering departments which are highly regarded internationally for their scientific and technological research". And as was also pointed out in that report, "since Israeli industry does not have in-house research

comparable to what one finds at the universities, the Israeli EE departments are an important vital component of the Israeli infrastructure." These observations are clearly still valid today, with the universities considered to be a primary research arm for both the IDF and Israeli industry. Another important role of the universities, particularly at the undergraduate level, is the training of engineers for project leadership roles in industry and the IDF.

The Electrical Engineering departments at many of the universities continue to be highly regarded in the international research community. However, they face some significant challenges, as detailed in the individual visit reports and as discussed more broadly below. Many of these issues and challenges relate to their budgets and the overall CHE budgeting model, faculty recruiting and retention, student/faculty ratios, and the evolving technologies and models for teaching.

The Colleges

Quoting from the 2007 report "There is (in 2007) an ever increasing need for more highly qualified Electrical Engineering graduates in Israel. With this in mind, to substantially increase the number of such graduates, colleges were encouraged to offer a first degree program in Electrical Engineering. As of now (2007), 9 colleges have already been accredited by CHE to give a B.Sc. in EE. Originally, it was assumed that a large number of high school graduates whose achievements were high, but short of the demanding qualifications for admittance to the EE university programs, would be attracted to a first degree EE program at the colleges."

In this context, this committee's understanding of the role of the Electrical Engineering programs in the colleges is that the colleges have as their primary mission preparing students to either proceed, after graduation, to a university graduate program or directly to an engineering role in industry. If this understanding is accurate, the primary role of the colleges is education and the primary role of the faculty is teaching. Some of the colleges have an additional role of bringing a particular segment of the Israeli population into the higher education

system, coupled with or in addition to attracting industry to the geographic area in which the college is located.

II. ISSUES AND RECOMMENDATIONS

II.1 Budgets and the Effect of the CHE Budget Model

Defense and education seem to be generally acknowledged as key areas vital to the future of Israel. Developing, expanding, and maintaining a quality educational infrastructure requires ongoing and creative investment. It appears to us that the current funding levels and model are insufficient to sustain, let alone grow the quality of the Israeli higher education system in Electrical Engineering.

In essentially all of the visits, both at the universities and at the colleges, the impact of the government budgeting and budget model was apparent. Of course, all institutions wish for more financial resources and a larger share of the available budget. As noted in the 2007 General Report severe budget constraints not only negatively impacted the ability to recruit and retain top faculty but also resulted in high student/faculty ratios. While this situation is well recognized at the institutions, and while CHE has established desirable student/faculty ratio targets for the universities and colleges, budgetary restrictions have made it impossible to achieve these targets. Adequacy of the funding levels and the funding model must be addressed if the higher education system intends to achieve its goals.

Other serious issues that stood out to the committee were:

- The perceived inflexibility of the teaching funding model and formula
- The research funding model and formula
- And the specific manner in which various parameters are weighted.

While this may well represent an attempt at transparency, fairness, and equity, the fundamental needs of different institutions may differ and it is inevitable that there is a need to moderate these precise and seemingly inflexible formulas with

subjective judgment. More significantly, with the published budget formulas as they are interpreted, there is a natural inclination at all levels to mathematically optimize against the formula. This can often lead to unintended distortions relative to the more subjective underlying objectives of quality education, institutional stature, and impact on the high tech industry.

With regard specifically to the teaching funding model, the fact that the same formula apparently applies equally to both the universities and the colleges seems inappropriate because of the differences in the missions of the various institutions, the populations that they are intended to serve, and the preparation of the entering students. With regard to the research funding model, it became particularly apparent during many of the visits that undue emphasis was given to a number of metrics that are intended for and traditionally used more for rough calibration rather than precise measurement. This undue emphasis is evident in all aspects, including budget allocation, faculty evaluation, and faculty hiring. In a number of the visits it was evident that throughout the leadership chain, starting at the top and percolating down through the deans, faculty and to the students, strong emphasis (too strong in our view) was placed on optimizing the parameter values in the budget equation.

