The Initiative for Applied Education Research

Insights from Past Initiatives to Promote Science Education in Israel

Learning from Selected Issues

Coordinated and Edited by:
Niv Strauss

Project Report — Summary

The Initiative for Applied Education Research
The Israel Academy of Sciences and Humanities

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Unrevised Translation from the Hebrew Original

Jerusalem, 2017

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The Israel Academy of Sciences and Humanities was founded in 1959. Its membership currently comprises close to 100 top Israeli scientists and scholars. The Israel Academy of Sciences and Humanities Law, 1961, declares that its principal objectives and tasks are to foster and promote scientific activity; to advise the Government on research activities and scientific planning of national importance; to maintain ties with foreign academies of science; to represent Israeli science at international institutes and conferences; and, to publish articles that can further science.

The Initiative for Applied Education Research (the Initiative) places up-to-date, scientific, critically-appraised knowledge and information at the disposal of decision-makers in the field of education. This kind of information is crucial for the intelligent formulation of policy and for optimal planning of interventions to improve educational achievements in Israel.

The Initiative's vision: Research knowledge is an essential component for planning public policy or comprehensive interventions. In the planning phase, critically-appraised research knowledge supports the formulation of policy whose chance of success is greater, and at a later point, enables rational public discourse to take place. The Initiative implements this vision in the field of education.

The Initiative's method of operation: The issues the Initiative addresses are those raised by decision-makers and it consults with senior Ministry of Education officials and other stakeholders. The Initiative's steering committee, appointed by the president of the Israel Academy, is responsible for the Initiative's work program and the peer-review processes of documents it creates. The Initiative operates by means of expert committees and by convening joint symposia for researchers, professionals in the field and decision-makers. It publishes a variety of reports and makes them available to the public. Members of expert committees carry out their work on a voluntary basis.

History of the Initiative: The Initiative was established in late 2003 as a joint venture of the Israel Academy of Sciences and Humanities, the Ministry of Education, and the Rothschild Foundation (Yad Hanadiv). Since the beginning of 2010, the Initiative has been operating as a unit of the Israel Academy. In the summer of 2010, the Israeli Knesset amended the Israel Academy of Sciences and Humanities Law, regulating the Israel Academy's advisory role vis-a-vis government ministries seeking its consulting services. The Initiative directs the consulting activities on education related issues which the Israel Academy provides to the government and various authorities.

THE TRUMP FOUNDATION
קרן טראמפ

The Trump Foundation was founded in 2011 to help the education system in Israel stem the decline in excellence in the study of mathematics and the sciences in secondary schools, and to nurture significant improvement.

The foundation sees its mission as addressing a national call, aimed at enabling Israel to catch up to the world's leaders in educational achievement and better position itself towards the second quarter of the 21st century. For this purpose, the foundation chose to invest in teachers and teaching. This stems from an understanding that there is no shortcut to an outstanding teacher who makes all the difference. Therefore, our strategic plan seeks to foster and instill **high quality teaching**, and make it more accessible.

We strive to help teachers enhance their teaching practice. In order to do this we work with teachers, schools, educational organizations, school networks, districts and local government authorities, as well as universities, colleges, hi-tech companies andthe national government, to transform the decline into growth and to firmly establish the desired improvement.

About the Learning Process

In response to a request by The Trump Foundation, the **Initiative for Applied Education Research** engaged in a joint learning process for researchers and professionals in order to study from policy and development processes that have taken place in Israel during the last thirty years to improve science education, in general, and promote excellence, in particular.

Promoting mathematics and science education in Israel, beginning in early childhood and up to the secondary school stage, is an important component of educational goals and practice in Israel. However, while Israel, considered a "Start-Up Nation" has acquired an international reputation for excellence in innovation and research and development based on mathematics-science education, its students are ranked as middling on international tests that examine knowledge in math and science such as PISA, and the percentage of outstanding students in Israel is not high.

In line with worldwide trends, mathematics and science education in Israel has experienced many changes throughout the years. These changes reflect prominent advances that have occurred in research and development in the field, as well as progress in knowledge about learning that have accrued over time. Some changes are the result of processes taking place outside the field of education (such as growth and change in the composition of the population of learners), and some stem from processes within the education system (for example, changes in the curriculum). Among the changes that affected curricula and how they are organized, some (such as the middle school reform) apply to all the subjects studied in the education system, and some (for example, the addition of "STS" – Science and Technology in Society studies) are unique to science and mathematics education. However, it appears that in Israel, a culture and tradition of learning lessons from past experiences has not yet been developed, and at times, consideration of issues of continuity or innovation in reforms announced is limited.The learning process was designed to place current practice in the field of mathematics and science education within the context of time-society-education, with the assumption that understanding relevant connections will benefit policy makers and practitioners to better direct their practice. It would also enable establishment of an infrastructure for future learning based on past processes and present experience.

The learning process, which took place in 2016, included three study sessions. The first meeting addressed "Tomorrow 98" as an example of science education reform. The second meeting discussed the importance of science education among institutions external to the Ministry of Education – philanthropic organizations, education networks and local authorities. The third meeting was concerned with the topic of teachers and their role in science education reforms.

The activity was led by a team of experts which included academic researchers and professionals from the field. Also taking part in the activity was a permanent "core group of learners", comprised of two teachers and six senior officials from the Ministry of Education. Apart from these, other professionals and stakeholders involved with this issue were invited to the sessions.

It is important to stress a prominent fact evident throughout the activity – namely, that many of the stakeholders and professionals participating in the learning process were, in one way or another,

connected to the science teaching centers which, since the 1960s, have been developing research, knowledge and joint practice together with practitioners in the areas of science teaching (there are no similar centers for subjects outside the areas of science, technology and mathematics).

The activity was carried out with the full cooperation of the Trump Foundation, which also provided the funding.

Expert team members:

Prof. Israel Bar-Joseph (Chair), Weizmann Institute of Science

Ms. Shlomit Amichai, "Chotam" program

Prof. Benny Geiger, Weizmann Institute of Science and Israel Science Foundation

Prof. Shaul Hochstein, Hebrew University of Jerusalem

Ms. Esther Magen, Ostrovsky High School and Weizmann Institute of Science

Members of the "core group of learners":

Ms. Bayan Abu Katish, Hand in Hand School, the Center for Gifted Pupils in East Jerusalem, and "Amirim" program

Dr. Noa Cohen Eliyahu, Leyada High School, Hebrew University of Jerusalem and Jerusalem College

Sheikh Muhana Fares, Ministry of Education

Ms. Dalia Fenig, Ministry of Education

Dr. Miri Gottlieb, Ministry of Education

Dr. Hannah Perl, Ministry of Education

Mr. Moti Taubin, Ministry of Education

Ms. Meirav Zarbiv, Ministry of Education

Activity Coordinator: Niv Strauss

Acknowledgements

This report is the fruit of many people's labor who assisted me, voluntarily, all through the learning process and generously contributed of their time, experience and expertise: Academicians, Ministry of Education officials, teachers, and others. I would like to thank all those without whom this report would not have been realized.

Expert Team Members

I am grateful to Professor Israel Bar-Joseph, Team chairperson, vice president for resource development at the Weizmann Institute of Science, dean of education at the Institute, and Department of Physics researcher in the area of condensed matter, for devoting so much of his time to the success of the activity and for giving his all to our mission – in leading the learning process and guiding it with dedication, responsibility, wisdom and in a courteous manner. I also give heartfelt thanks to the rest of the team members for their fruitful cooperation all throughout the activity and for the great assistance they extended to me while investing their utmost time and energy: Professor Benny Geiger, researcher in the Department of Molecular Cell Biology at the Weizmann Institute of Science and chairperson of the Israel Science Foundation; Professor Shaul Hochstein, researcher in the Neurobiology Department of the Life Sciences Institute and the Safra Center for Brain Sciences at the Hebrew University of Jerusalem; Ms. Esther Magen, physics teacher at the Ostrovsky School in Ra'anana and project coordinator and member of the physics group in the Science Teaching Department at the Weizmann Institute of Science; Ms. Shlomit Amichai, chairperson of the HOTAM (Teach First Israel) project and former director general of the Ministry of Education.

Members of the "Core Group of Learners"

The "core group of learners" included education professionals – teachers and senior Ministry of Education officials – whose participation in the learning process made a significant contribution to imparting important insights on the topics deliberated within the framework of the activity. I would like to thank all the members of the core group for taking part in the learning sessions and assisting me throughout the process with advice and by providing ideas for appropriate speakers to address the learning sessions: Ms. Bayan Abu Katish, sciences teacher at the Hand in Hand bilingual school in Jerusalem, director of the Center for Gifted Children in East Jerusalem, and an instructor in the Amirim program, the Ministry of Education's (MOE) Division for Gifted and Outstanding Students; Dr. Noa Cohen Eliyahu, mathematics teacher at the Hebrew University High School ("Leyada") in Jerusalem and lecturer in the School of Education at the Hebrew University of Jerusalem and at the Michlala Jerusalem College; Sheikh Muhana Fares, director of the Division of National Programs and Projects at the MOE; Ms. Dalia Fenig, deputy chairperson of the Pedagogic Secretariat and director of Division A for Pedagogical Development at the MOE; Dr. Miri Gottlieb, director of Division A for Education Employees' Professional Development at

the MOE; Dr. Hannah Perl, outgoing director of the Pedagogic Secretariat's Sciences Division at the MOE; Mr. Moti Taubin, head of the Strategy Division at the MOE; Ms. Merav Zarbiv, director of the Division of Research and Development at the Experimental Schools and Educational Initiatives at the MOE. I wish to express my special thanks to Sheikh Muhana Fares and to Dr. Miri Gottlieb for the lectures they gave at the seminar we held within the framework of the learning process and for the background materials they prepared ahead of the seminar.

The Speakers and Guests at the Learning Sessions

I thank all of the speakers at the learning sessions who invested much of their time in preparing instructive lectures, writing impressive background materials ahead of the sessions, and traveling long distances from all ends of the country to the venues where we met in order to share of their rich and priceless knowledge and experience with us. Likewise, I extend my thanks to the other guests who responded to my invitation to take part in the sessions and contributed much from their knowledge and experience to the discussions held during the sessions.[1]

The First Learning Session

Speakers: Professor (Emerita) Miriam Ben-Peretz, Faculty of Education at the University of Haifa; Ms. Shoshy Cohen, former MOE chief inspector for science and technology instruction in primary and middle schools; Professor Bat-Sheva Eylon, researcher in the Science Teaching Department at the Weizmann Institute of Science; Professor Haim Harari, past president of the Weizmann Institute of Science and chairperson of the Higher Committee for Science and Technology Education ("Tomorrow 98," 1992). I would like to express my special thanks to Prof. Bat-Sheva Eylon for the extensive assistance she gave me and the expert team that continued even after the first learning session – with advice regarding speakers suitable for the second learning session and in providing feedback to the scientific literature review commissioned by the expert team on the topic of "Tomorrow 98" – the report and its implementation.

The Second Learning Session

Speakers: Ms. Irma Ben Moshe, director of the *Eshkol HaPayis* Center for Sciences, Technology and the Arts in Ma'ale Adumim; Dr. Amos Cohn, academic-pedagogic director of the Acheret Center (Arab-Jewish Center for Physics Research in the Galilee), director of the "Archimedes Fulcrum" *Beit Midrash* (house of study) and lecturer in physics and science teaching at Oranim College of Education; Ms. Ayelet Dlayot, director of the Department of Innovation and Program Development in the Education Administration in the city of Ra'anana and advisor to the mayor of Ra'anana on the advancement of women; Dr. Eli Eisenberg, senior deputy director for research, development and training at the ORT Israel network; Mr. Shmuel Har Noy, director general of the

[1] The names of the speakers and guests appear in the sections which describe the session in which they participated; their names are listed alphabetically by surname.

Zefat Academic College and former director of the Madarom (Science in the South) project – a joint project of the Rashi Foundation and the Ministry of Education; Mr. David Sharet, director of the Education Division in the Ma'ale Adumim municipality; Ms. Anat Shayer, coordinator of the Haifa municipality's Department for Educational Empowerment program to promote sciences study and eligibility for matriculation; Mr. Muhana Tafesh, head of the Education Administration in Beit Jaan.

Additional participants: Ms. Orit Cohn-Snir, anthropologist, researcher and developer in the field of sciences teaching; Mr. Avi Grossman, director of the northern district at the "A Different Lesson" association; Mr. Yoram Hamo, strategic planner, Brigadier General (Res.) (who also took part in the third learning session); Dr. Gilmor Keshet, incoming director of the Sciences Division of the Pedagogic Secretariat at the MOE (also participated in the third learning session); Ms. Rivi Lakritz, MOE director of "Youth for the Sciences" and inspector for the *Eshkolot HaPayis*; Ms. Zafit Lukach, regional pedagogic coordinator of the Galilium project; Mr. Liran Melzer, director of partnerships with cities and education networks at The Trump Foundation; Ms. Shahar Rosenak, coordinator of the Collective Impact area at the 5p2 Project; Ms. Orna Somech, project manager at the 5p2 Project at the Sheatufim Association; Ms. Hana Stempler, director of the KIAH (Alliance Israélite Universelle) organization's "Breaking the Glass Ceiling" program in the Division of Excellence.

The Third Learning Session

Speakers: Dr. Aliza Bloch, principal of the Branco Weiss Network of Six-Year Schools; Dr. Yaron Lehavi, lecturer at the David Yellin Academic College of Education and head of the National Center for Physics Teachers at the Weizmann Institute of Science; Dr. Nir Michaeli, rector of the Oranim College of Education; Dr. Michal Nachshon, chief inspector, "Science and Technology for All," Academic Track, MOE; Dr. Irit Sadeh, chief inspector for biology at the MOE; Dr. Tili Wagner, head of the clinical programs to train math and physics teachers at the Beit Berl Academic College.

