



Inspiring Excellence in Science in Middle School

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Abstract

*Middle school is the optimal time to ignite students' passion for science, trigger their curiosity, and raise their motivation to pursue science studies in high school. The best agents for this important mission are well trained, inspiring, science teachers. However, science in the middle school is one of the most challenging subjects to teach, since, no matter whether the teacher is a biologist, a chemist or a physicist, he/she will have to teach at least two additional profound and evolving subjects, in which he did not major. The **Shavit** program (Hebrew for "comet") aims at bridging this gap. The program is designed for teachers of excellent middle school students, and includes unique curriculum-enriching, hands-on - mind-on activities. Teachers, from schools joining the program, participate in a dedicated training programs as well as mentorship throughout the entire school year. They receive workbooks, lab equipment and materials, as well as assessment tools, all meticulously prepared by the program's staff. This "all - in" package helps teachers to lead scientific-excellence groups, and reinforces their professional status. This, in turn, results in increased interest on the part of the students, who demonstrate more enthusiasm, curiosity and engagement in science lessons, and indeed, we have found that the program increases the number of students who choose advanced science studies in high school. Moreover, some of the program's methods and tools "leak" into other classes, allowing many more students to benefit from the program. To assess the program's value for the students, we checked whether **Shavit** graduates gain better scientific skills, in comparison to other students. To check this claim, we distributed a scientific assignment at the beginning of the school year designed to test a range of scientific skills in 10th grade students, from classes majoring in sciences. Overall the average score of the students who graduated the **Shavit** program was significantly higher than that of their peers who did not take part in the program during middle school.*

Keywords: Middle school, science, excellence, teachers, training, hands-on

1. Introduction

Middle school is an important window of time to engage students into science and raise their motivation to pursue science studies in high school. Teaching through Hands-on - Mind-on activities enables active, enjoyable science lessons, assists students to better understand scientific concepts and thus helps engaging students in pursuit of science [1]. In addition, such activities support development of skills such as: asking question, critical thinking, scientific models, data collection and analysis, etc. One major key to success in this task is a good science teacher that inspires students to explore different subjects by themselves and guide them through their learning process [2]. For this purpose, teachers must have a deep understanding of scientific subjects included in the curriculum. Unfortunately, many middle school science teachers have to teach physics, chemistry, biology and technology, profound and evolving subjects, while having studied themselves only in one of them. The **Shavit** program was developed at the Davidson Institute of Science Education [3] to address these needs. The program is designed for excellent level students in middle school and their teachers. It offers a unique supplementary plan to the national middle school curriculum, including Hands-on-Mind-on activities, scientific enrichment texts and constructive evaluation components. The program's staff works with the teachers of **Shavit** classes, providing them with training courses, scientific and pedagogical ongoing support throughout the entire school year. This, in turn, leads to an increased interest on the part of the students, who become more excited, curious and engaged in science lessons, enhancing the possibility of drawing them to advanced science studies.

2. A toolbox for teachers and students

Schools who join the program are equipped with workbooks, lab equipment and materials, as well as assesment tools – all meticulously prepared by the program's staff – offering optimal setting for their

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students. In addition, the program includes several day trips to the Weizmann Institute, and participation in a dedicated space and astronomy event.

2.1 Hand-on - minds-on

Many of the Shavit program activities are based on students' independent lab work, others involve challenges and games [1]. The students practice experiential learning, making educated assumptions and testing them, thus nurturing their curiosity and developing their research skills, and critical and scientific thinking. For example, in order to learn the concept "density of matter" term, students are invited to check whether different kinds of fruits and vegetables float or sink in water. These observations raise questions, motivating them to start solving the "mystery". At the next activity, students get metal and wood "bodies" of the same size and shape, measure their mass and volume, and organize the results in tables. At the next step students draw a mass vs. volume graph of for both the wood and the metal bodies. Recognizing the difference in slopes, and comparing it to that of water, they are introduced to the mathematical concept of ratio and its association with the scientific concept of density. A final activity combines creativity with a chance to assimilate the "average density" term in a boats building challenge. Additional examples for fun and engaging activities include the use of salt dough to create a variety of electric circuits for exploring electricity principles, and the "carbon cycle" board game, where each student is assigned a carbon atom that wanders between carbon pools on earth and the atmosphere via "real world" processes.



Figure 1

2.2 Training teachers, inspiring students

The paradigm underlying this program is that better teachers make better students [2], and thus, teachers are the true agents of change. For this reason, the Shavit program puts a major emphasis on the tools provided to participating teachers: A three-day training seminar during the summer, an ongoing support by a designated staff member, online seminars, and enrichment lectures and workshops throughout the school year. This ongoing support is critical for the program's success, especially on the first three years of operating the program in school. During these first years of training we introduce the teachers with new activities, new pedagogical insights and relevant scientific background. As a valuable side effect, teachers report that they introduce a number of the activities and teaching methods to the other classes they teach, making the Shavit program beneficial for the entire school and not only for selected student. Recently we started to evaluate the influence of the Shavit training process on the professional development of teachers, aiming at optimizing the training scheme based on the results.