Of course, we all recognize the importance of research impact and recognition through publication in quality conferences and journals. However, it is often too easy for institutions and researchers to over-emphasize the numerics. One amusing anecdote from the visit that seemed to capture this issue was a discussion in a meeting with several students at various stages of their Ph.D. research program. When each student was asked how far along he or she was on their research, the measure with which they answered was related to how many conference or journal papers were completed or submitted. There was no comment about the quality or impact of the work being conducted. The students clearly all had heard the message that publication numbers weighted by a numerical metric for each conference or

journal forms the relevant measure of research progress. Similar comments apply equally to the formulas used to determine funding levels and faculty promotion.

Summary Recommendations

Because the budgeting parameters are governed by a formula, the evaluation of the individual Electrical Engineering programs and the resources that are made available to these programs for carrying out their mission are driven by this formula. This process in turn drives the administration and faculty at the universities and colleges to act in ways that maximize their "score" relative to the metrics represented in the formula (as that formula is interpreted).

• The committee suggests that the evaluation of institutions and individual faculty members should take into consideration both research and teaching contributions, but should move away from a single, formula-oriented approach to recognize differences that exist across institutions as well as offer greater flexibility in capturing impact along different dimensions.

• The committee recommends that the CHE require each Electrical Engineering program, in collaboration with the CHE, to articulate a set of metrics that measures the extent to which it has attained its mission. The committee further recommends that the CHE require each program to regularly collect data that allow it to determine, based on these metrics, how well it is achieving its mission, recognizing that the mission may be different for each institution. This evaluation should guide the CHE in its interpretation of the allocation formula for the purposes of budgeting.

- The evaluation of research contributions should include:
    - Quantitative scholarly metrics such as number of publications, number of citations, citation indices such as *h*-factor, impact factors of publication venues (or its ranking in the discipline, i.e, the quartile system), etc., as well as less traditional factors such as number of users/downloads of a new open-source system, highly cited patents, entrepreneurial contributions, etc.

- Qualitative assessments of the quality and impact of the research such as input provided by evaluations and recommendations from peer researchers and high profile scientists.
- Assessments of the contributions provided by individuals in academia and in industry. This is particularly important for "systems" research that often produces artifacts whose contributions are not always well recognized by traditional venues such as publications.
- Impact on students' educational experience and development of their ability to apply their skills to open-ended and unstructured problems, *e.g.,* as recognized through student success in national and international engineering competitions (robotics, solar cars, etc.), or in high-profile joint projects with industry.

- The evaluation of teaching contributions should incorporate:
  - Not only the number of course units taught, but also the quality of instruction as indicated by student course evaluations and peer evaluation of instructional quality.
  - Feedback from industry regarding students' preparedness for employment.
  - Pedagogical contributions, e.g., development or experiments with new teaching methods and vehicles such as online learning, flipped classrooms, MOOCs, etc.
  - Guidance of students in challenging R&D senior year projects. The project experience can often benefit from industrial collaboration provided that the collaborating companies clearly understand and accept the educational priority of the project experience.

II.2 The Nature and Role of Research in the Different Institutions

In almost every mission statement at both the universities and the colleges, the importance of research is mentioned. Research, in a fairly generic sense, could reasonably be taken to mean "unstructured exploration and the advancement of

knowledge." Unstructured exploration, i.e., "research", is important throughout the educational process beginning at the earliest stages so that one's knowledge and ability to explore is developed and enhanced. Hence, involvement of students in "research" should be an important component of training and education throughout the Israeli educational system both at the universities and at the colleges and even well before the B.Sc. level of education. However, for different programs and institutions, the nature of the knowledge being advanced can and should vary.

More often than not, particularly at the undergraduate level, the role of research is primarily that of helping students learn how to carry out unstructured intellectual exploration. Results of this kind of work typically need not or should not have as a primary focus publication at a conference or in a journal. In such an educational context and in particular at the colleges, the key goal should be to guide students in effectively carrying out open-ended investigations to advance their knowledge. Consequently, for the faculty involved in this kind of research, key goals of research participation should be the educational benefit to the students and facilitation of the faculty to stay current in their areas. When research is conducted in this context, the key element should be that the research process and results are new to the students, not necessarily new to the research supervisor or to the world at large. Such educational contributions rarely lend themselves to scholarly publications in top venues, and measuring the contribution of this research using metrics associated with publication is therefore inappropriate in general.