Additional participants: Dr. Bruria Agrest, faculty member (ret.) in the School of Education at Bar-Ilan University and former chief inspector for biology at the MOE; Ms. Revital Drori, head of partnerships at The Trump Foundation; Dr. Hagar Gal, senior lecturer and head of the Master's (M.Teach) program and the "From One End to the Other – Teaching Students Gifted in Math and Science" program at the David Yellin Academic College of Education; Dr. Dvora Katchevich, director of the National Center for Chemistry Teachers at the Weizmann Institute of Science; Dr. Miri Kesner, former head of in-service education for the science and math teachers area at the Davidson Institute for Science Education's Hemda (science education) unit; Dr. Aurelie Lachish-Zalait, director of the teachers unit at the Davidson Institute for Science Education; Ms. Smadar Levy, physics teacher and PhD student in the Department of Science Teaching at the Weizmann Institute of Science; Ms. Nurit Ron, director of the implementation assessment of the Research & Development Division at the MOE; Dr. Zahava Scherz, faculty member in the Department of Science Teaching at the Weizmann Institute of Science.

The Seminar

I thank all of the speakers at the seminar dedicated to summing up the learning process who, with their fascinating lectures, helped us hold an interesting and instructive event. I also thank them for the abstracts they prepared ahead of the seminar – abstracts which make up a significant portion of this report. Aside from the five expert team members and the two members of the "core group of learners" who gave lectures at the seminar, I would like to convey my heartfelt thanks to the rest of the speakers: Professor Yehudit Judy Dori, dean of the Science and Technology Education Faculty at the Technion and a senior researcher at the Samuel Neaman Institute for National Policy Research; Professor (Emeritus) Avi Hofstein of the Weizmann Institute of Science; Mr. Eli Hurvitz, executive director of The Trump Foundation and a member of the National Education Committee; Dr. Sara Klein, lecturer in the fields of science and teaching science at the Orot Israel College of Education and at the Hemdat HaDarom College of Education; Professor Marcia C. Linn, professor of development and cognition at the Graduate School of Education at the University of California, Berkeley (US); Ms. Ganit Richter, lecturer and PhD student at the University of Haifa and lecturer in the MBA program at the Open University; Ms. Haya Shitay, director of the MOE's Tel Aviv district; Dr. Bat Chen Weinheber, director of the Mifras incubator for education initiatives; Professor Menahem Yaari, chairperson of the Initiative for Applied Education Research's steering committee and president (Emeritus) of the Israel Academy of Sciences and the Humanities; Professor Anat Zohar, incumbent of the Besen Chair at the Hebrew University of Jerusalem School of Education and a faculty member at the Mandel School for Educational Leadership; Dr. Heftsi Zohar, deputy mayor and acting mayor of Beersheba, responsible for the municipality's education and welfare portfolios. Naturally, I convey my thanks to all those who honored us with their presence in the seminar audience – participants too numerous to name in this limited space.

Scientific Literature Review Authors

I thank the authors of the three scientific literature reviews commissioned by the expert team within the framework of the learning process. The reviews we received are comprehensive and of high quality and I am grateful to their authors for investing so much effort in collecting the information, writing, editing and revising review drafts to the complete satisfaction of the expert team members and the Initiative for Applied Education Research. My thanks go to Dr. Sara Klein who wrote the scientific literature review on "Tomorrow 98" – the report and its implementation; Dr. Daphne R. Raban and Ms. Ganit Richter who wrote the review on changes in mathematics and sciences curricula and in the knowledge about their learning and instruction in Israel – in light of developments around the world regarding knowledge about learning and the view of the teacher's and the education system's role and, to the MOFET Institute team which composed the review on the topic of successes and failures of science education reforms abroad: to Dr. Daniel Sperling for the writing, to Professor Avi Hofstein for the academic advice, and to Dr. Liat Josefsberg Ben-Yehoshua for managing the review writing process and its editing.

The Trump Foundation

Great thanks are conveyed to The Trump Foundation for enabling the learning process to take place. I thank the entire Foundation staff for their fruitful cooperation during this past year, and in particular Mr. Eli Hurvitz, executive director of the Foundation and Dr. Tammy Halamish Eisenmann, the Foundation's program director – for closely following the effort all throughout the activity, for their presence at the learning sessions and for their significant contribution in enhancing the final products of this activity.

Additional Contributors to the Learning Process

All through the year, I received guidance, advice and assistance with different aspects related to the learning process from many people who did not take part in the learning sessions. I would like to thank all those who showed their good will and helped me when I asked and those who, on their own initiative, contacted me: Mr. Danny Bar-Giora, director of the Mandel School for Educational Leadership, who helped me in locating suitable speakers for the second learning session and was even prepared to be a speaker himself at the session – a plan that did not materialize due to his prior commitments; Mr. Avi Kaminski, deputy director for Education, CYS (Culture, Youth and Sport) and Welfare at the Hod Hasharon Municipality and chairperson of the Association of Education Department Directors, who assisted me in disseminating a request for information among directors of education departments in local authorities in Israel; Mr. David Maagan, head of the Higher Education and Teaching Manpower Statistics area at the Central Bureau of Statistics, who contacted me in order to present data on the topic of science education to the expert team; Dr. Deborah Pal, lecturer in the sciences at the Zefat Academic College and lecturer in science instruction at the Arab College for Education in Israel – Haifa, who contacted me and shared her insights regarding implementation of "Tomorrow 98" in light of her experiences from in-service courses for teachers conducted within the framework of the report's implementation; Mr. Eyal Ram, deputy director and director of the Teaching Personnel Administration at the MOE, who wrote a comprehensive background paper on the topic of "Where will Teachers for the 5p2 Program Come From?," as background material for the third learning session; Dr. Dan Sharon, a past director general of the MOE, coordinator of the Higher Committee for Science and Technology Education ("Tomorrow 98", 1992)[2], and founder of the Branco Weiss Institute, who met with me and offered advice regarding organization of the learning sessions; Dr. Varda Shiffer,

[2] We thank Dr. Dan Sharon for bringing the following details to our attention:
Dr. Dan Sharon served as advisor on matters of science and technology to Mr. Zevulun Hammer, the Education and Culture Minister. Dr. Sharon also initiated the establishment of the committee, served as its coordinator and formulated its recommendations. Within the framework of the Branco Weiss Institute, he was later responsible for implementing the committee's conclusions in the Western Galilee, at the *Zavit Rehava* ("Wide Angle") Teacher Center. At the request of Professor Haim Harari, Minister Hammer in advance pledged to allocate a budget towards activities that would emerge from the committee's conclusions, and this was indeed the case. It is fitting to mention the contribution of Mr. Nachum Blass who provided the data for the committee's activity and wrote the appendix regarding the budget. It is likewise fitting to thank Ms. Esther Kneller and Ms. Zvia Abuhazeira who were responsible for all the organizational work and production of documents throughout the committee's operation.

senior research fellow at the Van Leer Institute in Jerusalem, who advised me with respect to appropriate speakers for the second learning session.

The Initiative for Applied Education Research Staff

I am, obviously, very grateful to the entire staff at the Initiative for Applied Education Research who were at my side throughout the learning process and extended their help with whatever I needed: Dr. Avital Darmon, executive director of the Initiative, who worked tirelessly for the success of the learning process, devotedly provided me with professional guidance and was always available for any question I might have; Mr. Uri Charush, administrative manager at the Initiative, who handled all the of the activity's ongoing operational issues behind the scenes and assisted me in organizing the learning sessions and the seminar; Ms. Ada Paldor, the Initiative's language editor, who carried out professional, thorough and learned editing of the many materials that were used throughout the activity; Ms. Ayala Vlodavsky-Yovel, the Initiative's production coordinator, who managed the Internet page for the activity and provided me with support in producing the materials all throughout the year; my colleague, Mr. Oded Busharian, who coordinates another Initiative activity and advised me with respect to the activity and supported me all along the way.

I, likewise, wish to thank the staff of the Israel Academy of Sciences and Humanities for their help with respect to the Initiative's operations, in general, and for holding this learning process in particular, and to "Yad Hanadiv" for their ongoing professional assistance with the Initiative's activities.

The report was subject to the customary process of independent peer review. The report editor is appreciative of the review, which helped ensure its clarity, its quality and its independence. Responsibility for the report's contents rests solely with its editor.

Niv Strauss, Activity Coordinator

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[3] The Table of Contents lists the sections of the complete Hebrew-language report. The sections included in the English-language summary appear in black font while the sections included only in the Hebrew-language report appear in gray.

The Trump Foundation Remarks

> *"We are like dwarfs sitting on the shoulders of giants. We see more, and things that are more distant than they did, not because our sight is superior or because we are taller than they, but because they raise us up, and by their great stature, add to ours."*
> *John of Salisbury*

That was the spirit of the remarks made by the wise and experienced Shlomit Amichai as we started our journey as a philanthropic foundation supporting science education in Israel. "Many good people before you," she began, "giants of their generation pioneered, led, attempted, at times succeeding more, at times less. Learn from their wisdom, draw from the lessons they learned," she recommended, "stand on the broad shoulders of their experience."

The attempt to strengthen science education in Israel crystallized once again in recent years, and this time around a common goal: To arrest the deterioration in excellence and to jumpstart significant growth. This is a national maneuver the government is decisively and unswervingly leading together with dozens of organizations and many hundreds of teachers, schools, local authorities, universities, corporations, and others.

This maneuver, important and exciting as it may be – and it is indeed important, and thus far, even successful – is still one more step on a long road, another link in the generational chain. We, therefore, decided together, all those involved in its realization, individuals from all areas of endeavor, to attend to the echoes of the past and to learn from those who came before. Together, we learned that it is advisable to remember and to retell what clever and good people who thought deeply did, that they labored with skill and effort and attained impressive achievements. These achievements represent the infrastructure and basis of all our activities today.

We wish to especially thank Professor Israel Bar-Joseph for leading this joint and sharing learning process with diligence, determination and sensitivity, as well as the dear members of the expert team, and the learning group. Heartfelt thanks to the Initiative for Applied Education Research, part of the Israel Academy of Sciences and Humanities, for their great seriousness, skill and commitment to a professional and critical process like no other.

I will close with the hope and prayer that we will have the good sense to show respect for our elders by learning from those who preceded us and that with the help of their knowledge and rich experience, we will be able to see into the distance, for the benefit of those who follow.

Eli Hurvitz, Executive Director

The Trump Foundation

Abstract

This report summarizes an activity whose objective was to formulate insights useful for promoting science education in Israel. The insights derived were based on past initiatives whose goal was to change education system policy. The expert team chose to focus on three selected issues: 1) "Tomorrow 98" as an example of science education reform; 2) the importance of science education among institutions external to the Ministry of Education – philanthropic organizations, education networks and local authorities; 3) teachers and their role in science education reforms. In addition to these, the expert team sought to learn from science education reforms carried out abroad. The topics discussed in the report were selected at the discretion of the expert team members. Naturally, within the amount of time available to the team it was not possible to examine all of the issues related to promoting science education in Israel and thus, the report does not presume to present an exhaustive review of all the topics worthy of inclusion in a discussion in this context. **The team's insights that appear in the report are based on content from learning sessions that were held within the framework of this activity, team members' professional experience, the views of team members, and information gathered from the scientific literature reviews commissioned by the team. They are not based, however, on a comprehensive and critically appraised summary of the literature in the field.** Below is a summary of the main insights contained in the report.

"Tomorrow 98" as an example of science education reform: The "Tomorrow 98" report (Ministry of Education and Culture, 1992) and the reform that followed in its wake represent a significant milestone in the development of science and technology instruction in Israel. From the example of "Tomorrow 98," the expert team learned that education reform must be rooted in a vision, have a clear definition of the changes needed to the existing situation, goals, and a plan of work. In the team's estimation, the experience accumulated from the "Tomorrow 98" implementation indicates that it is preferable for a program for reform to be articulated more as a statement of principles that serves as a point of departure for a change process in the education system, and less so as a detailed recipe for action. From the case of "Tomorrow 98," the team also learned that successful implementation of education reform is dependent on the ability to adapt the reform to evolving reality. In order to make modifications, ongoing long-term follow-up of the reform's implementation must be conducted. The team believes that the preferred mechanism for updating reforms is an independent body vested with authority that would operate within the Pedagogic Secretariat at the Ministry of Education, and that establishment of such an entity would be able to uproot the Ministry of Education's tendency to invalidate reforms after changes in personnel that occur in the Ministry's leadership. With respect to the influence of "Tomorrow 98," it would be too simplistic a determination to state that its implementation "succeeded" or "failed." There is no doubt that a portion of "Tomorrow 98's" goals were not achieved and it appears this was the case due to how it was implemented as well as to a number of aspects in the reform report which presented obstacles. For example, the fact that the report recommended that the "Science and Technology for All" subject (in middle school) be taught for six weekly hours was its undoing

since its broad scope made it an easy target for cutbacks. Other features that were obstacles to the report's implementation were the lack of sufficient consideration of the complexity of implementation, excessive detail regarding the method of operation in parts of the report, non-development of appropriate tools for developing teacher communities, lack of reference to the tier of school principals and the importance of local authorities in advancing science education in Israel, lack of authorized entities whose objective is professional, controlled and long-term implementation of the report, and absence of mechanisms for continuous follow-up of the reform implementation and periodic assessments of its achievements. In the team's opinion, such mechanisms are required in order to consistently examine the new circumstances brought about by changing reality and to intelligently adapt reforms such as "Tomorrow 98" to developments occurring the world over. Furthermore, perhaps the idea of the interdisciplinary teacher – an idea the report attempted to advance – was too presumptuous, but closure of the regional teacher centers certainly did not contribute to realization of this idea. One of the main lessons learned from the "Tomorrow 98" implementation is that planning an education reform cannot focus exclusively on science and technology subjects but rather, must be based on a systemic view that takes all components of the education system into account. Another lesson which emerges from this issue is that the Ministry of Education must make a long-term commitment to the reforms it institutes. In spite of the above, the expert team believes that the "Tomorrow 98" reform brought about important successes: Development of learning materials which express the balance and integration between different scientific disciplines, formulation of a curriculum that emphasizes scientific-technological literacy, and more.

