Committee for the Evaluation of Computer Science Study Programs

General Evaluation Report – Recommendations to CHE

December 2014

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Chapter 1: Background

The Council for Higher Education (CHE) decided to evaluate study programs in the field of Computer Science during the academic year of 2012-2013.

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. Maurice Herlihy - Computer Science Department, Brown University, USA - Committee Chair
- Prof. Robert L. Constable - Computer Science Department ,Cornell University, USA[1]
- Prof. David Dobkin - Department of Computer Science, Princeton University, USA[2]
- Prof. Sarit Kraus - Department of Computer Science, Bar Ilan University, Israel[3]
- Prof. Dmitry Feichtner-Kozlov - Department of Mathematics, Bremen University, Germany
- Prof. Joe Turner, Jr. - (Emeritus) - Department of Computer Science, Clemson University, USA - ABET Representative
- Prof. Moshe Vardi - Department of Computer Science, Rice University, USA

Ms. Maria Levinson-Or served as the Coordinator of the Committee on behalf of the CHE.

Within the framework of its activity, the Committee was requested to:[4]

[1] In accordance with the CHE's policy, Prof. Robert L. Constable did not participate in the evaluation of the Computer Science department at Ben Gurion University to prevent the appearance of a conflict of interests.
[2] Due to scheduling constraints, Prof. David Dobkin did not participate in the site visits to the Jerusalem College of Technology, Hadassah Academic College, Ariel University, the Weizmann Institute of Science, the College of Management Academic Studies, Holon Institute of Technology, the Hebrew University of Jerusalem, and the Technion.
[3] In accordance with the CHE's policy, Prof. Sarit Kraus did not participate in the evaluation of the Computer Science department at Bar Ilan University to prevent the appearance of a conflict of interests. Due to scheduling constraints, Prof. Sarit Kraus did not participate in the site visit to Tel-Hai Academic College.
[4] The Committee's letter of appointment is attached as **Appendix 1**.

1. Examine the self-evaluation reports, submitted by the institutions that provide study programs in Computer Science, 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 (October 2011).

Chapter 2: Committee Procedures

The Committee held its first meetings on May 21, 2013, during which it discussed fundamental issues concerning higher education in Israel, the quality assessment activity, as well as Computer Science Study programs in Israel.

In May - June 2013, the Committee held its first round of visits of evaluation, and visited the Hadassah Academic College, Jerusalem College of Technology, Ariel University, Tel Aviv University and Bar-Ilan University.

In January 2014, the committee held its second round of visits of evaluation, and visited Ben-Gurion of the Negev, the Open University of Israel, the Interdisciplinary Center Herzliya, Tel-Aviv Yaffo Academic College, Netanya Academic College, Weizmann Institute of Science, College of Management Academic Studies, and Holon Institute of Technology.

In May 2014, the committee held its third round of visits of evaluation, and visited the Hebrew University of Jerusalem, the University of Haifa, Tel-Hai Academic College, and the Technion. During the visits, the Committee met with various stakeholders at the institutions, including management, faculty, staff, and students.

Chapter 3: The State of Computer Science Study Programs in Israel

This Report relates to the situation current at the time of the visit to the institution, and does not take account of any subsequent changes. The Report records the conclusions reached by the Evaluation Committee based on the documentation provided by the institution, information gained through interviews, discussion and observation as well as other information available to the Committee.

Introduction:

The Information Revolution is transforming all advanced industrial societies and their research universities. Google, for example, has revolutionized our access to knowledge. Its search algorithms are based on deep theoretical results about the structure of information networks. Amazon has revolutionized commerce based on efficient automation of transactions. Facebook has created a new way of communicating and provided new tools for studying how instant communication is changing patterns of social interaction. All of these transformative innovations were made possible by results from computer science research.

Computer science studies the science of automating processes, the information technology necessary to accomplish automation in practice, and their core applications to human endeavors. All three aspects are rapidly advancing. The science is based on the theory of algorithms and information processes. The technology is based on advances in hardware and software. A large dynamic industry leverages these advances for commercial applications. Government-funded computer science research has led to the development of a large information-technology industry, with some of the world's largest corporations.[5]

Computer Science in Israel

Computer science is extremely important to the economy and security of Israel; thus, it is crucial for Israel to promote the role of computer science and information technology in research and education. Israel needs a plan to bring and maintain its

[5] http://www.cccblog.org/2012/07/24/continuing-innovation-in-information-technologynew-nrc-report-links-government-research-investments-to-nations-leadership/

major computer science departments at a level comparable to the very best in the world.

