MadaTech - National Museum of Science, Technology & Space
DANIEL AND MATILDE RECANATI CENTER (R.A.)
מדעטק
יש מקום לסקרנות
מדעטק -המוזיאון הלאומי למדע,טכנולוגיה וחלל
מרכז דניאל ומטילדה רקנאטי (ע"ר)
Museum activies under the auspices of the Technion - Israel Institute of Technology
פעילות המוזיאון בחסות הטכניון - מכון טכנולוגי לישראל

The Gelfand Center

For Model Building, Robotics & Communication

Activity Report
July 2012 – December 2013
Submitted to Mark Gelfand
Thank You to the Gelfand Family Charitable Trust for your continued generous support.

I. Robotics Programs for Children & Teens

• The 2012-2013 school year

A. Animal-like Robots Workshop – 3-year program

This very special activity, a definite favorite among the Gelfand Center's youngest students, is continually enhanced and expanded. Implementing the Constructivist and Constructionist philosophies of learning, and using the RoboCroc, RoboDog and RoboMonkey based on the LEGO® Education WeDo™ construction sets, the workshops encourage children to investigate by designing and interacting with robots. The program, launched in 2009, was the first in Israel to offer first through third graders a window into Robotics.

1. **Program for first graders (24 students, 6 sessions):** the children activate RoboCroc and RoboDog, preprogrammed animal-like robots, comparing them to the animals they represent, and learning about the robots' capabilities and reactions to external stimuli.

2. **Program for second graders (31 students in 2 groups, 6 sessions):** continuing their investigation of RoboCroc and RoboDog, the children learn about the robots' sensors (motion & tilt), mechanical transmission (pulleys and gears) and control system; transforming the mysterious 'black box' into a better understood 'glass box'. In the final sessions, the youngsters implement a storytelling application in which RoboCroc and RoboDog interact with one another and with other objects, creatively combining technology with theater.

3. **Program for third graders (24 students, 6 sessions),** offered for the first time during the 2012-2013 school year: a third animal-like robot, a monkey drummer, now joins the already familiar RoboCroc and RoboDog. This time the children build the robots by themselves, thereby acquiring in-depth knowledge of the follower operational mechanisms.

B. 3-Year Robotics Program for Gifted Students

1. **Program for gifted 4th graders (20 students, 6 sessions / 24 students, 12 sessions):** a one-year Animal-like Robots Workshop, that offers the entire 3-year program (Section A of this Report) in a single academic year.

2. **Program for gifted 5th graders (20 students, 12 sessions):** the program acquaints students with the basic principles of Robotics through the construction and use of LEGO® Mindstorms® RCX automatic motor vehicles. Students develop and build their own vehicle models, and program them to execute specific tasks, like complying with traffic regulations and signals on the road.

3. **Program for gifted 6th graders (52 students, 12 sessions):** this program involves a major innovation, specially developed by the staff at the Gelfand Center - combining the activation of a physical robot with virtual agents (Scratch Avatar) in game tasks.

C. Mobile Robotics Project

In 2011-2012 MadaTech and the Gelfand Center brought Robotics to **17 classes in 11 schools** in Haifa and its vicinity. This excellent program was unfortunately discontinued in 2012-2013, due to lack of funding. One of the participating schools did, however, send its **7th graders** to **5 sessions** at the Gelfand Center.

D. City of the Future Workshop

This unique program for **7th graders (20 students, 12 sessions)** focuses on traffic in an urban environment, using robotic motor vehicles made from a LEGO® Mindstorms® RCX kit. The students activate robotic vehicles, aiming to drive them safely and prevent traffic accidents.

E. V2V – Vehicle to Vehicle Communication

In this futuristic, state-of-the-art program, recently piloted in the U.S., **9th graders (20 students, 12 sessions)** at the Gelfand Center were asked to create NXT vehicles that communicate with the environment and with other vehicles through sound sensors, NXT wireless cameras and Bluetooth communication systems. The program introduces students to both technological capabilities and scientific knowledge (sound, light, radio waves), which clearly serve the urgent needs of modern society.