The importance of science education among institutions external to the Ministry of Education – philanthropic organizations, education networks and local authorities: The team believes that the education system's lack of resources combined with the absence of a guiding hand that would outline the Ministry of Education's clear policy regarding curricula, leads to an ongoing process of decentralization of science instruction and to the creation of a void at the local level. Increasingly, philanthropic foundations, some seeking to promote a certain agenda, are penetrating this void. On the one hand, the decentralization described and local authorities' decreasing dependence on Ministry of Education monies stream new resources into the education system and enable unique and local needs to be perceived and formulation of special courses of action that are adapted to the local reality. Philanthropic organizations also help promote particular topics which the Ministry of Education does not always handle optimally. On the other hand, the above-mentioned decentralization leads to a discernible variation in the quality of instruction, its subject matter, and values between the different local authorities. Moreover, given that the activity of philanthropic organizations is not uniform throughout the system, in all likelihood it increases inequality. Not infrequently, it turns out that the Ministry of Education does not have the personnel that would allow it to be an active partner in joint projects together with philanthropic foundations and it transpires that it operates as a secondary, at times even restrictive, entity instead of being a partner in leading the project. The activity of these entities tends to be limited in time while the Ministry is, in general, not adequately prepared in order to take over and continue the foundations' initiatives over the long-term. The conclusion that emerges from the above is that the Ministry of Education must operate

as a regulator of curricula and limit its role as an operator to those places where concentrating its resources has added value, to those places where its activity will contribute to reducing the inequality in the education system.

Teachers and their role in science education reforms: It appears that there is broad consensus regarding the importance of ongoing professional development for teachers. However, it is the team's impression that there is a wide gap between this position and its actual implementation. This is seen in the nature of the employment contracts with teacher unions – agreements which are characterized by their concern with issues of remuneration, occasionally at the expense of pedagogic values. The closure of the regional teacher centers along with the Ministry of Education's withdrawal of support for the national centers represent the manifestation of this gap. The teacher communities developing of late are a positive attempt to offer a solution to the blows teachers' professional development has sustained. At the same time, these communities do not constitute an alternative to reinforcing the national teacher centers and to creating a unifying regional or municipal framework. Moreover: It should be noted that in the final analysis, any change in the education system affects the teaching and learning processes, at the center of which is the teacher. The frequent changes in the Ministry of Education's messages which accompany change in ministers and in the Ministry's leadership, generates suspicion among the teachers. In addition, with the involvement of teachers in designing change processes, local needs are taken into account, and this is very critical to the success of education system reforms. Another issue with many implications for the education system, in general and for science teachers, in particular, is **administrative autonomy**. In the "Meaningful Learning" reform and other steps taken by the Ministry of Education, there is a distinct trend of transferring greater responsibility to school principals. Nevertheless, the Israeli education system is still rather centralized. In view of the changes taking place in the field of education as well as in society, and in light of the challenges they present, it would seem that the autonomization process of schools is an unavoidable development. Such autonomy, if it comes to fruition, must affect both administrative and pedagogic aspects and at the same time, stress the role of the Ministry of Education as a regulating and balancing body.

General insights: The chance of education reform meeting with success grows when it is a systemic reform containing multiple and broad targets and includes a new curriculum, a framework for teacher evaluation, and professional development programs. It is important for the reform's aims to be clear and that the courses of action for implementing the aims be determined within the reform framework. Nonetheless, success of the reform is not measured by the ability to fully realize all its aims but rather, depends on the scope of realization of its various goals – in different areas and among different populations. When developing reform, cultural, conceptual and organizational aspects of the environment in which the reform will be implemented should be taken into account. In addition, it is important for decision makers, experts and professionals to be involved in all stages of the reform. The success of reforms hinges on continually carrying out learning and evaluation as well as carefully examining the areas of study and the subjects tested, along with attention to the ideological-value background of these fields and topics in society.

The possibility that promoting "science education for all" may conflict with promoting excellence in science education must also be considered.

Structure of the report: The report contains five chapters. The topic of the first chapter is "Tomorrow 98" as an example of science education reform. The second chapter discusses the importance of science education among institutions external to the Ministry of Education – philanthropic organizations, education networks, and local authorities. The third chapter concerns teachers and their role in science education reforms. Each one of these three chapters includes a summary of the learning session held on the topic the chapter addresses, a summary of the expert team's remarks delivered by one of the team members, responses to the team's remarks made at a seminar the team held, and a summary of the discussion with the audience at the seminar, which was held at the end of the session addressing the chapter topic. The first and third chapters also include abstracts of scientific literature reviews commissioned by the team on the topic discussed in the chapter. The fourth chapter deals with learning from science education reforms abroad and is based on a scientific literature review the team commissioned on the topic and on a lecture delivered at the seminar by a guest speaker from abroad. The chapter also includes a summary of the discussion held with the audience at the seminar, following the guest lecture. The fifth and final chapter presents the expert team's general insights regarding the implementation of reforms and the Ministry of Education's reaction to these insights.

Scientific Literature Review Abstract: "Tomorrow 98" – The Report and its Implementation[4]

Sara Klein

The "Tomorrow 98" report was written by the Higher Committee for Science and Technology Education, which was appointed in 1990 by the then Minister of Education and Culture, Mr. Zevulun Hammer. The Chairperson of the Committee was Professor Haim Harari, President of the Weizmann Institute of Science. The Committee's mandate was to examine the status of science and technology education in Israel, and to recommend new programs and special projects with the goal of promoting Israeli science and technology education towards the 21st century.

The publication of the "Tomorrow 98" report in 1992 inaugurated a new period in science education in Israel. The essence of the report is: Perception of science and technology as a single entity, technology as an applicative aspect of science, and emphasizing scientific principles for all students, at all ages ("Science for All"). The report's vision has been and still serves as a base for the science education system in Israel, which is dynamic and strives towards excellence.

The present review deals with implications and consequences of the "Tomorrow 98" report over the years, including two issues: **mathematics and science & technology education** and **the teachers – training and professional development** (focusing on junior high school and senior high school).

The review is based on three sources: official documents – Ministry of Education, Central Bureau of Statistics and State Comptroller; studies of the Henrietta Szold Institute and periodicals in the field of science education; Interviews with directors, supervisors and instructors in the field of science education.

Following are the major findings of the review:

A. Mathematics, science & technology education injunior high school

1. **Science & Technology curriculum:** The curriculum published in 1996 served as a basis for science & technology curricula in the coming years, until the present (2016). The curriculum is comprised of several central subjects. Its rationale is spiral, following elementary school education, and characterized by an interdisciplinary approach centered on the main topics. The 1996 curriculum gives autonomy to the teaching staff to create a variety of **combinations of teaching sequences**. Its implementation has faced many difficulties due to the lack of multidisciplinary and interdisciplinary knowledge of the teachers. Teaching a unified Science and Technology course led to a lot of student misunderstanding of the constituent subjects: physics, chemistry, biology and technology. Indeed, the essence of science and technology has not been made clear to the students. In 2009 a new program was designed, and since then the curriculum has been upgraded and updated each year. The present curriculum is

[4] This abstract was translated by the author.

characterized by growing clarity and specificity in wording and explicit reference to the basic disciplines: Physics, Chemistry, Biology and Technology. In recent years there is an increase in centralization of the Ministry of Education, and reduction in the extent of autonomy given to the school teaching staff.

2. **Science and technology for all:** The idea of giving a chance of studying science and technology to everyone, so that they all may contribute to society, is manifest in the curriculum and textbooks, and particularly in local and national projects, implemented by the Ministry of Education. As examples are: The Competition in Astronomy and Space in memory of Ilan Ramon, and the National Exhibition of Science & Technology. These projects reflect the interdisciplinary context of science and technology, and serve as learning environments for developing science and technology literacy. Moreover, these projects give opportunity to all groups of students from all over the country, to prove their abilities and creativity in science and technology.
3. **Educational projects for enrichment and excellence:** Fostering excellence, generally, and particularly in mathematics and science, is one of the explicit goals of Ministry of Education. A special project is Atuda (future reserve) for scientific-technological leadership. The aim of this project is to enhance learning mathematics, science and technology for talented students, so that they can specialize in the sciences in senior high school.
4. **Student achievement:** Israeli junior high school students are tested in three national or international exams: The national exam: Meitzav, and two international exams: TIMSS and PISA. Achievements in mathematics and science technology are measured and summarized in an annual report for each exam. Following are main common findings (Meitzav 2014-2015, TIMSS 2011, and PISA 2012): In the three exams there is improvement in student grades, in both mathematics and science. Israel improves its relative location among the OECD countries. However, in Israel, there are continuous sectorial, gender and socio-economic gaps in the achievements.
5. **Facilities for science and technology in junior high school:** In many schools there are laboratory facilities and computers for teaching, which require updating and upgrading. Still, in many other schools, experiments and projects are carried out at regional Art and Science Centers. (These centers were first built in 1998 as alternatives for particular laboratories in every school, as recommended in the "Tomorrow 98"report sections a/6, b/6.)

B. Teachers

1. As background to the section regarding teachers the report brings data concerning **students majoring in science**, and thus taking 5-unit science Matriculation exams. The main finding is a decrease since 2001 in percent of students taking the 5-unit Matriculation exams in: Mathematics, Physics and Computer Sciences.
2. **The teachers:** a. Over the ten-year period 1999-2009, there is a decrease in number of teachers in: Physics, Chemistry and Computer Sciences, while there is an increase in number

of mathematics, biology and technology teachers b. Over the same period, there have been changes in the proportion of younger and older high school mathematics and science teachers: There has been a considerable increase of the percentage of older teachers (ages 55 or above) from 9.9% in 1999 to 19.9% in 2009, whereas the percentage of younger teachers (ages 35 and under) decreased from 24.6% in 1999, to 21.5% in 2009 c. There is a continuous need for Physics teachers.

3. **Teacher Training:** There are faculties for science teacher training in the university and academic colleges of education. There are special programs of career change for university graduates, such as the *Chotam* (Teach First Israel) and "The Best for Education" programs. The majority of graduates (90%) in fact become teachers, and 80% on average, continue in teaching at least 5 years after the period of commitment to teach in schools (3 years).
4. **Professional development:** In the beginning of the implementation period of the "Tomorrow 98" Report's recommendations in junior high school (1993-1998), there was a mass of programs of professional development for science & technology teachers. Along the period of 1994-1996, 12,500 teachers took part in such continuing education programs. Over the years since then, there has been a gradual reduction in allocated budget, and thus in the number and duration of such programs (224 hours for a single program in 1994-1999, comparing to 30 hours, today). Teachers' professional development is carried out in two channels: 1. Education programs, organized by the Ministry of Education, and managed by the discipline supervisor, in Pisga Centers (centers for teachers' professional development) or in schools 2. Continuing education programs within teacher centers, as recommended in the "Tomorrow 98" report (b/9, d/6). The teacher centers are located in various academic institutes. The main activity of the teacher centers is fostering communities of teachers, which continuously meet and study together. Some communities, like other unique projects for promoting teacher quality, are supported also by philanthropic foundations, such as The Trump Foundation.

It may be concluded from this review that the "Tomorrow 98" report has had a significant impact over the years since 1992 in many aspects of science education, regarding junior high school education programs and the science teachers. Some recommendations should continue to be implemented, especially those recommendations regarding mathematics studies (a/2, b/2), and those regarding computerization and communications on the national system level (b/5, c/4, c/5, c/6).

Undoubtedly science education in Israel is dynamic. There is a continuous process of assessing, evaluating, and drawing conclusions. The curriculum is updated and upgraded each year, and teachers are guided professionally.

The Ministry of Education allocates significant facilities in strengthening and intensifying student education for abilities and competences of learning science. In recent years there has been a general educational budget reduction, and thus, external sources, such as philanthropic foundations, have become more involved in educational scientific projects, dealing with students or teachers. There has also been a reduction of budget for the"Science Teaching Center" (STC), which was founded in 1967 at the Hebrew University of Jerusalem. The STC goal was to

strengthen and deepen involvement of academic institutions in science education. In light of "Tomorrow 98", at the beginning of its implementation, (from 1994), the STC had vast activity in implementing recommendations, which were based on research and development. Thus, the STC laid the foundation for the new curriculum, 'Science & Technology for All'. Today, the STC concentrates on supporting academically the teacher centers and developing textbooks of science and technology.

From the review one can draw the conclusion that coordination between junior and senior high school should be strengthened, as junior high school is the time for developing scientific thinking, and preparing suitable students for majoring in science. Likewise, the connection between mathematics and science should be intensified, in order to develop mathematical literacy, as an essential component of science literacy.

Scientific Literature Review Abstract: Changes in Mathematics and Sciences Curricula and in the Knowledge about their Learning and Instruction in Israel – In Light of Developments around the World Regarding Knowledge about Learning and the View of the Teacher's and the Education System's Role[5]

Ganit Richter and Daphne R. Raban

The importance of the Israeli educational system is generally acknowledged, however, there is a plurality of opinions concerning the essence of the desirable education, and criticism of the current educational system. Recognizing the importance of science and technology education for adult participation in modern society versus the low rate of students taking high level matriculation exams in mathematics and science, and the fact that most students complete their schooling without substantial scientific skills and understanding, highlights the need to re-examine the appropriateness of curricula to the changing educational needs. The purpose of this review is to study the changes and developments in the junior and senior high school curricula in mathematics and the sciences as of the 1990's in light of international changes and developments of educational approaches such as STS (Science, Technology, Society), science literacy, 21st century skills, and the development of learning theories. This review presents the way in which international developments in learning research and in perception of the role of teachers and of the educational system have influenced curricula in mathematics and science in junior and senior high schools in Israel.

The review contains five parts. Part one is an overview of mathematics and science curricula in junior and senior high schools as they are presented in the Ministry of Education (MOE) web sites. According to the MOE, the sciences include: biology, chemistry, earth science, science and technology in society, mathematics, and physics. The curricula are the professional framework for teaching and learning each subject. Lack of curricula or outdated programs pose an obstacle to the future success of the students based on the 2007 report by the State Comptroller.