Israel ranks by various measures as the second or third most influential country in computer science, behind the United States and perhaps the United Kingdom. This influence is felt in computing research, where four Turing Awards, viewed as the Nobel Prize of computer science, have been given to Israeli computer scientists. Only the United States has more such awards.

Israel's influence is also noticeable on the technology side in industry where major corporations such as IBM, Intel, HP, Google, and Microsoft have opened research facilities in Israel, and several important information technology companies, such as Mobileye, and Waze have been started in Israel. Israel's influence in technology is also reported in books such as *Start-Up Nation*. Nevertheless, just as in the early development of computer science in the United States and the United Kingdom, academic computer science in Israel is still dominated by theoretical work, where it is easier to evaluate excellence and intellectual impact. This fact reveals an imbalance in the nature of Israel's computer science research. This imbalance can be partly attributed to a misunderstanding of the discipline at high levels of the government, including PBC and CHE. *The formulas for allocating resources to computer science treat the discipline as if it were mathematics. This view is already 25 years out of date, and yet nothing has been done to correct it.*

Theoretical and Experimental Computer Science

The experimental side of computer science in the United States was expanded substantially after the government responded to the Feldman Report: *Rejuvenating Experimental Computer Science, Report to the National Science Foundation*, *Communications of the ACM*, 1979[6]. This report called for the development of experimental computer science in American universities. It had a dramatic impact

[6] Attached to this report.

both on the shape of computer science in the US and then on industrial growth. The following points from the report apply nearly verbatim to Israel today.

- Computation is a large and growing component of the intellectual, economic, and military strength of the nation and constitutes an area where the nation has the strongest international position.
- Academic computer science provides much of the research thrust and trains most of the professional manpower for this sector.
- The confluence of major advances in microelectronics, communications, and software technology has brought a greatly expanded need for experimentation in computing.

The report recommended that universities recognize the special resource needs of experimental computer science, and use appropriate criteria in evaluating experimental computer science programs and faculty.

Computer Science Education in Israel

Education is the foundation of the success of both the Israeli high-tech industry and its research enterprise. The Israeli computer science students are among the very best students in Israel. Yet, the undergraduate learning experience has suffered from the increased popularity of the field. The programs are often over-subscribed and under-resourced, resulting in a less than first-rate education.

While computer science is a dynamic, fast-moving field, where curricular requirements are updated quite often, computer science programs in Israel are so burdened by the task of maintaining such large programs without adequate resources that pedagogical and curricular innovations have suffered. Moreover, costly high student attrition rates and lengthening time to degree are prevalent. The risk to Israel is that its high-tech "engine" will slow down because of declining quality of the educational programs caused by overcrowding and underfunding.

Furthermore, in prestigious American universities computer science departments

are shouldering the responsibility of teaching computational thinking to students in many disciplines. In fact, the introduction to computer science course is often the most popular course in a university. Unfortunately, the PBC and university funding models do not encourage such an undertaking by computer science departments in Israel. The risk to Israel is thus not limited to computer science education but extends to education in all disciplines.

Computer Science Organization in Israel

Computer science in Israel lacks a body that speaks for the discipline as a whole, analogous to the role of the Computing Research Association (CRA) in North America. The CRA states "CRA's mission is to enhance innovation by joining with industry, government and academia to strengthen research and advanced education in computing. CRA executes this mission by leading the computing research community, informing policymakers and the public, and facilitating the development of strong, diverse talent in the field." Given the importance of computer science to the economy and security of Israel, a similar organization is urgently needed to address both research and education in Israel.

Chapter 4: Recommendations to CHE

Looking over the 17 program reports it issued, the Committee found some recurring themes which it wishes to comment on and offer advice to CHE:

1. **Research in Universities vs Colleges**:

   While it is clear that research is a core mission of Israeli universities, it is much less clear what the role of research is in the colleges. On one hand, the main distinction between universities and colleges is that the core mission of colleges is undergraduate education. At the same time, research is a major consideration in the promotion criteria for academic staff in the colleges, and the labor agreement with college academic staff allows academic staff to substitute research for some of their required teaching. Indeed, several colleges wish to develop research-based graduate programs. The Open University also wishes to develop research-based graduate programs, even though its core mission is undergraduate education. There is a risk that research may distract colleges and the Open University from their core mission.