At a number of the colleges the view was expressed that research and publication are a critical aspect of recruiting, retaining, and promoting faculty. It appears to this committee that this perspective may serve to distort the fundamental mission of the colleges. An important aspect of practical research conducted at the colleges is the interaction with industry on advanced R&D projects. These interactions are critical because they not only align with the educational mission of the colleges by offering the students opportunities and challenges through involvement with state-of-the-art technology in a research and development environment, but also serve to

strengthen Academia-Industry cooperation to the benefit of the State of Israel. This emphasis has a positive impact on the branding of the Institutions.

Conversely, at the research universities, there is the need within the context of the institutional mission to provide cutting edge research for the country and for maintaining and enhancing the stature of the university and the faculty. In such a setting, and in particular in research conducted at the Ph.D. level, it is more appropriate to evaluate research in part on the extent to which it advances knowledge in a broader community or in the world. However, in the current Israeli higher education climate and for that matter worldwide, too often excessive importance is placed on evaluating and measuring research and defining its role through counting publications, using numerical metrics such as the *h*-index, etc., and focusing on the perceived stature of the institution. While metrics of this kind are perhaps somewhat and sometimes useful, they are too often over emphasized, particularly in faculty evaluation and promotion.

The discussion above concerning the nature of research addresses the issue primarily from the perspective of the mission of the particular institutions. In many individual cases, there is a strong desire among faculty members in the colleges to participate in fundamental research. This desire can often be achieved through collaboration with the universities, industry, or elsewhere but in any case should not distract from the fundamental educational mission and should not be a pre-requisite or decisive criterion for promotion.

Summary Recommendations

- Each of the individual universities and colleges has a somewhat different mission. Specifically, the extent to which each institution has a mandate to carry out fundamental research differs, as does the extent to which the institutional mission is focused on education of professionals who will contribute to the nation's technological infrastructure and products. These differences have an impact on the nature and role of research in the institutions and should be reflected in the expectations framed for each institution

- The committee strongly recommends that the CHE explicitly acknowledge differences in the role of research at colleges and universities. Research at the former includes a strong educational component, while novelty of contributions as recognized by high impact publications is of greater importance at the latter.
- The committee recommends that those differences be reflected in the faculty evaluation and promotion process at colleges and universities. The evaluation and promotion parameters at the colleges and at the universities should be governed by contributions in both teaching and research Balancing the standards in teaching and research and recognizing the nature of the research expectations in the institutional context are critical to a fair evaluation of the faculty.
- IP and commercialization is part of the return to the community, and should be encouraged and accounted for in faculty evaluation.

II.3 The Importance of Clearly and Crisply Articulated Mission Statements

The committee understands that a key part of the mission of the Israeli higher education system in engineering is to provide well-trained engineers to Israeli industry and to the IDF. The graduates of Israeli engineering programs may be suited for either hands-on engineering tasks, or project management tasks, and/or very forward looking advanced development or "blue-sky" research. Whichever of these roles an engineer fills can be highly dependent on the mission and character of the individual institution from which he or she graduated. The self-evaluation reports from each of the institutions typically included mission statements expressed at several administrative levels of the institution. As mentioned in a number of the more detailed visit reports, in some cases the mission statements were overly generic, lacked clarity, and were not sufficiently specific. Furthermore, a crisp and consistent mission statement was not always uniformly clear across levels. In addition, the mission statements often did not clearly identify or differentiate the particular strengths and purposes of the institution. For example, the Electrical Engineering departments at all of the research universities have faculty with solid

research accomplishments and world-wide reputations. Often many of the faculty at these institutions are less motivated by the teaching responsibilities. Conversely, while many of the colleges pride themselves on their educational programs and faculty interest in excellent teaching and in involving students in research for its educational benefit is high, faculty members at the colleges also often feel pressure to have significant research accomplishments as evidenced by publications. This conflict is in part because the institutions often see the importance of research in terms of both the CHE budget model and in terms of the stature of the institution.

The committee strongly encourages each institution and each department that we visited to develop a crisp and specific mission statement that is also openly shared with the faculty, the students, and the public. The CHE mission statements and budgeting model should reflect the potentially different missions at each institution.

Summary Recommendations

- Both colleges and universities should articulate in their mission statements the institution's vision regarding the role of research as an intrinsic component of a student's education, as well as the research contributions expected from faculty beyond teaching. The committee is of the opinion that research expectations may be expressed differently across institutions. For example, Institutions with a primary focus on teaching might emphasize research as a means by which faculty can remain aware of and be involved in the latest developments in their field. More traditional research universities might position research contributions as being central to their faculty's responsibilities, with expectations of high impact to science or technology.
- The committee strongly recommends that the CHE clearly articulate its understanding of the missions of the individual universities and colleges. As is often stated in many contexts, “when going on an important mission, it is essential that all the stakeholders be fully on board.”