Part two describes changes and developments in educational approaches in preparing for the 21st century and accounting for the development of learning theories, from the behavioral/behaviorist approach describing the teacher as a source of knowledge and the student as knowledge acquirer and on to the constructivist theory which disputes the passive image of the learner and stresses the active nature of learning, and including the recognition of learning styles and differing learning strategies. Identifying personal learning style and matching teaching to these preferences may contribute to student involvement in the learning process. Kolb's model and Gardners multiple intelligences are presented here as central in this context. In addition, this part describes the way in which 21st century skills are reflected in curricula.

[5] This abstract was translated by the authors.

Part three covers international comparative assessments in which Israel has taken part since 1991 and reflects on program reforms in several countries. The review briefly describes central principles identified by policy makers in those countries. Each country demonstrates its successful way toward educational improvement as evidenced in international comparative assessments.

Part four focuses on the human factor and briefly examines the changes needed in schools and by teachers in light of the approaches described earlier and the changing student characteristics. The review raises the need for renewed thinking about teacher training and professional development given the expectation that the educational system should adjust to changing needsand reshape the perceptions about teachers and the meaning of learning. This section also raises issues emanating from the educational system's aim to respond to variability among students and describes the manner of adapting curricula in order to fill a variety of student needs. Teacher flexibility in selecting topics and applying teaching continuity, increasing collaboration among students, technology usage, learning assessment, independent project-based learning in teams are some of the ways summarized here for renewing teaching and learning methods. Part four ends with examples from other countries regarding the handling of student variability by teacher training for accommodating various learning styles and levels in a single classroom and student counseling about developing their learning skills.

Lastly, part five expands on learning in the information society by covering topics such as wisdom of crowds, citizen science initiatives, and serious games. Information technologies are designed to enrich teaching but also to blur boundaries between formal learning and the external environment. Citizen science initiatives allow a broad audience to become actively involved in science through computer networks. Rich game environments aid in combining formal and informal approaches and assist in expanding knowledge and understanding even of those students who will not become mathematicians, scientists or engineers in their adulthood. The review provides many examples for serious games in science and technology.

In summary, this is a somewhat critical review of the current state of the Israeli educational curricula in the areas of mathematics and sciences and the processes that led to this state. Relying on reports and articles from Israel and from the world, the review exposes various coping methods to accommodate the rapid changes in the educational environment which beg suitable response from the educational system, including greater reliance on information technology. The review concludes with a list of points which summarize highlights and insights gained from reading the various sources.

Scientific Literature Review Abstract: Successes and Failures of Science Education Reforms Abroad[6]

Daniel Sperling, Avi Hofstein, Liat Josefsberg Ben-Yehoshua

The literature review examines successes and failures of reforms in scientific education from the past three decades in high schools in the US, England, Finland and Singapore, as well as international reforms in the organization of science teaching relating to content and pedagogy, and in particular integration of science, technology and society (STS). The reforms reviewed relate to various areas and their combination, including reforms in curricula and their contents; reforms in scope, frequency and coordination of science education; reforms in the goals of science education (science literacy) and reforms in pedagogy (inquiry-based teaching, problem solving and cooperation-based teaching, interconnected teaching, context-based learning, critical thinking teaching and teaching for interest in learning). The review also covers reforms in teacher training, reforms in evaluation of science education and its components, and reforms in the means and infrastructure of scientific education and its relation to technology.

The review refers to significant reforms in the US, most importantly the formulation of standards for scientific teaching in two central stages. In this respect, a special contribution for the construction of such reforms is identified with non-governmental professional organizations like the American Association for the Advancement of Science. Nevertheless, the literature suggests that the strength and quality of established standards, especially those relating to sensitive and controversial issues such as evolution, do not predict student achievement, since teachers find it difficult to teach following such standards.

With regard to reforms in pedagogy and teaching methods, and their relationship with the goals of science education, the literature review found that context-based teaching as suggested by the Salters reform in England increased the interest in science education and the understanding of its relevancy to practicality and reality while it did not necessarily lead to improvement in student achievement. The STS movement also increased the interest in science education, especially in England and Australia, and it also led to more educational equality and improved access to scientific materials. In contrast, the reform in critical thinking teaching in Singapore had minimal impact on student's critical thinking. Moreover, teachers either refused to implement this new classroom pedagogy, or found it difficult to implement. This reform also did not result in changing the evaluation of science education and its components. Evaluation of reforms in pedagogy and teaching methods also pointed to the fact that some reforms benefited and were well integrated by stronger students, but at the same time created difficult challenges for weaker students.

As to developing and strengthening the relationship between science education and technological education, the Finnish experience suggests that schools did not meet the high expectations of the

[6] This abstract was translated by the authors.

reform and that integration of these new technologies in the educational system was slower than expected, mostly because of diminished interest among teachers or their lack of skills and training.

Analysis of the reforms supports the claim that reforms in science education should be regarded holistically and systematically as purporting to bring about changes in content, teaching methods, preparation of teachers and their development as well as to changes in school-based support. Changing only the curricula can result in diminished interest in coping with the challenges of science education and ignoring the more serious problems concerning the need to support the program and its implementation.

Acknowledgment and respect of sciences among teachers and parents can influence the general classroom climate, specifically, and the quality of teaching, more generally. Respect for science is increased, as its study is made more relevant to the student. However, teachers may oppose implementing such reforms due to their unwillingness to risk losing control of the teaching environment, their investment in the old teaching system, and the difficulty of evaluating learning under the new system. For such a reform to succeed, teachers need to internalize – as early as possible – the need for the reform, as well as the personal and societal benefits that can be derived from it.

The reforms reviewed represent a conceptual shift from the view that prevailed in the 1950's and 1960's that relegated science education to the cadre of excellent students and saw it as a means for advancing excellence, to an egalitarian and integrative approach seeking general understating and use of science by all students. It is also apparent that there is agreement among scholars that the major goal of science education is to promote science literacy. However, this is a broad concept encompassing educational ideas that have changed over the years. It follows that reforms need to clarify what they mean by "science literacy" so that they may be implemented successfully.

The review also finds that reforms that do not consider knowledge, beliefs and existing practice of teachers may fail and may not be implemented successfully. Involvement of teachers in reforms can take place in various forms, including initiation of reforms, choosing their targets, writing curricula, choosing the courses, which are object of the reform, etc. In order to successfully integrate teachers' practical knowledge with their experimental knowledge and personal perceptions, teachers should receive continuing professional development combining a variety of strategies, including learning communities, peer learning, cooperation, and so forth.

The review does not establish clear success metrics for reforms – a fact that has implications in their evaluation. A significant number of the reforms relate to multiple aspects of teaching and they extend over long periods, even decades. While the majority of the studied reforms share their intention to strengthen student interest in science, their future educational and professional choices, and their related achievements, comparing the different reviewed reforms is difficult. This is not only due to their different backgrounds, but also because the reforms have different goals and complex implementation strategies.

The success of science education reforms depends on their design for the long term, their including clear, structured and obligatory plans, a system-wide approach including involvement of science teachers together with scientists and decision makers in centralized educational systems. It is

important that such reforms be evaluated on a long-term basis and that they avoid issuing new reforms that conflict with previous ones. Reforms need to be accompanied by a culture of learning concerning its implementation, drawing conclusions regarding its methodology, and management of significant unexpected outcomes. With regard to reforms in curricula, these should take place in accordance with changes in pedagogy and in parallel with continuous teacher training. Finally, success of such reforms also depends on public involvement in their content including relevant professional audiences, who may contribute to their successful implementation.

Educational Reforms in the United States: What Have We Learned?[7]

Marcia C. Linn

Reforms of science education in the United States have multiple origins including global competitiveness (spurred by the Soviet launch of Sputnik in 1957), assessments including the National Assessment of Educational Progress starting in 1970, international comparison tests starting with the 1995 Third International Mathematics and Science Study (TIMSS), and waves of efforts to articulate what everyone should know about science including the National Science Education Standards (NSES) in 1996 and the Next Generation Science Standards (NGSS) in 2011.

Reforms resulting from national policies such as the much publicized No Child Left Behind (NCLB) legislation have had both intended and unintended consequences. In particular, NCLB essentially eliminated science education in elementary school by basing school quality ratings on improvement in reading and mathematics.

Funding of science education has impacted both the activities and the leadership of reforms. The National Science Foundation (NSF) policies resulted in shifts in the power structures among the participants. Science education was initially led by natural scientists who often sought to prepare individuals like themselves. NSF funding for curriculum materials and for teacher institutes in the 1960s put natural scientists in charge. NSF funding for research on teaching and learning starting in the 1980s, and for centers starting in 1995 called for collaborations where leadership was shared across natural scientists, engineers, psychologists, science educators, computer scientists, and science teachers. Importantly, in 1980 Erich Block, the eighth director of NSF, called for diversifying the workforce by broadening participation in science education, initiating a trend reflected in NSF guidelines for all funding today.

Science education reforms have drawn on advances in research on learning and instruction. Behaviorist research by psychologists such as Thorndike and Skinner focused on memorization and recall. This aligned with an emphasis on transmitting knowledge common in curriculum materials developed prior to 1960. Developmental theorists, especially Piaget and Vygotsky, inspired research on the ways students made sense of scientific phenomena and on the collaborative nature of learning reflected in some of the reforms of the 1960s. The cognitive revolution starting in the 1960s featured multidisciplinary efforts to understand learning involving collaborations of psychologists, linguists, computer scientists, anthropologists and others. The learning sciences, emerging in the 1990s, featured multidisciplinary collaborations that included practitioners. Learning scientists developed design-based research methods, inspired by fields like architecture and engineering, that advanced understanding of complex learning and instruction. Starting in the 1980s NSF funding for science education research rewarded respectful, multidisciplinary collaborations involving science teachers.

[7] This summary was originally written in English by the author.

Starting with teaching machines in the 1920s and kits of materials in the 1960s science education reforms have taken advantage of advances in technology. Efforts to build intelligent tutors by cognitive scientiests spurred detailed analysis of student learning and resulted in systems well-suited to fields like mechanics. Recently learning environments such as the Web-based Inquiry Science Environment (WISE) have incorporated powerful scientific models and simulations, natural language processing, logging of student actions, data mining, and other technologies to guide inquiry learning in classrooms.

Examples

Curriculum materials 1960s

A major reform in the 1960s arose in response to Sputnik. The newly founded, National Science Foundation (NSF) funded projects led primarily by natural scientists to design curriculum materials. Biological Sciences Curriculum Study (BSCS), CHEMstudy, Physical Science Curriculum Study (PSCS), Science Curriculum Improvement Study (SCIS), and Science a Process Approach (SAPA) among other programs resulted from this funding. The leaders of these programs drew on an influential conference held at Woods Hole and captured in Bruner's *A Process of Education*. Bruner emphasized the generalizable science processes involved in problem solving and refuted developmental constraints asserting that any topic can be taught to learners of any age.

Next Generation Science Standards (NGSS)

Science standards such as NSES and high stakes assessments starting in the 1970s packed the curriculum as each science discipline lobbied for more time for their topics. These standards along with classroom pacing guides that specified the duration of each topic necessitated fleeting coverage of science topics and constrained teachers and schools. Multiple-choice assessments reinforced an inadequate model of learning and teaching grounded in memorization and discriminated against language learners and students from non-dominant cultures by measuring vocabulary development rather than science reasoning.

The NGSS offers an alternative, specifying science practices, cross-cutting themes, and sustained projects. This reform is in progress. Assessments are not yet aligned with instruction. Schools and districts are struggling to determine effective ways to incorporate science practices. Assessments embedded in learning activities comprise a promising alternative to standardized assessments and can be incorporated into instruction featuring science practices. For example, students doing project based learning can document their progress during "pin-ups." Logs of student interactions allow teachers to monitor student progress, personalize guidance, and base curricular customizations on classroom evidence.

Learning sciences research is shedding light on ways to engage students in science practices in the context of projects. For example, comprehensive programs often supported by NSF funding, such as Thinker Tools and WISE can integrate science practices into instruction and document progress

with embedded assessments. Research reviews have integrated classroom-based research studies focusing on specific practices of science such as (a) argumentation, (b) explanation, (c) modeling, (d) visualizing, (e) collaborating, and (f) conducting experiments. These studies demonstrate the tight link between the practice of science and advances in students' conceptual views of science.

Conclusions

Reforms of science education are shaped by policies with uncertain impacts and power struggles among stakeholders. They depend on support from foundations and industry and benefit from advances in research and technology. Funding for partnerships and centers has resulted in productive, promising innovations and inspired efforts at scaling innovations in science education to more schools, teachers, and students. As the examples illustrate, reform remains a work in progress.

Main Insights Regarding Implementation of Reforms

Israel Bar-Joseph

The "Tomorrow 98" report and the reform that followed in its wake represent a significant milestone in the development of science and technology instruction in Israel. The report laid out a detailed plan to reorganize and upgrade science, technology and mathematics subjects and their instruction. In its formulation, structure, method of implementation and its long-term effect on the system, this report constitutes an interesting case study for examining education reforms.

The reform's underlying rationale was the need to adapt curricula and the methods by which it was taught to the substantial changes that were taking place around us – and at their center, the beginning of the technology era. This rationale guided the report's authors in setting out their vision and in composing the more than 60 recommendations it specifies. Indeed, a distinct feature of this report was that it was essentially a systemic reform that included profound structural changes alongside curricular changes. In light of the awareness of the risks inherent in instituting such a broad reform, an attempt was made to ensure its implementation by including Ministry of Education decision-makers as members on the committee that authored the report.

In the initial years, the reform did indeed create far-reaching changes in instruction of the sciences in Israel, some of which still exist and are implemented until today. At the same time, just several years after its implementation took place, there began an ongoing process of erosion and diminution of some of its main recommendations (teaching hours, teacher centers). Implementation of other elements – integrated instruction of science subjects, for example – came up against great difficulties mainly due to a shortage of suitable teachers.

This reform's evolution raises a number of fundamental questions and offers lessons learned regarding future reforms in this arena.