   The Committee recommends the establishment of a national committee to propose detailed guidelines for research in colleges. The Committee proposes the following basic principles for this undertaking:

   a. The core mission of colleges ought to be undergraduate education.
   b. When research is carried out in colleges, it should be in the *service* of education, rather than research for its own sake, which should be left to universities.
   c. Colleges should be able to develop non-thesis master's programs, subject to CHE standards for such programs. Colleges should not be allowed to offer thesis master's or Ph.D. programs.
   d. Promotion criteria should be consistent with these principles. College academic staff members should be promoted on the basis of their

teaching and professional development rather than on the basis of their research record.

e. Non-budgeted institutions should be allowed to grow their research mission and research-based graduate programs, subject to CHE standards for such programs.

2. **Publication Standards**:

We found some of CHE standards for publications to be inconsistent with current publishing standards in computer science:

a. Computer-science research is often collaborative, and multi-author papers are quite common.

b. Computer science conferences are often quite selective and conference publishing is highly valued.

c. PBC should revise its publication standards for computer science, recognizing single-author and multiple-author publication, as well as both journal and selective conference articles, as valid ways to publish computer science research results.

d. A basic reference in this area is a best-practice memo "Evaluating Computer Scientists and Engineers for Promotion and Tenure", issued by the Computing Research Association.[7]

3. **High School Programs**:

Many of the institutions we visited offer degree programs for high school students. We were offered little information on these programs and were not able to evaluate them. For example, many of these programs were claimed to be "identical" to the mainstream institutional undergraduate programs, but in practice were different from them in substantial ways.

a. CHE should develop clear standards for programs that offer academic

[7] http://cra.org/resources/bp-view/evaluating_computer_scientists_and_engineers_for_promotion_and_tenure/ as well as a more recent effort: http://cra.org/resources/bp-view/evaluating_computer_scientists_and_en

credit to high school students.

b. The self-evaluation questionnaire should require institutions to describe their high school programs in detail so the Quality Assurance and Assessment Division can evaluate them properly.

4. **Funding**:

The Committee was surprised to learn that PBC's funding model clusters computer science with mathematics. This view of computer science as a mathematical discipline is dated and must be revisited. In the USA, computer science has been recognized as a primarily experimental discipline since 1980[8]. Computer science researchers often require labs to conduct their research. As in natural science and engineering, computer science students require labs sessions, supervised by teaching assistants. PBC must revise its funding model to recognize the experimental nature of computer science. In particular, Computer Science should be clustered with Electronics and Computer Engineering, rather than with Mathematics, in the Budget Model Tariffs.

5. **Educational outcomes**:

Education, at all level, is a core mission of colleges and universities. Thus, quality assessment must assess the quality of the educational value provided to the students. It is extremely difficult, however, to assess such value directly. Thus, student-career outcome is often used as a proxy for educational value. This is particularly true in a discipline such as computer science, where an academic degree is also a professional degree. The Committee was surprised to see that the self-evaluation reports do not include any data on student-career outcomes.

[8] J.A. Feldman: Rejuvenating experimental computer science: a report to the National Science Foundation. CACM 22:9 (1979), 497-502.

Furthermore, for students to make good choices in the education market place, it is critical that such marketplace be transparent with supply and demand data publicly available. For example, in North America the Computing Research Association provides data annually, in its widely consulted Taulbee Survey[9] on the labor market for computer science doctorate holders. The Committee was surprised that it was provided with no data on the Israeli computer science labor market. The labor market in Israel is vastly simpler than the labor market in the North America. CHE should undertake to compile data on the Israeli computer science labor market, collecting data from college and universities on degree-holder production, as well as data from the Israeli Bureau of Statistics on the demand for degree holders. Availability of such data would not only make the education marketplace in Israel more efficient, but would also facilitate quality assessment of academic educational programs with respect to educational value.

6. **Standards:**

   The CHE standards for computer science programs need to be reviewed and revised. The requirement that a department have 20 permanent academic staff members makes sense for university departments that offer PhD degrees, but is excessive for MSc degrees. The requirement that math courses be taught only by PhD mathematicians may have been reasonable in the past, but is unreasonable today, and is not always followed in practice. The curricular requirements should be revised and brought into harmony with internationally-accepted standards such as the *ACM-IEEE Computing Curricula 2013*. The committee recommends to CHE to appoint a special committee to review and revise its *Standards for Computer Science Studies* (2008).

[9] http://cra.org/resources/taulbee/

7. **New Programs:**

   There do not seem to be any clear criteria for starting new programs. As a result, there are weak, under-resourced programs, which once started cannot realistically be shut down. There should be a stronger, rational connection between the criteria used to decide whether to start programs and the criteria used to evaluate them. The special committee for computer-science standards should also develop standards for establishing new computer-science programs.