II.4 The Need for Branding and Marketing of the Colleges

Among the colleges there is considerable variability in the level of academic ability and preparation of the students and in the core missions. It is also the committee's perception that in many instances, students at colleges are receiving better mentoring and hands-on education than they would at the universities. Particularly, at the colleges that have clarity about their mission and the community they serve, there is more opportunity for close interaction with and guidance from the faculty. However, many students at the colleges expressed the sense that there is a stigma associated with receiving an engineering degree from a college rather than from one of the universities. The students find evidence for this perceived stigma as they talk to their peers and in their eventual job search in industry.

The committee believes that this perspective can and should be changed through more creative and pro-active branding and marketing of the individual colleges to make it clear to the country at large and to the students and faculty at the colleges what the colleges have to offer and what differentiates each particular college. Industry, which is one of the primary beneficiaries of the educational system should be a partner in raising awareness of the special educational aspects, particularly at the undergraduate level, offered by the colleges that might not be available at the research universities.

A useful parallel regarding the type of image that at least some of the colleges should seek to acquire is that of the many small, yet highly competitive Liberal Arts Colleges in the US education system, *e.g.,* Harvey Mudd College, Amherst College, Oberlin College, Lafayette College, etc. and such engineering colleges as Olin College. These institutions typically do not offer graduate programs and are primarily focused on delivering a high quality undergraduate education. They boast smaller class sizes than most universities, a faculty dedicated to teaching and teaching innovation, and a supportive environment that is proactive in helping students navigate the perils of college life towards ensuring that most if not all successfully graduate. As a result, these colleges attract many highly qualified students looking for a more individualized experience than that offered by larger universities, and

maintain admissions standards and statistics that are as competitive as those at any of the top universities. Consequently, their graduates are highly sought after by industry as well as by graduate programs at top universities that compete aggressively to recruit those interested in pursuing graduate studies. Some of the Israeli colleges should and can aspire to a similar role in the Israeli education system. Developing such an "image" for the colleges will not happen instantaneously, but the goal can be achieved through a systematic process of marketing the colleges' unique educational advantages to industry and potential students alike. The CHE may also be able to assist in developing promotional material for the colleges, as also would alumni of those colleges. Alumni represent an under-utilized resource that should be more systematically exploited to raise a college's profile.

Among the many ways to improve the branding is perhaps to establish the colleges as hubs for Academia-Industry cooperation through engagement in collaborative applied research projects. Such cooperation can be established under the auspices of the Israel Innovation Authority in the Ministry of Economy and Industry, which operates the largest applied research program in Israel.

Summary Recommendations

- The committee recommends that the colleges actively develop focused marketing campaigns aimed at establishing the unique advantages offered by the education being provided. Those campaigns should target both students and industry (potential employers), and should leverage alumni working in both academia and industry towards articulating a strong message.
- The committee recommends that the CHE actively assist colleges in developing appropriate promotional material as well as in disseminating this material to prospective students.

II.5 The Teaching Mission at the Colleges

The committee observed that there appears to be a disconnect that is evident at many of the colleges that we visited between the faculty's emphasis on excellent teaching and mentoring, and administrative pressure for more research as measured largely by publication count. Many of the faculty at the colleges are dedicated teachers with a genuine interest in teaching and in providing a quality engineering education to students who often, although not always, may not have considered or been ready for a university environment. The college faculty do understand that teaching excellence requires remaining current with and even contributing to the evolution of knowledge in their field. While currency and contribution can certainly be sustained while one is engaged in fundamental research, the college environment often calls for more "applied research". In the context of the educational mission of the colleges, the value of these advanced development and applied research projects should not be measured by numerical metrics solely related to publications but rather by the experience gained by the students, the intellectual contributions of the faculty, and feedback from Industry.

If this difference is not explicitly acknowledged, an unhealthy and untenable tension between maintaining a focus on teaching and the need to develop a large research enterprise is created. This tension is notable when one considers the much higher teaching load on faculty that prevails at the colleges. It seems imperative that the Israeli government recognize the difference in the missions of the colleges and universities in the context of research, and in particular *the difference in the role and nature of research at the colleges.* This difference is particularly important in the context of faculty evaluation and promotion within the colleges, which today appears to be based on criteria essentially similar to those used in the universities. It is imperative to *formally* recognize those differences and explicitly reflect them in the evaluation and promotion criteria used for the faculty within the colleges and universities. The current system is unhealthy and detrimental to the core teaching mission of the colleges.