Vision statement or plan of action: An inherent tension exists between writing a statement of principles which leaves room for choosing among implementation alternatives, and creating a detailed document that includes a long list of interrelated actions. The advantage of a general statement of principles is that it is a tool for setting a direction that can be adapted to the changing circumstances. On the other hand, it would appear that a document lacking concrete statements can turn out to be worthless in Israel's political reality in which the Ministry of Education leadership frequently changes hands with these transitions generating great upheavals in direction and emphases. At the same time, the history of the "Tomorrow 98" reform demonstrates the relative ease with which the Ministry apparatus managed to do away with the main substance of a document as detailed as the report. This tension is heightened in light of various developments that have occurred in teaching during recent decades and which stress the importance of an open and evolving learning environment, better adaptation to the individual student and teacher, less rigid standards, and imparting of tools from an oft-updated toolbox. Under these circumstances it appears that it is more appropriate to view a plan for reform as an ideological document that serves as the starting point for a process, and not as a detailed prescription for action. In this

way, it becomes possible to operate in line with a statement of principles which outlines a vision along with defined milestones, within a multi-year vision, a document whose implementation and modification to changing reality would accompany and serve a trusted professional body whose activity is backed by the Ministry of Education administration (see below).

Long-term follow-up: A fundamental question in implementing any reform, which due to its nature, its implementation is typically a multi-year process, is how to ensure long-term stability and continuity. Even if "Tomorrow 98" were implemented as written, the great changes that took place in the employment structure of teachers (such as the "New Horizon," "Courage to Change" programs) and their training (such as the academization of colleges of education), the advent of online capabilities and more, would have required an ongoing process of modifications. The above raises questions – what is the right mechanism for carrying out these modifications, and whether it is right thing to create an entity that will take charge over it. It is clear to us that such an entity, if established, must be comprised of people of stature in the education field who represent professional authority that is hard to challenge, and whose independence is manifest by they not being Ministry of Education employees. The probability of establishing an independent entity to work alongside the Ministry is not high since its mandate would be to limit the Ministry's freedom of action. An example of this is the Education Council that was created in recent years and which has, in practice, remained a non-functioning entity. It is likely that the appropriate place to establish such an entity is within the Pedagogic Secretariat which is accustomed to working with independent professional organizations (subject-matter committees). A step of this kind could restore the secretariat to its centrality and prestige which, in recent decades, have been dimmed. Due to this topic's importance, in our opinion, it is fitting that a research study be commissioned with respect to the method in which this is carried out in other education systems and perhaps, to even turn to an organizational consultant regarding the correct way to implement this step in Israel.

Focus on science education: At the core of the "Tomorrow 98" reform was science and technology instruction, while relatively little attention was paid to incorporating its recommendations within the general fabric of educational practice. In retrospect, it appears that the roots of the difficulty in its implementation can be traced to this approach. The exclusive focus on science education, disconnected from the system's other needs and pressures creates imbalance and in response, the system corrects itself. An example of this is the declaration of an expanded subject area of six weekly hours which eventually led to a reduction of just four weekly hours of instruction in the subject. It seems to us that a key lesson for future reforms is the importance of a systemic view, carrying out a change with the understanding of its broad effects and understanding the various contexts in which the change occurs, including the emotional and familial contexts, as well as the context of societal changes. Moreover, it should be recognized that reform in one particular discipline has far-reaching implications for the entire education system (for example, for the professional development of teachers in other disciplines).

Teachers' professional development: The "Tomorrow 98" reform, like other reforms and reports that came before it as well as after, placed teachers' professional development at the core of its

recommendations. It appears that there is broad agreement, across reforms and organizations, regarding the importance of teachers' continuing professional development that makes it possible for them to stay up-to-date and to reinvigorate, to learn from successes and failures within a community of colleagues, and with professionals. There is, however, a deep gap between these statements and the implementation of this view in practice. A prominent expression of this is the encounter between this pedagogic conception and the teachers' employment agreements. In this context, often the emphasis is placed on compensation and benefits to the point where the pedagogic conception is emptied of substance. At the heart is a profound cultural failure whose solution lies in creating a true separation between these two worlds – pedagogy and professional unionization. The history of the teacher centers is another expression of this gap. Closure of the regional centers and weakening of the national centers created a large void and dealt a real blow to the professional development of science teachers, mainly from high school. The currently developing teacher communities are an interesting attempt to bridge this gap. The emphasis on teacher involvement and providing solutions for local needs are optimally expressed in those communities but this is not sufficient in order to respond to the need of reinforcing the national professional centers and of creating a unified regional or municipal framework (see below).

Involvement of the local government, external organizations and philanthropic foundations: In the absence of a unifying rationale and a clear conception on the part of the Ministry of Education, against a background of lack in sufficient resources to set innovative programs in motion, and as a result of a continuing process of growing involvement of the local communities and extra-system parties, we are witness to a decentralization-of-sciences-instruction process and to vast variation in the quality of instruction, its content and its values between different local authorities. Particularly prominent is the correlation between the authority's financial status and its investment in education (for example, affluent Ra'anana as opposed to Ma'ale Adumim with its relatively meager resources). In certain local authorities (for instance, Haifa), great emphasis is placed on the teachers' professional development in the goal of filling the void left by the closure of the regional centers. It is worthwhile noting that large investments made by the stronger authorities do not necessarily lead to better education: The over-investment in robotics in these authorities is, in our opinion, a prime example of an expensive populist-driven investment whose educational fruits are doubtful.

In parallel, philanthropic foundations wishing to promote a particular agenda – be it social (the Madarom project[8] – the Rashi Foundation) or subject-based (math, physics – The Trump Foundation), enter the void. These foundations' activities are not uniform throughout the system and there are cases in which it intensifies inequality. The activity of these foundations is generally limited in time – an initiative, followed by departure within several years. For its part, the Ministry is not generally set up to be able to continue these initiatives over time. It seems that this trend will continue, intensify and will require the Ministry to define and refine its position as the regulator of curricula and values, and to limit its role as an operator to places where concentrating resources has added value, and to assist in reducing inequality in the education system.

[8] Madarom – A joint project of the Ministryof Education and the Rashi Foundation to promote science and technology education for children in the south of the country.

School autonomy and self-management: One of the consequences of the frequent changes in the messages emerging from the Ministry of Education following leadership turnover, is suspiciousness and skepticism among the teachers, who view these changes as fleeting whims. A central insight derived from our work is the importance of integrating teachers in the design and implementation of change processes. For teachers, such integration produces a sense of ownership over the process as well as belonging to it and at the same time, makes it relevant to their needs. This insight raises the question of managerial autonomy as a key to success. A recently published study (Nir, Ben-David, Bogler, Inbar, & Zohar, 2016) indicates that despite its declared policy that apparently supports such autonomy, the Israeli education system is still very centralized at its core and prevents significant changes towards greater independence for schools, teachers and principals. The changes in the structure of the matriculation exams and the increase in the weight given to the school's assessment are presented as expressions of schools' increased independence but, in practice, they are essentially technical and declarative and do not fundamentally change the relationship between the Ministry and practice. The large number of instructors and inspectors, supervisory and subject-matter entities with whom the school is in touch is a pointed example of this centralization. The research is still divided regarding the effect of school autonomy on students' achievements and its possible influence on equality of opportunity. Despite this, in view of the changes taking place in the field of education and in society, and in light of the challenges they present us with, it appears that the process of autonomization is an unavoidable development. The evolutionary pull towards this process, complete with the struggle between the conservators of the old order and the generators of change is not necessarily the right path. This kind of autonomy, if it is to be implemented, must affect the managerial aspects as well as the pedagogic, but at the same time, also preserve the Ministry's role as a regulating and balancing body.

Ministry of Education Remarks – Science Education: From Instituting Reforms to Ongoing Activity

Muhana Fares

An age-old question in education is who needs to learn what. The answer to this question is a matter of considerable controversy especially when science studies are in question. But when pure science studies at advanced levels is under discussion, the debate goes beyond the scope of pedagogy and content, and enters into political, economic and ideological spheres. Determinations and decisions with respect to this question lead to organizational decisions at the school and classroom levels: Is it advisable to open classes or groups for outstanding students? What is the school's position regarding tracking or ability grouping? Despite these questions, students and parents continue to view science subjects as contributing to success in life, to opening doors – in the military, in higher education studies, and in the labor market – as well as in improving future earning prospects. The science and technology subjects are considered more important and more relevant for the labor market. In Israel, their status continues to rise and in our experience, it is easier to convince a student to study math or physics at the level of five units than to convince him or her to study five units of literature or another humanities or social sciences subject.

The above introduction comes to remind us that every reform to science education takes broader aspects into consideration, those which are not necessarily related to science education.

Reforms in the sciences are similar to reforms instituted in other areas of education during the past 100 years. Professor Zvi Lamm surveyed about 50 large reforms conducted within the last century (Harpaz, 2000). Not a single one of them succeeded in bringing about a fundamental change in the school system culture. At best, each had a marginal effect.

Today, the Ministry of Education is more open to changes with reference to science subjects and is more willing to engage in collaborations that promote science education. The national program in mathematics and the sciences is proof that the Ministry at all levels – the policy level, at the organization level and at the professional staff level – is willing and open to cooperating with external parties, to build coalitions and to bear responsibility for the process and the budget.

In light of these processes and owing to significant collaborations the Ministry of Education has engaged in, questions arise about changes in science instruction, some of which are technical and tactical questions, some strategic, and some partly ideological.Below are questions the Ministry is now facing and those it ought to face in order to improve science instruction in Israel:

1. How to cope with the tension that exists between technology studies and classical science studies?
2. What is the profile of the teacher of mathematics, of physics, or chemistry, or of biology? From where can he or she be recruited?
3. How should teachers' professional development be carried out?

4. Given the lack of success in incorporating advanced teaching and learning processes at the system level, such as integrative teaching, development of thinking processes, and research environments – is it better to give up on this idea?
5. Should teacher communities be generic or discipline-based?
6. How should a balance be achieved between the instrumental approach versus the intellectual approach in science?
7. How can science studies be adapted to the rapid developments occurring in the sciences, industry and academia?
8. How many students must, have the ability, or desire to study science at advanced levels?
9. How can the relationship between the education system and the academic community of science teaching researchers be strengthened? How can the involvement of these researchers in subject committees be increased?
10. How can the training of science teachers be enhanced, especially of those who teach in primary and intermediary schools, and particularly in the discipline they teach?
11. At what age is it important to begin science education?
12. Who are the forces influencing the essence of the reforms: Industry, the military, educators, intellectuals?

Appendices

Appendix A: The Learning Sessions and Seminar Agendas

First session: "Tomorrow 98" as an example of science education reform

Friday, March 18, 2016, Davidson Institute of Science Education, Weizmann Institute of Science, Rehovot

08:15-08:30	Gathering
08:30-09:00	Opening remarks and presentation of the activity roadmap – **Professor Israel Bar-Joseph**, Expert team chair
09:00-10:00	"Tomorrow 98" – Planning of the Process and the Underlying Vision – **Professor Haim Harari**
10:00-10:35	The Education Reform Lifecycle – from Circumstances Surrounding their Birth to the Stages of their Demise – **Professor Miriam Ben-Peretz**
10:35-10:50	Break
10:50-11:25	The Impact of "Tomorrow 98" on Middle Schools and Curricula – **Professor Bat-Sheva Eylon**
11:25-12:00	The Impact of "Tomorrow 98" on Middle Schools and Curricula – **Ms. Shoshy Cohen**
12:00-13:00	Discussion with the members of the "core group of learners"

Second session: The importance of science education among institutions external to the Ministry of Education – philanthropic organizations, education networks and local authorities

Tuesday, August 23, 2016, Jerusalem Auditorium, Herzl Center, Jerusalem

09:30-10:00	Gathering
10:00-10:05	Greetings and opening remarks: **Professor Israel Bar-Joseph**, Expert team chair
10:05-10:50	**First session: The contribution of philanthropy to promoting science education: Example of *Madarom* and the Rashi Foundation**
	Madarom – Joint project of the Ministry of Education and the Rashi Foundation to promote science and technology education for children in the south of the country – the view from 20 years on: **Mr. Shmuel Har Noy**, Director general of the Zefat Academic College and past *Madarom* project director on behalf of the Rashi Foundation and the Ministry of Education

10:50-11:35	**Second session: Education networks and their work with local authorities in science-technology education**
	Science-technology education in the interfaces between the education network, local authority and Ministry of Education: **Dr. Eli Eisenberg**, Senior deputy director for Research and Development, and Training at ORT Israel
11:35-12:55	**Third session: Local authorities that foster science education – examples**
	The example of Haifa: **Ms. Anat Shayer**, Coordinator, program to promote sciences study and eligibility for matriculation, Haifa municipality: Unit for Excellence, Department for Educational Empowerment The example of Beit Jaan: **Mr. Muhana Tafesh**, Head, Beit Jaan Education Administration
12:55-13:35	Lunch break
13:35-14:55	**Fourth session: Local authorities that foster science education – more examples**
	The example of Ra'anana: **Ms. Ayelet Dlayot**, Director of the Ra'anana municipality's Department of Innovation and Program Development; Advisor to the mayor of Ra'anana on promoting the status of women The example of Ma'ale Adumim: **Mr. David Sharet**, Director , Education Division, Ma'ale Adumim municipality; **Ms. Irma Ben Moshe**, Director, *Eshkol HaPayis* (the lottery-funded center) for the Sciences, Technology and the Arts in the city of Ma'ale Adumim
14:55-15:40	**Fifth session: Activities promoting science education at the regional level: The example of the *Acheret* Center (Arab-Jewish Center for Physics Research in the Galilee) and the "Archimedes Fulcrum" *Beit Midrash* (house of study) to train expert researchers in physics**
	Acheret Center and the "Archimedes Fulcrum" *Beit Midrash* – an example of activity in the Western Galilee contributing to advancement of science education throughout the country: **Dr. Amos Cohn**, Academic-pedagogic director of the *Acheret* Center and director of the "Archimedes Fulcrum" *Beit Midrash*; lecturer in physics and science education at Oranim Academic College
15:40-16:45	Comments by meeting participants, summary, and directions for furthering the activity

Third Session: Teachers and their role in science education reforms

Tuesday, September 13, 2016, the Accelerator Hall, Weizmann Institute of Science, Rehovot