8. **Other Computer Science Programs:**

   The Committee noted that several institutions include programs in which computer science is a major component, but are offered by units other than computer science. Such programs often compete for resources with existing computer science departments, and many do not appear to meet CHE standards. The Committee recommends that the quality assurance process should cover *all* programs that include substantial computer science components in the reviewed institutions.

9. **Quality Assurance Follow-Up**:

   For a quality-assurance process to be effective, it is not sufficient to conduct self-evaluations and quality-assurance reviews. There must be a robust follow-up that ensures that academic units leverage the review process to improve their quality. But quality improvement requires change, and change is difficult. In reviewing the 2006 quality-assurance reports and the 2012 self-evaluation reports, the Committee was struck by the number of major weaknesses that were identified in 2006 but not addressed by 2012. The current follow-up process relies mostly on the cooperation of the institutions under review. In many cases, reviewed institutions have not been cooperative, but the quality-assurance process lacks explicit incentives for compliance.

The Committee recommends an explicit financial incentive for reviewed institutions to fully participate in the quality-assurance process, by including quality assurance in the research component of PBC's budgeting model. By grading the performance of institutions in the process, PBC should be able to build a direct connection between quality assurance and the budget model.

10. The CHE should take the lead and appoint an ad-hoc committee, consisting of the chairs of university computer science departments, to form a plan to implement the following:
    a) Israeli computer science departments must become more balanced between theoretical and experimental areas, like the top 50 departments in the US[10].
    b) Computer Science must be treated like an experimental science by universities, funding agencies, and the PBC.
    c) Computer science education in Israel needs a new set of standards to reflect these observations.
    d) To give computing research and education in Israel a common voice, the Israeli academic computer science community should establish an association, modeled on CRA or Informatics Europe. That association should schedule regular summits to discuss current issues in Israeli computer science research and education.

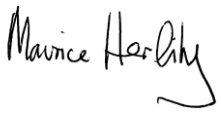
Implementation: The Committee recommends that

a. Within one year, each reviewed institution must submit a plan for implementing the response to the final report.
b. Within two years, each reviewed institution must submit a report describing progress in implementing the plan.
c. Within four years, each reviewed institution must submit a report

[10] http://cs.brown.edu/people/alexpap/faculty_dataset.html

describing progress in implementing the plan.

Signed by:



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Prof. Maurice Herlihy

Committee Chair

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Prof. Robert L. Constable

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Prof. David Dobkin

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Prof. Dmitry Feichtner-Kozlov

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Prof. Kraus Sarit

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Prof. Joe Turner, Jr

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Prof. Moshe Vardi

Appendix 1: Letter of Appointment

Planning & Budgeting Committee | הוועדה לתכנון ותקצוב

12.5.2013
Jerusalem

Professor Maurice Herlihy
Computer Science Department
Brown University
USA

Dear Professor Herlihy,

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, provide the public with information regarding the quality of study programs in institutions of higher education throughout Israel, as well as ensure the continued integration of the Israeli system of higher education in the international academic arena.

As part of this most important endeavor we reach out to world-renowned scientists to help us meet the critical challenges confronting Israeli higher education by extending our invitation to participate in an international evaluation committee. This process represents an opportunity to assess the current state of the field and plan for the future. This systematic process of quality assessment also establishes a framework for the interactive consultative process taking place between scientists around the globe regarding common academic dilemmas.

It is with great pleasure that I hereby appoint you to serve as chair of the Council for Higher Education's Committee for the Evaluation of Computer Science. The composition of the Committee will be as follows: Professor Maurice Herlihy, Committee Chair, Professor Moshe Vardi, Professor (Emeritus) Joe Turner Jr., Professor Robert L. Constable, Professor Sarit Kraus, Professor David Dobkin, and Professor Dmitry Feichtner-Kozlov.

Ms. Yael Herzstein will coordinate the Committee's activities.

In your capacity as Chair of the Evaluation Committee, you will be requested to function in accordance with the enclosed appendix.

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

I wish you much success in your role as the Chair of this most important committee.

Sincerely,

Dr. Avital Stein
Director General,
The Council for Higher Education

Enclosures: Appendix to the Appointment Letter of Evaluation Committees

cc: Ms. Michal Neumann, The Quality Assessment Division
Ms. Yael Herzstein, Committee Coordinator

\P.O.B 4037, Jerusalem 91040, ISRAEL. Fax: +972-(0)2-5094686. Tel: +972-(0)2-5094500\02 .טל ,91040 ירושלים ,4037 .ת.ד
www.che.org.il | email: director-general@che.org.il