F. Humanoid Robots

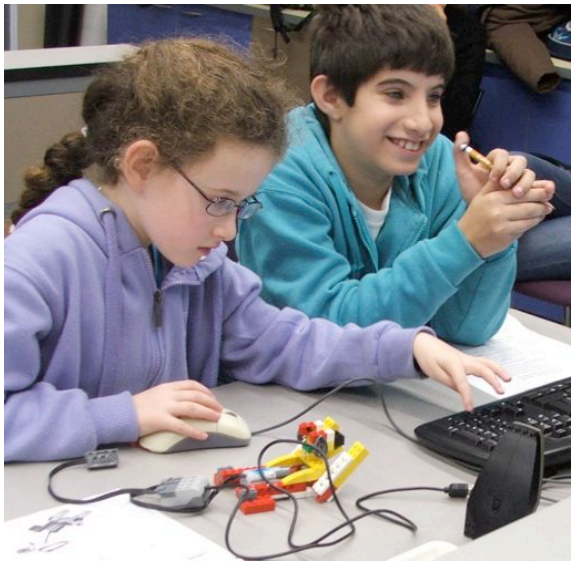
1. **Program for 9th graders (20 students, 12 sessions):** the students carried out experiments in computer simulations and with real NAO robots. They learned to design multitasking robot behavior, applying the concepts of center of gravity & locomotion, as well as speech recognition, speech creation, face detection and object recognition.

2. **Inquiry-based learning mediated by RoboThespian, the robot teacher:**
   In this innovative **Robotics Education** program for **5th graders (151 students),** RoboThespian conducted the science lesson **"Function and Law of the Lever"**, which included experiments with levers. Based on the most recent advances in Human-Robot Interaction, this project was a joint initiative of MadaTech, the Technion's Department of Education in Science and Technology and the Koba Lab at the Tokyo University of Science.

G. Introductory Single-Session Programs

Hundreds of young students were introduced to the idea of Robotics for the first time, through a range of single-session programs:

1. **400 3rd graders** took part in 3-hour Animal-like robots sessions, held weekly at the Gelfand Center.



2. Over **500 middle and high school students**, who participated in MadaTech's two Peak Days, enjoyed a 40-minute maximum-exposure Robot Theater Performance.

3. 144 girls (7th & 8th graders) from MadaTech's special yearlong Girls to the Technion science program took part in a one-day Robotics workshop entitled “Mobile Robots in Labyrinths”.

4. 30 8th graders, who had reached the semi-finals of the 2012 OlympiYeda competition, participated in a summer workshop on Robotics. The students used the LEGO® Mindstorms® NXT robot construction kit to learn about the gyroscope and its applications in Robotics.

5. The general public enjoyed Robotics sessions and demonstrations during EUs annual Researchers Night.

H. The Robot Theater

In order to reach larger audiences, and expose one-time visitors to the wonders of Robotics, the Gelfand Center team has developed several robot shows, starring NAO, the charming humanoid robot, and his fellow robots. Performances include:

1. A robot show presenting four types of robots that represent the leading trends in Robotics today: a robotic arm, Roomba the robotic vacuum cleaner, AIBO – the Artificial Intelligence dog robot, and NAO, the humanoid robot.

2. A presentation by NAO, who tells the audience about his functions and abilities, and invites spectators to check for themselves. This presentation is given in Hebrew for the younger children and in English for the older students.

3. A new act performed by two NAO robots, on the topic of encryption. The robots use their sensors to break codes and communicate with each other through infrared transmission.

4. An athletic performance in which NAO responds to the audience's requests and demonstrates his sportsmanship in various fields, such as tennis, soccer, golf, ski, gymnastics and even horseback riding.

- **The 2013-2014 school year**

Continued from the previous year

A. 3-Year Robotics Program for 75 Gifted Students

B. City of the Future Workshop

7th graders use the more advanced LEGO® Mindstorms® NXT kit.
8th graders who took part in the program last year, are offered an advanced program with more complex tasks and challenges.

C. Humanoid Robots

RoboThespian, the robot teacher, conducts science lessons.