09:30-10:00	Gathering
10:00-10:05	Greetings and opening remarks: **Professor Israel Bar-Joseph**, Expert team chair
10:05-11:35	**First session: The story of the national and regional teacher centers**
	The national teacher center from the perspective of the teacher, the instructor and the inspector: **Dr. Irit Sadeh**, Incoming Chief Inspector for Biology and outgoing Chief Inspector for the Environmental Sciences at the Ministry of Education The regional teacher center: The historical, professional, political and personal story: **Dr. Tili Wagner**, Head, Clinical programs for training teachers for math and physics, Beit Berl Academic College
11:35-12:20	**Second session: The teacher's role in the science education reforms**
	What's up what's down? Teachers' involvement in education reforms: **Dr. Nir Michaeli**, Rector, Oranim Academic College
12:20-13:00	Lunch break
13:00-13:45	**Third session: The principal's place in the science education reforms**
	The principal as reform integrator and as adapter of reforms to the reality of the school: **Ms. Aliza Bloch**, Principal, Branco Weiss Network of Schools
13:45-14:50	**Fourth session: Teacher training and professional development**
	Teacher training and professional development in colleges and universities in light of the science education reforms: **Dr. Yaron Lehavi**, David Yellin Academic College of Education; Head, Israel National Center for Physics Teachers in the Department of Science Teaching at the Weizmann Institute The Challenge of Integrating a Thematic Subject in High School – The Example of the "Science and Technology for All" Teachers: **Dr. Michal Nachshon**, Chief Inspector, "Science and Technology for All", Academic Track, Ministry of Education
14:50-15:30	Comments by meeting participants, summary, and directions for furthering the activity

Seminar: Learning from past initiatives to improve science education in Israel and promote excellence

Tuesday, November 1, 2016, the Convention Center at the Ramat Rachel Hotel, Kibbutz Ramat Rachel

08:30-09:00	Gathering
09:00-09:10	Greetings: **Mr. Eli Hurvitz**, Executive Director, The Trump Foundation
09:10-09:20	Opening remarks: **Professor Israel Bar-Joseph**, Expert Team Chair
09:20-09:35	Remarks, Ministry of Education: **Sheikh Muhana Fares**, Director, National Systemic Programs and Projects Division, Ministry of Education
09:35-10:45	**First session: "Tomorrow 98" as an Example of Science Education Reform** **Chair: Professor Benny Geiger, Expert team member**
	Description and summary of the team's work on the topic: **Professor Benny Geiger**, Expert Team member "Tomorrow 98" – The Report and its Implementation: Presentation of the scientific literature review commissioned by the team: **Dr. Sara Klein**, review author Respondents: **Ms. Haya Shitay**, Director, Tel Aviv District, Ministry of Education and **Professor Yehudit Judy Dori**, Dean, Faculty of Science and Technology Education, Technion and Senior Researcher, Samuel Neaman Institute Open discussion with audience participation
10:45-11:00	Break
11:00-12:10	**Second session: Teachers and their Role in Science Education Reforms** **Chair: Ms. Esther Magen, Expert Team member**
	Description and summary of the team's work on the topic: **Ms. Esther Magen**, Expert Team member Changes in Mathematics and Sciences Curricula and in the Knowledge about their Learning and Instruction in Israel – In Light of Developments around the World Regarding Knowledge about Learning and the View of the Teacher's and the Education System's Role: Presentation of the scientific literature review commissioned by the team: **Ms. Ganit Richter**, University of Haifa, member of team authoring the review Respondents: **Dr. Miri Gottlieb**, Director, Division A, Education Employees' Professional Development, Ministry of Education and **Professor Anat Zohar**, Hebrew University and Mandel School of Educational Leadership Open discussion with audience participation

12:10-13:05	**Third session: The Importance of Science Education among Institutions External to the Ministry of Education – Philanthropic Organizations, Education Networks and Local Authorities** **Chair: Ms. Shlomit Amichai, Expert Team member**
	Description and summary of the team's work on the topic: **Ms. Shlomit Amichai**, Expert Team member Respondents: **Dr. Heftsi Zohar**, Deputy Mayor and Acting Mayor, Beersheba, responsible for education and welfare portfolios and **Dr. Bat Chen Weinheber**, Director, "Mifras" Open discussion with audience participation
13:05-13:45	Lunch break
13:45-13:55	**Professor Menahem Yaari**, Chair, Steering Committee, Initiative for Applied Education Research
13:55-15:15	**Fourth session: Learning from Abroad** **Chair: Professor Shaul Hochstein, Expert Team member**
	The Extent to Which We Can Learn from Research on Long-Term Planning in the Field of Science Education: **Professor Shaul Hochstein**, Expert Team member Successes and Failures of Science Education Reforms Abroad: Presentation of the scientific literature review commissioned by the team: **Professor Avi Hofstein**, Weizmann Institute of Science, advisor to the MOFET Institute in writing the review Educational Reforms in the United States – What Have We Learned?: **Professor Marcia C. Linn**,Graduate School of Education, University of California, Berkeley Open discussion with audience participation
15:15-15:50	**Fifth session: Expert Team Insights and Proposals** **Chair: Professor Israel Bar-Joseph, Chairperson, Expert Team**
	The Expert Team's Insights and Proposals: **Professor Israel Bar-Joseph**, Chairperson, Expert Team
15:50-16:00	Summarizing remarks: **Professor Israel Bar-Joseph**, Chairperson, Expert Team

Appendix D: Brief Bios of the Main Partners to the Learning Process

Bayan Abu Katish, member of the "core group of learners". Abu Katish is a science teacher at the Hand in Hand bilingual school in Jerusalem, director of the Center for Gifted Pupils in East Jerusalem, and an instructor in the Amirim program for excellence in schools, administered by the Ministry of Education's Division of Gifted and Outstanding Pupils. Previously, she coordinated the "Scientific Thinking and Research" project, sponsored by Hebrew University and the Jerusalem Education Administration, and coordinated environmental studies at Hebrew University's Belmonte Science Center for Youth, where she also was an instructor in the fields of life sciences and environment. Earlier, Abu Katish taught science and technology in a Karev Foundation program. Throughout her years of teaching, she has led her pupils to prizes in national competitions.
Ms. Abu Katish received a bachelor's degree in 2005 and a teaching certificate in 2008, in life sciences from the Hebrew University, and a master's degree in science teaching from the Hebrew University in 2013.

Shlomit Amichai, expert team member. Chairs *Chotam* [Teach First Israel], a program aimed at narrowing social gaps in Israel by creating a community of educators and activists. The program, which operates in cooperation with the Ministry of Education, JDC Israel and the Naomi Foundation, recruits visionary university graduates as teachers and social leaders in the geographic and social periphery. In 1977, Amichai began working at the Adult Education Division in the Ministry of Education and Culture. Over the years, she filled various positions at the ministry, including head of the Examinations Division, deputy director of the Pedagogic Administration, head of the Teaching Personnel, Training and Professional Development Administration, and more. From 1999-2001, she served as director-general of the Ministry of Education. Amichai went on to direct the ELKA association at JDC Israel, and managed the organization's Division for Volunteers and Philanthropy. She returned to the Ministry of Education in 2007, serving as director-general until April 2009. In May 2009, she initiated and helped to establish the Chotam program, which she continues to direct. Amichai is also a board member of various third-sector organizations.
Ms. Amichai received a bachelor's degree in history and political science from the Hebrew University in 1980, and a master's degree in educational administration from Tel Aviv University in 1995.

Israel Bar-Joseph, expert team chair. Has served as vice president for resource development at the Weizmann Institute of Science since 2006, and as dean of education at the institute since 2007. Bar-Joseph has filled numerous scientific management positions at the Weizmann Institute, including director of the Braun Submicron Research Center, the Physics Services Unit, the Goldschlager Center for Nanophysics, the Department of Condensed Matter Physics, and more. His main fields of research are nanophysics and electro-optics of semiconductors. Prof. Bar-Joseph serves on the editorial boards of professional journals and has received several scientific awards. In his public work, Prof. Bar-Joseph focuses on environmental and educational issues. He was a member of the executive committee of the Society for the Protection of Nature in Israel, and served on several government committees on science education.
Prof. Bar-Joseph received a doctorate in physics from the Weizmann Institute of Science in 1986.

Irma Ben Moshe, director of the *Eshkol HaPayis* (the lottery-funded center) for the Sciences, Technology and the Arts in the city of Ma'ale Adumim, a job she has been doing for the past eight years. The *Eshkol* is a sciences center serving the school and all the community in the city. In the framework of her position, she manages the city's science programs with the goal of increasing community awareness of the importance of scientific areas of knowledge. She is, in addition, a teacher of sciences and technology at the Dekel Vilnai ORT Junior High School.
Ms. Ben Moshe holds a BS degree in biology and a teaching certificate from the Hebrew University of Jerusalem and an MS degree in science education from the Michlala Jerusalem College.

Miriam Ben-Peretz, professor (Emerita), Faculty of Education at the University of Haifa, was the head of the Learning, Instruction and Teaching Program, head of the School of Education, founding director of the Center for Jewish Education in Israel and the Diaspora, and president of the Tel-Hai Academic College. Her research is concerned with curriculum development and evaluation, setting education policy, teacher training and their professional development, and Jewish education in Israel and the Diaspora. Professor Ben-Peretz has organized and participated in many conferences in Israel and abroad. She has published many articles, book chapters and books. Among her published books are: "The Teacher-Curriculum Encounter: Freeing Teachers from the Tyranny of Texts" (SUNY, 1990), "Learning from Experience: Memory and the Teacher's Account of Teaching" (SUNY, 1995), and "Policy-Making in Education: A Holistic Approach in Response to Global Changes" (Rowman & Littlefield, 2009). Professor Ben-Peretz has headed minister of education-appointed committees including the Committee to Reform Matriculation Examinations, the Committee to Prepare a Five-Year Plan for the Arab Sector, and the Committee to Examine Teacher Training in Israel. She has been a visiting professor at many universities abroad, including the University of Michigan (US), Cambridge University (UK), Stanford University in California (US), the University of Alberta and the University of Toronto in Canada, and since 2006, is also a visiting professor at the University of London's (UK) Institute of Education. Professor Ben-Peretz heads the steering committee of the MOFET Institute's School for Teacher Educators. In 2006, she was awarded the Israel Prize in Education, in 1997 she was recognized by the American Educational Research Association (AERA) for her work in Curriculum Studies, and in 2012, she received the AERA Lifetime Achievement Award for research on teacher training. She also received an Honorary Fellowship from the Open University. In 2010, she was made a member of the National Academy of Education (NAEd) in the US. Professor Ben-Peretz is a recipient of the EMET Prize for Education Research, awarded in 2015 by the Prime Minister's office. Professor Ben-Peretz, who has combined extensive public activity with academic work, today continues her research and publication work.
Served as member of "Master Teachers as Agents of Improvement in the Education System" expert team and of the "Language and Literacy"committee.

Aliza Bloch, director of the Branco Weiss network of schools; the network is involved in furthering public education in Israel among various sectors – secular, ultra-Orthodox, Arab, and Bedouin – as an extension of its inclusive outlook and its view of each pupil from the perspective of the place s/he currently occupies. From 1999 to 2013, she was the principal of the Branco Weiss School in the city of Beit Shemesh, where it led change processes and was awarded the National Education Prize. Dr. Bloch is involved in teaching for understanding, has researched the development of

secondary school education in the period between the minister of education Zalman Aran's reforms and the minister of education, Amnon Rubinstein. Her research addresses the social, educational and political processes that created the reforms within the Ministry of Education.
Dr. Bloch holds a PhD degree in education policy from Bar-Ilan University, received in 2015.

Shoshy Cohen, senior worker of the Ministry of Education from which she retired in 2015, after 34 years of service. Ms. Cohen held diverse positions in the field of science and technology education: teacher, profession coordinator, instructor (school, district, and national levels), district supervisor for subject matter instruction and coordinating supervisor for the subject. From 2010 to 2015, she directed the Science area and was the coordinating supervisor for science and technology instruction in primary and middle schools. She established and directed the urban "LaTeva" center in the city of Bat Yam and directed district teacher center. Ms. Cohen participated in the first national instructors course to implement the "Science and Technology Studies" curriculum in 1996, and during her Master's studies, she researched the achievements of middle schools boys and girls in science and technology and their attitudes towards science. She was a member of the National Council for the Advancement of Women in Science and Technology and a member of the "Motivation" staff within the framework of the 5p2 initiative of "Sheatufim" (Strategies for Social Impact).
Ms. Cohen holds a Master's degree in science teaching from the Hebrew University of Jerusalem, received in 2000.

Noa Cohen Eliyahu, member of the "core group of learners". Has been teaching for the last eight years at the Hebrew University's School of Education, training teachers, where she leads didactic workshops related to the experience of teaching secondary school mathematics. Since 2010, she has been a lecturer at the Jerusalem College in the MA degree program in teaching sciences and mathematics. In this capacity, she teaches courses in "Research Issues in Mathematics Education and Science Teaching" and "Teaching Math for Gifted Students," and advises students on their final projects in the research seminar in science teaching. From 1997 to 2013, she was a math teacher at the Hebrew University Secondary School ("Leyada") where she taught in the middle school and high school. She has also taught in-service courses for math teachers in various settings which addressed the topics of "Professionalization of Math instruction" and "The Math Teacher Initiates and Implements Educational Initiatives."
Dr. Eliyahu holds a PhD degree in teaching mathematics from the Hebrew University of Jerusalem, received in 2011.

Amos Cohn, academic-pedagogic director of the *Acheret* Center (Arab-Jewish Center for Physics Research in the Galilee) and directs the "Archimedes Fulcrum" *Beit Midrash* (house of study) to train expert researchers in physics. He also serves as a lecturer of physics and science education at the Oranim Academic College of Education. Dr. Cohn has been involved in teaching physics and physics research for 36 years as a high school teacher, a lecturer and a researcher. At Oranim College, he created the *Beit HaYotzer* (Breeding Ground) workshop to train teachers and students to mentor physics, mathematics and sciences research. Dr. Cohn, together with Moshe Reich, created the *Acheret* Center and the two have been directing the Center for the past eleven years. Together with Moshe Reich, he is the co-founder of the "Archimedes Fulcrum," *Beit Midrash*,

and for the past three years has served as its director. He is the author of the book entitled, *The Well-Thought Out Act – A Guide to Learning through Creative Science Projects*.
Dr. Cohn holds a Bachelor's degree in physics and mathematics from the Hebrew University, a Master's degree in physics from the Hebrew University, and a doctorate in science education from the University of Haifa.