Summary Recommendations

- The committee strongly recommends that the CHE develop distinct evaluation and promotion metrics for colleges, which explicitly acknowledge their primary mandate and its implications regarding the role of research at the colleges.
- The committee recommends that resources be allocated at the colleges to facilitate the offering of educationally focused research activities. These added resources are critical so that students interested in pursuing such activities are given the opportunity to, and so that the faculty supporting those activities have both the means and the proper incentives.

II.6 The Second Degree

The committee visited Electrical Engineering programs at twelve institutions. Because research activity is essential in the development of new technologies, education of well-trained engineers, and retention of high quality faculty, the matter of graduate education (or education to a second degree) is an important issue. All of the universities offer the second degree with tracks involving projects and tracks involving theses. Of those institutions classified by the CHE as colleges, some offer the M.Sc. degree without thesis, some have submitted a proposal to the CHE for an M.Sc. with thesis, some have articulated a desire to develop an M.Sc. program, and some do not appear to have a desire to establish an M.Sc. program at this point in time. Thus, it appears that the Electrical Engineering departments at the colleges are widely divergent in their interest in or degree of readiness to engage in the development of second degree programs.

As a general comment, it is our view that incorporating at least a strong project-based experience into a M.Sc. program at each college that offers that degree is an appropriate objective. A variety of motivations have been articulated for offering a second degree with thesis. One important consideration in a decision to offer a thesis-based M.Sc. is the institution's ability to provide an environment that appropriately supports the research being done including a sufficiently large selection of graduate-level lecture courses.

The committee heard from students at the colleges that the degree of M.Sc. with project is viewed as being stigmatized and those having completed the M.Sc. with project have a diminished chance of being admitted to a Ph.D. program at one of the universities. It should be noted that University regulations do allow admittance of students who have completed an M.Sc. with project. It is also true that in several of the Universities, there are administrative restrictions on the acceptance of students who have M.Sc. with project. The committee recommends that acceptance of students to Ph.D. programs in the universities be simplified and streamlined. Student should be admitted to a Ph.D. program based on their scholastic achievements and potential and not based on the specific track of their prior studies.

Summary Recommendations

- The committee recommends that colleges seeking to offer M.Sc. degrees with thesis should demonstrate that they are fully prepared to provide an environment conducive to high quality research. This might involve first focusing on developing M.Sc. degrees with projects, which would allow the programs to demonstrate their readiness to support applied research. The projects would also provide students the opportunity to explore a particular topic in greater depth while gaining experience in pursuing a more comprehensive task than may be available through regular course work and laboratories.
- The committee recommends that production of publishable results should not be the ultimate goal of projects that are the focus of non-thesis M.Sc. work.
- The committee recommends that acceptance of students to Ph.D. programs in the universities be simplified and streamlined. Student should be admitted to a Ph.D. program based on their scholastic achievements and potential and not based on the specific track of their prior studies.

II.7 Third and Fourth Year Full-time Students Working in Industry

Because of the requirement for most Israeli students to serve for several years in the IDF before entering the higher education system, the students at the universities and colleges are typically older than their peers in other countries. In many respects, this situation is a wonderful advantage for the higher education system in that the students are often more mature, disciplined, experienced and motivated. However, many of these older students also have families and other financial obligations or commitments, or they have a strong desire to be financially independent of their parents.

Consequently, it is evident to the committee that at the universities and often at the colleges, students in their third and fourth years, in addition to their "full-time" status as students, work half time and perhaps more, in Industry. With multiple time constraints and demands, these students often do not attend most classes while they are taking a full course load. Furthermore, their work assignments in Industry frequently are not in the form of an internship or co-op program with oversight on the part of the educational program. Nevertheless, it is clear in discussing this matter with students that in many cases the industrial experience is educationally valuable to them. Furthermore, it is more often than not a critical first step in obtaining an interesting job following graduation.