3. Implementation of the Shavit program in schools

Seven years of operating the program at schools endowed us with some valuable experience and knowledge regarding the elements required for its optimal implementation in schools. Though we tend to be flexible and adjust our program to the specific needs of each school, we find that some key principles are necessary:



- Regular meetings with the school's administration, targeted at perceiving their goals and discussing challenges and achievements.
- Incorporating the excellence group lessons in the regular school timetable and ongoing activities, and not treating it as an afterschool activity.
- Defining specific goals for each teacher, according to his/her preferences and class characteristics.
- Engaging the entire team of science teachers and the lab technicians at schools.
- Getting parents and the community involved.

The Shavit staff members consult school administrators and headmasters, coordinators and teachers on how to handle integrated operational and pedagogical challenges.

4. Evaluating our impact

The program is currently operational in 38 schools nationwide, from Yarka in Northern Israel to Sderot in the south. Some 20 schools are from the geographical and socio-economic periphery including schools from the Arab sector as well as the Jewish Orthodox sector. The program offers a high-level science curriculum for approx. 3,000 high achievement students, taught by 75 participating teachers. The schools taking part in this program represent a cross-section of the Israeli society: Jews, Arabs, and Druze, both religious and secular. The materials offered by the program are available both in Hebrew and Arabic. As the program becomes more successful, it also becomes more attractive to non-participating schools, creating a growing demand to further expand it.

The **Shavit** program has already gained a very positive reputation within students, teachers, school principals, and parents. It is perceived to have a meaningful contribution to the students learning experience and achievements. Students taking part in the program commit to additional science hours at school, and do so gladly. In many cases, the students develop a team spirit that affects the entire school, making it more attractive to both existing and prospective students. In some schools the methods and tools of the program have diffused into the regular, non-participating classes – thus allowing many more students to benefit from the program.

As the program is currently in its seventh year, we were able to check whether **Shavit** graduates gain better scientific skills compared to other students. To check that, we passed a scientific assignment to 10th grade students who study in classes majoring in scientific fields at the beginning of the school year which tests several scientific skills [4][5].

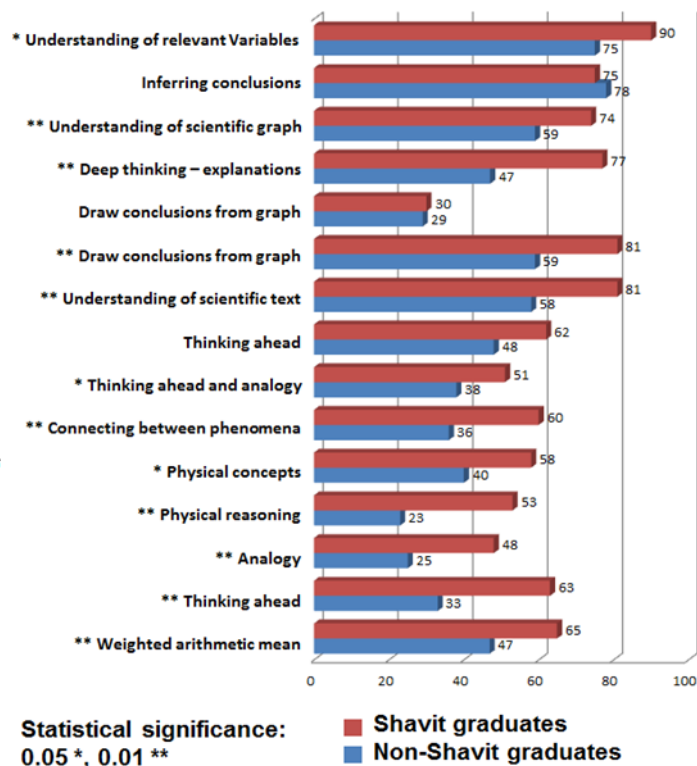


Figure 2



Overall the mean score of the Shavit graduated students was significantly higher than their peers who studied in regular classes during junior high school (Figure 2). Each bar represent one task in the assignment with the skill evaluated (some skills were evaluated more than once) and the score for each assignment was normalized (0-100).

In attitude evaluation questionnaires completed over the years by students, teachers, administrators and headmasters, as well as parents, the Shavit program scores high and receives very good feedbacks, allowing us to conclude that the program impacts science education in both, teachers and students perspectives alike.

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