Ayelet Dlayot, director of the Ra'anana municipality's Department of Innovation and Program Development, is responsible for development, initiation and operation of educational programs in the city in a range of areas, including fostering excellence, in general and excellence in the fields of science and technology, in particular. Ms. Dlayot leads the "Experimenting City" practice for the development of a unique educational model based on authentic leadership (the process is conducted with the cooperation of the Ministry of Education's Experiments and Innovations division). She also serves as the mayor's advisor for promoting the status of women and is active in advancing gender equality in the city and encouraging girls in the fields of the sciences and technology. Ms. Dlayot holds an MA degree in education, received in 2002 from Bar-Ilan University.

Yehudit Judy Dori, Dean of the Faculty of Science and Technology Education at the Technion and a Senior Researcher at the Samuel Neaman Institute for National Policy Research. From 2009 to 2013, she was the Dean of Continuing Education and External Studies at the Technion. Professor Dori's research focuses on learning that utilizes a combination of advanced technologies, scientific visualizations, high-level thinking skills, meta-cognition, and assessment of school and university-level educational projects. Her studies include development and integration of educational approaches and curricula and assessment of their pedagogical and technological contribution. Professor Dori is also a pioneer in the integration of computerized molecular modeling and computerized laboratory in chemical education. In the past decade, the success of her research has led to a change in the chemistry curriculum for high school chemistry majors in Israel. From 2003 to 2008, she served as the chairperson of the Subject Committee for Chemistry, and since September 2016 is serving as the chairperson of the Subject Committee of "Science and Technology for All." From 2000 to 2015, she was a Visiting Researcher and a Visiting Professor at the Massachusetts Institute of Technology – MIT.
Professor Dori holds an MSc degree in life sciences and a PhD degree in science teaching, both received from the Weizmann Institute of Science.

Eli Eisenberg, senior deputy director for Research & Development and Training at ORT Israel. Dr. Eisenberg has filled a range of professional positions. Among others, he established the Technology Center in the UK, was a Technion faculty member, served as a researcher at the Open University in the UK, and on behalf of ORT, established a comprehensive system of technology education in South Africa. In these frameworks, he was involved in research, development, and implementation and evaluation of educational programs, retraining and training of teachers in certificate and degree programs, development and integration of learning materials (hardware, educational programs and software programs), research and development of models for guidance and assistance in implementing technology education at different levels of schools, colleges and training courses in the industry. Dr. Eisenberg has 22 years of experience in teaching diverse student populations ranging from disadvantaged to gifted youth, training teachers and retraining

engineers. He has published tens of articles in the professional literature and at scientific conferences, has authored textbooks to train teachers in technology education.
Dr. Eisenberg has a BSc, an MSc and a D.Sc in technology education, all from the Technion I.I.T in Haifa.

Bat-Sheva Eylon, professor at the Weizmann Institute of Science. During the past eight years, Professor Eylon has been serving as head of the Department of Science Teaching. For many years, she served as head of the Physics Group and the Science and Technology in Middle School Group – both part of the Department of Science Teaching. She has also been an academic advisor to national teacher centers in these areas and chair of the Subject Committee for Physics. Professor Eylon is the pedagogic director of the Rothschild-Weizmann Program for Excellence in Mathematics and Science Teaching, a member of the American Association for the Advancement of Science (AAAS), and a member of the National Council for Research and Development. Her main areas of research interest are the study of physics and its instruction in seventh through twelfth grades and ongoing professional development for teachers and teacher-educators in the area of physics and the sciences. Professor Eylon is a recipient of the EMET Prize in Education for 2015. The prize was awarded her for her groundbreaking work in development of science education and the science of learning, in cultivating science teachers and empowering students.
Professor Eylon holds an MSc degree in physics from the Weizmann Institute and a PhD degree in science education from the University of California, Berkeley (US), received in 1979.
Served as member of the "Master Teachers as Agents of Improvement in the Education System" expert team.

Muhana Fares, member of the "core group of learners". A resident of Hurfeish, directs the Ministry of Education's national program to promote mathematics and scientific excellence. He previous served in various roles in the education system: national director of Druze and Circassian education at the Ministry of Education, supervisor of the Northern District, principal of a Druze school for sciences, principal of a community elementary school in Hurfeish, and math and computer teacher in several secondary schools in the Galilee. Fares, a graduate of the Mandel School for Educational Leadership, was awarded the President's Prize for school principals and the General Tamari Prize for excellence in education. In 2002, *The Marker* newspaper chose him as one of the 100 most influential people in Israeli society.
Sheikh Fares received a bachelor's degree in mathematics in 1986, and a master's degree in educational administration in 1999, both from the University of Haifa.

Dalia Fenig, member of the "core group of learners". Fenig is acting chair of the Ministry of Education's Pedagogical Secretariat and director of Division A for Pedagogical Development. She has worked in the field of education for 35 years: as a teacher, subject coordinator and instructor, and in administrative roles at the Ministry of Education. From 2002-2012, she was chief inspector of Geography and "Homeland, Society and Citizenship." Fenig has led pedagogical processes in the education system for years – implementing and integrating education for thinking, developing learning materials and revising matriculation exams, as well as integrating telecommunication processes in the subjects of study and in teaching – learning, assessing and promoting distance learning among teachers and pupils. One of the latest developments is an innovative online model of professional development for teachers that combines generic units on methods of teaching,

learning and evaluation, with units adapted for each field of knowledge – a model called "Unity versus Uniqueness."

Benny Geiger, expert team member, Press here

Miri Gottlieb, member of the "core group of learners". Dr. Gottlieb is the director of the Ministry of Education's Division A for Teachers' Professional Development. As part of her role, she is responsible for formulating a policy of professional development for teaching personnel, as well as mechanisms for integrating and implementing this policy. At the Branco Weiss Institute, Gottlieb directed the Hadera teachers' center and went on to head the institute's Development and Continuing Education Unit. In the Ministry of Education she managed the PISGA Center in Hadera and later the PISGA Center in Haifa.
Dr. Gottlieb received a doctorate in chemistry from the Technion in 1988.

Tammy Halamish Eisenmann, program director at The Trump Foundation. She previously taught mathematics at various high schools, and science education at teacher training colleges and at the Hebrew University's School of Education.
Dr. Halamish Eisenmann holds a PhD degree in mathematics education from the Weizmann Institute of Science and is among the founders of the unique MA program in education (MEd) in teaching mathematics at the Michlala Jerusalem College. Her research has focused on the relationships between the practice of teaching and learning and the cultural context in which it takes place.

Haim Harari
Born 1940 in Jerusalem, fifth generation native-born
Professor of theoretical physics, since age 26, at Weizmann Institute
One of the two founders of the "Perach" Tutorial Project and the first chairperson of the Perach Council, from 1974 to 2016
Israel Prize awarded for the Perach Project, 2008
Head, Department of Science Teaching, Weizmann Institute, 1970
Dean, Feinberg Graduate School, Weizmann Institute, 1972-1978
Chairperson, Council for Higher Education, 1979-1985
President, Weizmann Institute, 1988-2001
Founder and first chairperson of Hemda Tel Aviv (Science Education Center), 1987-2007
Founder and first chairperson of the Davidson Institute of Science Education, 1999-2015
Chairperson, "Tomorrow 98" committee, 1992
1973 Weizmann Prize for Physics, 2004 EMET Prize for Education, 1976 Rothschild Prize for Physics, 1988 Israel Prize for Physics
Member, The Israel Academy of Sciences and Humanities, 1978
Member, American Academy of Arts and Sciences, 2010
Various decorations and honors received from presidents of Germany and Austria and from the Max Planck Society
Four honorary doctorates

Shmuel Har Noy, director general of the Zefat Academic College. He has held a variety of positions during his years of service in the IDF. Upon his discharge, he was accepted as a fellow at the Mandel School for Educational Leadership where he focused on the area of education policy, institutional management and education systems. He later served as the Deputy Civil Service Commissioner for organization, administration and standards. From 1997 to 2002, he directed the *Madarom* (Science in the South) project – a program promoting science and technology in the education system in the south of the country, which was a joint project of the Rashi Foundation and the Ministry of Education. Since then, Har Noy has served in several positions in the private, public and non-profit sectors: director general of the *KIAH* educational organization, chairperson of Alliance Development Israel Ltd., deputy chairperson of *Mikveh Yisrael*, coordinator and member of the Dovrat Commission, head of the implementation committee for the Dovrat Report at the Ministry of Education, and the director general of the National Library of Israel. Alongside his work as director general of the Zefat Academic College, a position he has held since 2009, from 2013 to 2015, he served as the director general (in rotation) of the Council of Directors of Public Academic Colleges.
Mr. Har Noy holds a BA degree in communication disorders, received in 1975, from the School for Communication Disorders at the Tel Aviv University Medical School, an MSc degree in brain anatomy and physiology, also received from the Tel Aviv University Medical School, in 1982, and an MPH degree in public health and medical management from the Uniformed Services University of the Health Sciences in Maryland (US), received in 1991.

Shaul Hochstein, expert team member. Prof. Hochstein is a Greenfield Professor of Neurobiology at the Institute of Life Sciences and ELSC Safra Center for Brain Science (formerly ICNC Interdisciplinary Center for Neural Computation) at the Hebrew University, Jerusalem. His research focuses on different levels of the visual system, from transduction of absorbed light in the eye, through information processing by the eye and brain, to building and storing representations of the visual scene in the hierarchy of cortical areas and learning perceptional skills.
Hochstein received a doctorate in zoology from the Hebrew University, Jerusalem, in 1972.
Member of the Initiative steering team; Served on the "A Proposal to Revamp Schooling for the 21st Century" and the "Language and Literacy" committees.

Avi Hofstein, professor (Emeritus) at the Weizmann Institute of Science. His research studies focus on teaching and learning chemistry. Professor Hofstein served as the head of the Department of Science Teaching at the Weizmann Institute and in the past, headed the department's chemistry group and the Science and Technology in Society (STS) group. He also served as the director of the National Center for Chemistry Teachers at the Weizmann Institute and on behalf of the Ministry of Education and Culture, was a chief inspector for chemistry studies in high school. At the start of his career, he was a high school chemistry teacher. Professor Hofstein is currently a member of the Ministry of Education's "Science and Technology in Society" Subject Committee.
Professor Hofstein holds a PhD degree in chemistry education from the Weizmann Institute of Science, received in 1975.

Eli Hurvitz, Executive Director of The Trump Foundation and a member of the National Board of Education. At The Trump Foundation, he initiated the establishment of a virtual high-

school allowing students from Israel's periphery to study mathematics and physics at high levels; the development of teacher training programs for high-tech career changers; the creation of teachers' professional learning communities across the country; forging partnerships with municipalities and school networks to promote excellence; and convening a National Collective Impact Coalition on excellence in science education. In 2012 and 2016 Hurvitz was nominated by the *The Marker* Magazine as one of Israel's "100 Most Influential People". In 2015, the *Yedioth Ahronot* Newspaper selected him as one of Israel's "50 Top Social-Entrepreneurs". Formerly, from 2000 to 2011, Hurvitz served as the Deputy Director of *Yad HaNadiv*, a Rothschild family philanthropic foundation in Israel. He is a member of the Board of Directors of *Hemda*, a science teaching center located in Tel Aviv and was among the initiators and founders of *Avney Rosha* – the Israel Institute for School Leadership. Previously, he coordinated the operations of the Committee for Changing the Status of the National Library, chaired by Judge Yitzhak Zamir, and was a leading founder of Guidestar-Israel, a project to increase the transparency of Israeli non-profits. At the start of his career, he served as the assistant to the chairperson of the Knesset's Foreign and Defense Committee.
Hurvitz holds an MA degree in middle eastern history received from Tel Aviv University.

Sara Klein, lecturer in scientific fields and in science education at the Orot Israel College of Education and at the Hemdat HaDarom College of Education. She was previously a member of the Hemdat HaDarom's Research Committee. From 2012 to 2015, she also served as the head of the college's Sciences Department. In past, she was involved in developing curricula to train science and technology teachers at the Hemdat HaDarom College and for 17 years, following her establishment of the sciences laboratories at Orot Israel College, she managed them. For seven years, Dr. Klein was a staff member of "Science 2000," which was designed to promote science instruction in junior high school and in high school and which operated at Bar-Ilan University.
Dr. Klein holds a BSc degree in life sciences, received in 1979, a teaching certificate in chemistry, received in 1980, an MSc in biochemistry in 1981, and a PhD degree in education with a specialty in science teaching, received in 2008, all from Bar-Ilan University.

Yaron Lehavi, physics teacher by profession, is a Mathematics-Physics Department faculty member at the David Yellin Academic College of Education, and head of the Israel National Center for Physics Teachers in the Department of Science Teaching at the Weizmann Institute. Through his various positions, he is involved in a range of aspects related to teaching physics in Israel, including research, teacher training, development of educational materials, curriculum development, continuing education for teachers, and scientific and educational counseling. Dr. Lehavi is also the co-director of the *Vidactika* (Video-Didactics) project, supported by The Trump Foundation, which is concerned with development of didactic dialogues between math and physics teachers based on videos of their own lessons. Dr. Lehavi has been a member of subject committees on teaching the sciences in high school (physics and science and technology in society) and in junior high school (science and technology). At the start of his career he was a physics and math teacher at the Experimental School in Jerusalem.
Dr. Lehavi holds a BSc degree in physics and math, an MSc degree in physics and a PhD in science education, all received from the Hebrew University of Jerusalem.