These benefits notwithstanding, in many if not most cases this conflicting situation also seriously compromises the program's ability to accomplish its educational mission. For example, the company and the educational institution may not be geographically close. This can create severe scheduling conflicts between class attendance and job-related commitments. As a result, many students report that rather than attending classes they often study the topics through whatever resources they find on the Internet, *e.g.,* YouTube videos, on line course notes, MOOCs, etc., and much of this material is not properly vetted or evaluated by the faculty. This conflict between academic commitments and work commitments can prevent students in their third and fourth years from properly acquiring skills they may later need for career growth. The absence of half, and sometimes more, of the

students from class can also negatively impact the effectiveness of the course and the enthusiasm of the faculty.

The current situation has a clear advantage for industry in that it gives them access to students well before they graduate. For the students it is financially beneficial and also beneficial in providing industrial experience. However, in addition to the potential for interfering with a student's course of studies, the culture has also evolved in such a way that students who opt to not work in industry in the latter part of their undergraduate program, either because they are unable to find suitable positions or because they prefer to focus on completing their academic studies, are at a distinct disadvantage when looking for jobs near the completion of their studies.

The committee observes that involvement of third and fourth year students in industry has the potential to have significant advantages for the students, for the institutions, and for Israeli industry. However, because in the current culture this work experience is not structured in collaboration between industry and the educational institutions, it also has the potential for exploitation of the students and for a less-than-optimal educational experience for them.

The committee recommends that creative and constructive thought be given to a more structured approach to the student work experience and guidelines developed for a system in which students can work in industry as part of their educational program. This collaboration could, for example, be structured as a co-op or internship program. Whatever structure is developed, it is important that the educational institution provide an appropriate level of mentoring and oversight to ensure that the students receive some tangible educational value and experience. It is also important to facilitate broad access to those opportunities, in particular to students from colleges, to ensure that all students benefit from the corresponding educational experience, and that no student is handicapped when seeking employment after graduation. A comprehensive partnership between industry and educational institutions should help address this issue.

Summary Recommendations

- The CHE should strongly encourage the universities and colleges to develop a more structured system for overseeing the students' work involvement during their third and fourth years. The goal of such a system would be to consolidate the educational benefits and hands-on experience, while mitigating the impact on the students' course of study. Ideally, this oversight would be realized in the form of a partnership between the educational institutions and industry.
- The committee also recommends that institutions explore new pedagogical methods and course formats, such as online lecture segments combined with distributed lab/studio sessions that afford greater scheduling flexibility and therefore improve students' ability to reconcile work and academic scheduling constraints.

II.8 The Value and Importance of Internationalization

During the visits at all of the institutions, the topic of internationalization was raised, either by the committee or in the natural course of discussing future plans. It is the committee's position that moving in the direction of each institution developing programs that are attractive to students from other countries and to postdoctoral researchers from other countries should be an essential part of planning for the future. Internationalization will require that related courses be taught in a language other than Hebrew (most likely English). In addition, English must be more prevalent in the research environment, including important research seminars, if doctoral students and postdoctoral researchers are to be recruited. Overall, for growing the student population, and for attracting world-class faculty and postdocs from other countries, internationalization would seem to be an important step forward and should be strongly supported by the CHE. Internationalization will also help Israeli students to be better prepared for modern engineering careers that now commonly involve close interactions with international teams. The committee recognizes that internationalization is a major

commitment in terms of resources, but it appears vital to the future growth and health of the Israeli educational and research environment.

Summary Recommendations

- The committee recommends that universities and colleges be encouraged to pursue internationalization efforts, including increasing their offering of courses taught in English and course material made available in English. It further recommends that the CHE find ways to ensure that adequate resources are made available to support these efforts.

II.9 Student-Faculty Ratios

The CHE has set targets for the desirable student-faculty ratio at the universities and at the colleges. It appears that in many classes at both the universities and colleges, these ratios are significantly exceeded, often by a factor of two or more. Reducing this ratio was a key recommendation in the 2007 report and remains an important area of concern. Among the many drawbacks of a high student-faculty ratio is larger class sizes which has a serious negative impact on the opportunity for meaningful interactions between the instructor and the students. In addition, there is a negative impact on the opportunity for student mentoring. Perhaps a partial contributing factor to the large class sizes is the fact that students are allowed to re-take courses under certain circumstances**.** The specific policy is: "Students who fail must retake a course once in the consecutive year and if they fail again their studies are terminated. Students wanting to improve their grade in a particular course can retake that course in the consecutive year." The extent to which class sizes are affected by students retaking courses is not clear, but the policy undoubtedly impacts class size.