Marcia C. Linn, Professor of Development and Cognition, specializing in science and technology in the Graduate School of Education, University of California, Berkeley. She is a member of the National Academy of Education and a Fellow of the American Association for the Advancement of Science (AAAS), the American Psychological Association, and the Association for Psychological Science. She has served as President of the International Society of the Learning Sciences, Chair of the AAAS Education Section, and on the boards of the AAAS, the Educational Testing Service Graduate Record Examination, the McDonnell Foundation Cognitive Studies in Education Practice, and the National Science Foundation Education and Human Resources Directorate. Awards include the National Association for Research in Science Teaching Award for Lifelong Distinguished Contributions to Science Education, the American Educational Research Association Willystine Goodsell Award, and the Council of Scientific Society Presidents first award for Excellence in Educational Research.

Linn earned her Ph. D. at Stanford University where she worked with Lee Cronbach. She spent a year in Geneva working with Jean Piaget, a year in Israel as a Fulbright Professor, and a year in London at University College. She has been a fellow at the Center for Advanced Study in Behavioral Sciences three times. Her books include *Computers, Teachers, Peers* (2000), *Internet Environments for Science Education* (2004), *Designing Coherent Science Education* (2008), WISE Science (2009), and *Science Teaching and Learning: Taking Advantage of Technology to Promote Knowledge Integration* (2011).She chairs the Technology, Education—Connections (TEC) series for Teachers College Press.

Esther Magen, expert team member. Ms. Magen is a project coordinator and member of the Physics Group at the Weizmann Institute of Science's Department of Science Teaching. She guides learning communities of physics teachers, and also teaches the subject at Ostrovsky High School in Ra'anana and, until recently, at the Bleich High School in Ramat Gan. At both schools, she prepared students for matriculation exams in physics. From 2006-2015, Magen was head of physics at the Ministry of Education's Examinations Division, and was responsible for the national array of matriculation exams grading on this subject. From 2006-2012, she was engaged in a European Union research project on installing computerized laboratories in schools. For her excellence in teaching physics, Magen was awarded the Amos de-Shalit Prize (2011) and the Rothschild Education Prize (2015).

Ms. Magen received a bachelor's degree in mathematics and physics from Hebrew University of Jerusalem in 1980, and a master's degree in adult education from Derby University (England) in 2000.

Nir Michaeli, rector of the Oranim College of Education. He recently founded *Hashkafa* Research & Development (leading teachers) at the MOFET Institute. He formerly served as the chair of the Ministry of Education's Pedagogic Secretariat. In the past, he was the dean of Pedagogic Development and head of the Department of Education at the Kibbutzim College and the deputy director of the Kerem Institute for Teacher Training. In the framework of his teaching and research, Dr. Michaeli is involved in education policy, social and informal pedagogy, and civil and political education.

Dr. Michaeli is a graduate of the Mandel School of Educational Leadership. He holds a PhD degree in education policy from Tel Aviv University, received in 2007.

Served as chairman of the round table of the "Master Teachers as Agents ofImprovement in the Education System" expert team.

Michal Nachshon, senior associate lecturer in the Faculty of Science and Technology Education at the Technion and at the Oranim College of Education. She teaches didactics and advanced topics such as curriculum development and methods of evaluation in science teaching in the BSc and MSc programs. Her areas of academic interest are integrative-thematic teacher training, training teachers using diverse teaching strategies such as employing individual and team work, adapting pedagogy to heterogeneous student populations, promoting self-efficacy, adapting alternatives in evaluating diverse populations, etc. In addition, Dr. Nachshon has served as a chief inspector for the "Science and Technology for All" area almost from its inception and until its establishment as an official subject with five units of study (2000 to 2016). Within this framework, her work focuses on planning and development of programs to impart scientific-technological literacy to high school students in technology tracks and in academic tracks, this carried out by teaching scientific-technological language, concepts, skills and ways of thinking that will enable students, the citizens of tomorrow, to successfully integrate into life, work and society. Her research addresses topics in both teacher training and in the pedagogic issues mentioned above.
Dr. Nachshon holds a PhD degree in science education from the Department of Education in Science and Technology at the Technion, received in 2000.

Hannah Perl, member of the "core group of learners". Dr. Perl isdirector of the Sciences Division at the Ministry of Education's Pedagogic Secretariat. From 2004 to 2011, she served as a chief inspector for mathematics instruction, and previously was a math teacher and a middle school and high school instructor. Until 2004, she was a member of the mathematics staff at the Science Teaching Center at the Hebrew University and later, headed the team. During her tenure at the Science Teaching Center, she authored mathematics textbooks and, together with Professor Anna Sfard, edited the newsletter for math teachers. Dr. Perl collaborated on the development of courses for the Open University and for several years, edited the math teachers' newsletter at the Weizmann Institute.
Dr. Perl holds an MA degree in mathematics, received in 1976, and a PhD degree in science teaching, received in 2000 from the Hebrew University of Jerusalem.

Ganit Richter, lecturer in the Department of Information and Knowledge Management at the University of Haifa and a lecturer in the Open University's MBA program. She also serves as a research fellow in the Department of Business Administration at the University of Haifa. She is, in addition, studying for her PhD degree at the University of Haifa in information and knowledge management. Over the years, she has been a lecturer and teaching assistant for a range of courses at the University of Haifa and at the Open University.
Ms. Richter holds a BA degree in mathematics and art, received in 1988, an MA degree in mathematics, received in 1997, and an MBA degree (with distinction), received in 2009 – all from the University of Haifa.

Irit Sadeh, chief inspector for biology instruction at the Ministry of Education (since the beginning of the 2016-17 academic year). From 2009 to 2016, she was chief inspector for environmental sciences and also taught high school biology. Previously, she taught biology and environmental science in high school and serve as a biology mentor. Dr. Sadeh helped develop the "Biotour" Unit in biology, and the "Environmental Workshop" unit in environmental science, and also co-

wrote a number of textbooks – *'From Seed to Seed*', '*Biotechnology, Environment, and What Lies Between'*, and others. She is the Ministry of Education's representative to the Health Ministry's Committee on Animal Experimentation.
Dr. Sadeh holds an MSc in botany from the Hebrew University of Jerusalem and a PhD degree in science education from Bar-Ilan University's School of Education.

David Sharet, director of the Education Division in the city of Ma'ale Adumim, a position he has held for 15 years. In the past, managed a unit in the industrial sector, and served as the administrative assistant and deputy director in the Education Division.
Mr. Sharet holds an MA degree in educational administration, received in 2000 from the Hebrew University of Jerusalem.

Anat Shayer, senior worker of the Haifa municipality's Unit for Excellence which is a part of the Department for Educational Empowerment. The Department is responsible for all of Haifa's six-year municipal high schools. Ms. Shayer manages the "Excellence in the Sciences" and the "The Top (Girls) to the Technion" programs whose objective is to increase the percentage of graduates of five study units in math and the sciences, and the "Matriculation 81" program, to raise the percentage of students eligible for matriculation certificates. She manages the municipal teacher communities in the fields of mathematics and the sciences and is in charge of the community of pedagogic coordinators.
Ms. Shayer holds an MA degree in the social sciences (with a specialization in game theory) received from the University of Haifa.

Haya Shitay, director of the Tel Aviv District at the Ministry of Education. In her previous position, she was head of the Education Administration in the Modiin-Maccabim-Reut municipality and prior to that, she directed the PISGA Center in Tel Aviv – a teacher-training center serving 8,500 education employees. Formerly, she was a head teacher, a mathematics teacher and the coordinator of the mathematics track at the Maccabim-Reut High School. In the past, she has been a lecturer in the areas of math and statistics at the Interdisciplinary Center Herzliya.
Ms. Shitay holds a BA degree in mathematics and an MA degree in research and evaluation methods, both received from Tel Aviv University.

Niv Strauss, activity coordinator. Strauss previous worked as a research assistant at Hebrew University's Institute of Life Sciences and in the Ministry of Aliyah and Immigrant Absorption's Policy Planning, Budgeting and Research Division. In addition to his work at the Initiative for Applied Education Research, he volunteers as an advisor to the *Hitorerut* [Awakening] movement's economic development team.
Mr. Strauss holds a BSc degree in chemistry and biology from Hebrew University of Jerusalem (2010), a BA degree in economics and political science (with honors) from Tel Aviv University (2014), and an MA degree in public policy (with honors) from Tel Aviv University (2016).

Muhana Tafesh, head of the Education Administration in Beit Jaan since 2005. Prior to that role, he was a teacher of civics and geography at the Beit Jaan Comprehensive School and served as the pedagogic coordinator, the twelfth grade coordinator, and a member of the school management

staff. In addition, he served as the Ministry of Education's national instructor for educational initiatives and the University of Derby's educational administrator for Druze community.
Mr. Tafesh holds a BA degree in the social sciences and the humanities received from the University of Haifa, an LLB in law from the Carmel Academic Center and an MA degree in education administration from the University of Derby.

Moti Taubin, member of the "core group of learners". Heads the strategy division at the Ministry of Education. He was previously the deputy director of the Jewish Statesmanship Center, a school for Zionist leadership for outstanding students who seek to influence Israeli society through public action, academia and entrepreneurship. He also initiated a project to teach Hebrew in a high school in Abu Ghosh and taught in the program. In 2009, he founded the *Melach Ha'aretz* pre-military program at Ein Gedi, intended for youth from the periphery. Taubin has been involved in several other educational projects, and worked as a teacher and educator at the Yahad high school in Modi'in.
Mr. Taubin received a bachelor's degree in Jewish studies and a teaching certificate in bible from the Hebrew University in 2009, and a master's degree in public policy from Tel Aviv University in 2012.

Tili Wagner, member of the academic staff in the Faculty of Education and head of the clinical teacher-training programs in mathematics and physics (with the cooperation of The Trump Foundation) at the Beit Berl Academic College. Dr. Wagner is involved in teacher-training and instruction of the sciences. From 1996 to 2002, she was the head of the "HaSharon" Regional Teachers Center at the Beit Berl Academic College; from 2004 to 2007, she headed the National Teacher Center for Science and Technology in High School at the Weizmann Institute of Science's Department of Science Teaching, and from 2008 to 2014, she was head of the School of Education at the Beit Berl Academic College. She was a member of the Subject Committee on Science and Technology for High School and a member of the Committee to Develop Standards in Science and Technology. In the past, she taught at TelAviv University's School of Education and for many years, worked as a secondary school head teacher and physics teacher. The areas in which she conducts research are teacher training, especially teaching as a second career, clinical aspects of teacher training, and scientific literacy.
Dr. Wagner holds a PhD degree in curriculum development from Tel Aviv University, received in 2005.

Bat Chen Weinheber, specialist in development and management of educational initiatives, in leading complex planning processes based on diverse stakeholders, and in leading innovative thinking about old challenges. She directs the "Mifras" Program, which she founded. In the past, she founded and directed the Educational Initiatives Institute at the Beit Berl Academic College. The Institute researched the non-profit sector's and the private sector's involvement in the education system and promoted it. Dr. Weinheber has promoted educational-social planning processes in local authorities and has managed principal-training programs for the *Avney Rosha* Institute at the Beit Berl Academic College.
Dr. Weinheber holds a BA and an MA degree in education, both received from Tel Aviv University and a PhD degree in conflict management from Bar-Ilan University.

Menahem Yaari, chair. President (Emeritus) the Israel Academy of Sciences and Humanities and Professor (Emeritus) of economics, Hebrew University of Jerusalem. Prof. Yaari is a member

of the American Academy of Arts and Sciences, the American Philosophical Association, and the Berlin-Brandenburg Academy of Sciences. He is a recipient of the Israel Prize in Economics (1987) and the Rothschild Prize in the Social Sciences (1994).
EMET Prize Laureate, 2012.
Member of the Initiative steering committee since its foundation, he now serves as its chairperson (since 2008).

Meirav Zarbiv, member of the "core group of learners".Heads the Ministry of Education's R&D Division for experimental schools and educational initiatives. She previously directed the program for school choice controlling in 35 localities throughout Israel, involving about 900 schools, and she led processes of developing educational zones in local authorities and school uniqueness. Zarbiv has over 16 years of experience in the education system and has taught a range of subjects and all age groups, from elementary school through high school. She served in a series of positions at Hemdat Hadarom College: pedagogical instructor and lecturer in the Department for Teaching English, as well as various administrative roles in the Department for Evaluating Academic Quality, the R&D Department and in PDS experiments. She was also trained as an economist, organizational consultant, mediator and group facilitator.
Ms. Zarbiv received a bachelor's degree in economics from Bar-Ilan University in 2000, and a master's degree in school leadership from Achva College in 2009.

Anat Zohar, professor at the Hebrew University School of Education and a faculty member at the Mandel School for Educational Leadership. From 2006 to 2009, she served as the Director of Pedagogic Affairs at the Ministry of Education. In this position, she led an educational change process in the Israeli education system, focused on the integration of Higher Order Thinking (HOT) and deep understanding across the curriculum ("Pedagogic Horizon"). Her areas of academic expertise are science education, learning and instruction, developing students' HOT, meta-cognition, teachers' professional development with respect to teaching thinking, gender and science education, gender and gifted education, bridging the gap between educational policy and changes in learning and instruction, and methods of large scale implementation of educational projects in the area of teaching HOT.
Dr. Zohar holds a PhD degree in science education, received in 1991, from the Hebrew University of Jerusalem.

Heftsi Zohar, deputy mayor and acting mayor of Beersheba, and holds the city's education and welfare portfolios. As responsible for the municipal education portfolio, she is in charge of implementing the municipal administration's education vision and executing educational policy. Dr. Zohar is a graduate of the Mandel School for Educational Leadership. She established and directed for *Maof* School for Gifted and Outstanding Students in Beersheba for five years and later on, served as the national inspector in the Ministry of Education's Division for Gifted and Outstanding Students. Prior to starting her studies at the Mandel Institute, Dr. Zohar conducted research in the fields of molecular biochemistry and cancer research. She has published scientific articles in local and international forums and was awarded the Wolf Prize for outstanding doctoral students.
Dr. Zohar holds a PhD degree in biochemistry, received in 2000, from Ben-Gurion University.