Increasing budgets to provide for increasing the size of the faculty and staff is an important element in reducing student-faculty ratios. The use of alternative teaching models and incorporation of better technology in the classrooms can also mitigate the negative effects of large class size.

Summary Recommendations

The committee recommends that the CHE foster a reduction in the student-faculty ratio in the universities and colleges. Improving the student-to-faculty ratio will likely require a multi-pronged effort involving one or more of the following initiatives:

- Increasing funding level to attract and recruit additional faculty. Note that this initiative not only calls for creating additional faculty slots, but may also require enhanced resources to offer attractive startup packages and compensation.
- Exploring whether limiting course-retake options is feasible without overly penalizing students with compelling reasons for re-taking the course (for example, a medical event or military call-up as opposed to simply wanting to improve one's grade).
- Leveraging new technologies to develop course offerings that scale more easily, for example, short online video lecture segments together with parallel lab/studio sessions.

II.10 Teaching Models and Incorporation of Modern Teaching Technology

The two major missions of research universities in Israel and other countries have always been teaching and advanced research. It is well understood that there is a strong symbiotic relationship between the two. There are also typically differing views within both the faculty and the administration on the relative importance of, the relationship between, and the allocation of resources to these missions. High quality research not only contributes to the fundamental advancement of knowledge, but is also essential to maintaining a high quality educational environment in terms of subject content and relevance and the currency of the faculty. A high quality educational environment also requires faculty dedicated to the task of teaching as well as a continuing assessment and updating of the goals, methods, and technology for content delivery and for faculty engagement with the

students.

Throughout our visits, and primarily at the universities, the committee observed that the importance of quality teaching is not always perceived by faculty or administration as one of the main objectives of the Institution. This stems in part from the natural desire of faculty to carry out research, but it also reflects the metrics by which faculty members are measured and promoted and the current culture in many educational institutions. In our view, teaching should be a more important factor than it currently appears to be in the faculty evaluation and promotion process not only by referring to student surveys, but by utilizing self-evaluation and peer-evaluation that also address issues such as innovation and leadership in teaching, new courses/labs developed, student mentoring, etc. Having such a process may have a profound impact on the culture even if the final evaluation formula does not significantly change.

Throughout the visits at both the universities and the colleges, the committee also observed that there was limited creative experimentation with teaching models and with teaching technology. The current generation of students in Israel and other countries is very familiar with the Internet and expects ubiquitous access to information. They are also less tolerant of being required to be "at a certain place at a certain time". During our visits many of the students remarked that because of a combination of factors (their involvement in industry, the large class sizes, the style or quality of instruction, the necessary commuting time), it is often more efficient for them to search for course topics on the web and watch online video lectures. Clearly, this does not constitute an optimal experience, and teaching models need creative changes. The "chalk and talk" style delivery of course content is often much less effective than well-designed online videos which students can and/or are required to access in advance of the "face time" in class. Class time can then be used to provide additional perspective and better motivations. A number of experiments are being conducted worldwide for "lecture-free" models that offer both increased flexibility and educational experience. (Students can watch lecture material on their

own schedule, and the face-time sessions can be broken up into smaller groups supervised by graduate students with the instructor roaming from group to group. The face-time sessions can offer the opportunity to not only clarify concepts for students, but also provide enhanced motivation of the material.) Incorporating and extending initiatives of this kind in the Israeli education system can both improve its quality and partially alleviate some of problems caused by large class sizes. (Although this clearly does not eliminate the need for additional investment towards growing the faculty size.)

Summary Recommendations

- The committee recommends that the CHE encourage faculty to experiment with new teaching methods by providing the resources to support both the infrastructure needed to develop new course formats (e.g. support for video and content production) and incentives for devoting the required time and effort (e.g. offer teaching buyout to faculty willing to invest in these activities).

II.11 Consolidation of Programs

In many/most of the visits, the 2007 report contained recommendations for combining or consolidating EE and SE and or CSE programs. It is evident that there has been resistance to this consolidation. However, the world is changing, and boundaries between these areas are becoming increasingly diffuse. Articulating a clear distinction between EE and CS is increasingly difficult. At one end, devices and physical electronics clearly belong to the realm of EE, while topics such as computational complexity theory and cryptographic primitives are clearly CS. But other areas such as signal processing, information theory, statistical data analysis, embedded systems, and machine learning are much more difficult to classify. In the individual visit reports, the committee is more specific regarding potential and recommended consolidation of programs where it appears to be appropriate or important. As a general comment, it is the committee's position that there are many cases in which there are too many tracks and individual programs. Students have

remarked that a maze of programs and tracks is often difficult to navigate. Furthermore, it inevitably leads to inefficient use of resources.

Summary Recommendations

- The committee recommends that institutions more systematically explore consolidating departments to take advantage of synergies and advantages of scale so as to enhance their ability to offer students a greater choice of courses.

II.12 Handling, Incentivizing and Promoting the Development of Intellectual Property.

At many of the universities and colleges, at some point in the discussions, the question of how the institution handles intellectual property was raised. There is a variety of models that have been successful in other countries and also models that have resulted in conflict between the institutions and the faculty or students. Finding an appropriate model involves a complex balance of creating an atmosphere of fairness and identifying incentives, and ensuring that the system is not unduly encumbered with legality and bureaucracy. This committee is not in a position to propose a suitable model. However, it is clear to the committee that this topic is very much on the minds of the university and college communities and should be explored creatively and openly to arrive at an appropriate model for each of the institutions.

Summary Recommendations

- The committee recommends that institutions be encouraged to develop flexible approaches to handling intellectual property issues which will encourage rather than discourage new initiatives on the part of faculty. In general, lowering the barriers to entry for faculty wanting to initiate such activities and creating incentives for faculty and students interested in entrepreneurial activities are important components of a successful solution.

Signed by:

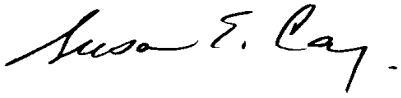
Prof. Alan Oppenheim - Chair

Prof. Eby G. Friedman

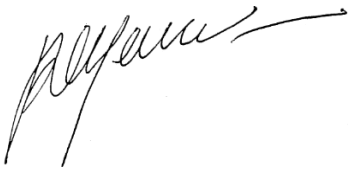
Prof. Ehud Heyman

Dr. Orly Yadid-Pecht

Prof. Mathukumalli Vidyasagar



Prof. Susan Conry



Prof. Roch Guerin

Prof. Dr.-Ing. Walter Kellermann

Appendix 1: Letter of Appointment

December 2015

Prof. Alan Oppenheim
Department of Electrical Engineering and Computer Science
MIT
USA

Dear Professor, AL

The Israeli Council for Higher Education (CHE) strives to ensure the continuing excellence and quality of Israeli higher education through a systematic evaluation process. By engaging upon this mission, the CHE seeks: to enhance and ensure the quality of academic studies, to provide the public with information regarding the quality of study programs in institutions of higher education throughout Israel, and to ensure the continued integration of the Israeli system of higher education in the international academic arena.

As part of this important endeavor we reach out to world renowned academicians to help us meet the challenges that confront the Israeli higher education by accepting our invitation to participate in our international evaluation committees. This process establishes a structure for an ongoing consultative process around the globe on common academic dilemmas and prospects.

I therefore deeply appreciate your willingness to join us in this crucial enterprise.

It is with great pleasure that I hereby appoint you to serve as the Chair of the Council for Higher Education's Committee for the Evaluation of the study programs in **Electrical and Communication System Engineering.** In addition to yourself, the composition of the Committee will be as follows: Prof. Susan Conry, Prof. Roch Guerin, Prof. Ehud Heyman, Prof. Mathukumalli Vidyasagar, Dr. Orly Yadid-Pecht, Prof. Eby Gershon Friedman, Prof. Dr.-Ing Walter Kellermann.

Ms. Daniella Sandler and Ms. Inbal Haskell-Gordon will be the coordinators of the Committee.

Details regarding the operation of the committee and its mandate are provided in the enclosed appendix.

I wish you much success in your role as a member of this most important committee.

Sincerely,
Hagit Messer

Prof. Hagit Messer-Yaron
Vice Chair,
The Council for Higher Education (CHE)

Enclosures: Appendix to the Appointment Letter of Evaluation Committees

cc: Dr. Varda Ben-Shaul, Deputy Director-General for QA, CHE
Ms. Daniella Sandler, committee coordinator
Ms. Inbal Haskell-Gordon, committee coordinator