C. Introductory Single-Session Programs

3rd graders take part in weekly 3-hour Animal-Like Robots sessions.

D. The Robot Theater

New Programs

E. Mobile Robotics Project

The project has been resumed at elementary schools in the towns of Beit Shean and Acre. MadaTech's mobile lab arrives once a week (56 hours per year), bringing the following programs:

1. 1st & 2nd graders (20 students) - **Animal-Like Robots workshop,** basic level**;**
2. 3rd & 4th graders (20 students) - **Animal-Like Robots workshop,** advanced level;
3. 5th & 6th graders (20 students) - **Automatic vehicles workshop**, based on the LEGO® Mindstorms® NXT kit;
4. Demonstrations of Robotics principles with Roomba & NAO robots.

F. **Workshop combining Robotics & FabLab (pilot, 10 middle school students):**

1. Students participating in the **City of the Future** workshop use FabLab's 3D printers and Laser cutter to create an actual model of the urban environment, in which they activate the robotic vehicles.

2. Students use the FabLab to create a bio-inspired robot capable of legged locomotion.

G. **Robotics-based Physics & Chemistry Lessons (9th & 10th graders)**. This program is designed to attract students to the fields of Science, Technology, Engineering and Math (STEM). The program makes use of the LEGO NXT adapter and Vernier sensors that detect and measure pH, conductivity, UV and other properties.

II. Purchases made/requested by the Gelfand Center

1. In the fall of 2013 we bought:

    - New cameras and microphones for RoboThespian, the teacher robot, for a total of about $5,000. These will improve the robot's ability to conduct HRI (Human Robot Interaction) through two operation modes: the lecture mode, consisting of preprogrammed behaviors, and the interaction mode - the Wizard of Oz method in which human teachers, hidden in a back room and unseen by the participants, assist the robot in his spontaneous interaction with the children via tele-operation.

    - Special sensors enabling robots to conduct scientific experiments and obtain accurate results - in innovative chemistry & physics classes. Total cost: approximately $15,000.

2. The following requests have been submitted:

    - 20 advanced EV3 innovative learning kits, at a total cost of about $25,000

    - Upgrade of digital equipment for investigative learning sessions with RoboThespian – about $5,000

    - Arduino experimentation kit - about $6,000

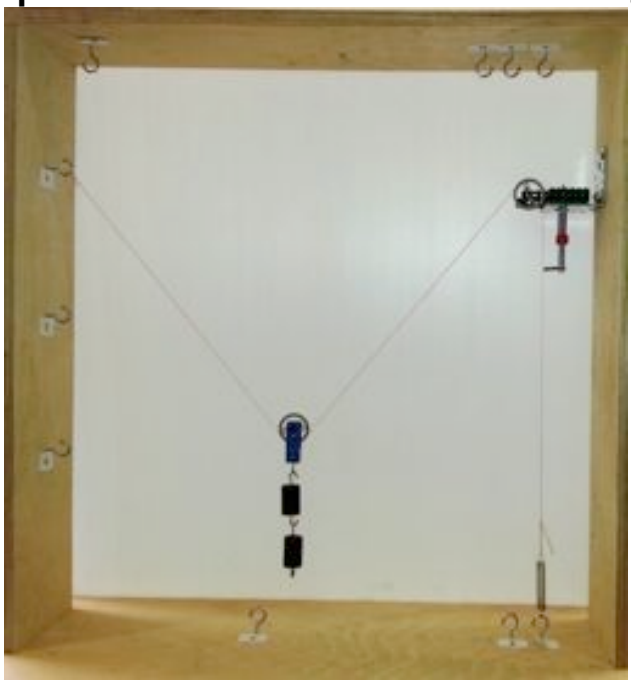
III. Showcase of Science Models in Memory of Boris Kiperman ז"ל

Boris Kiperman, the heart and soul of all model-building activities at the Gelfand Center, passed away in August 2012. MadaTech plans to honor his memory by building an elegant display case, where many outstanding models developed by Boris and others at the Gelfand Center will be exhibited permanently.

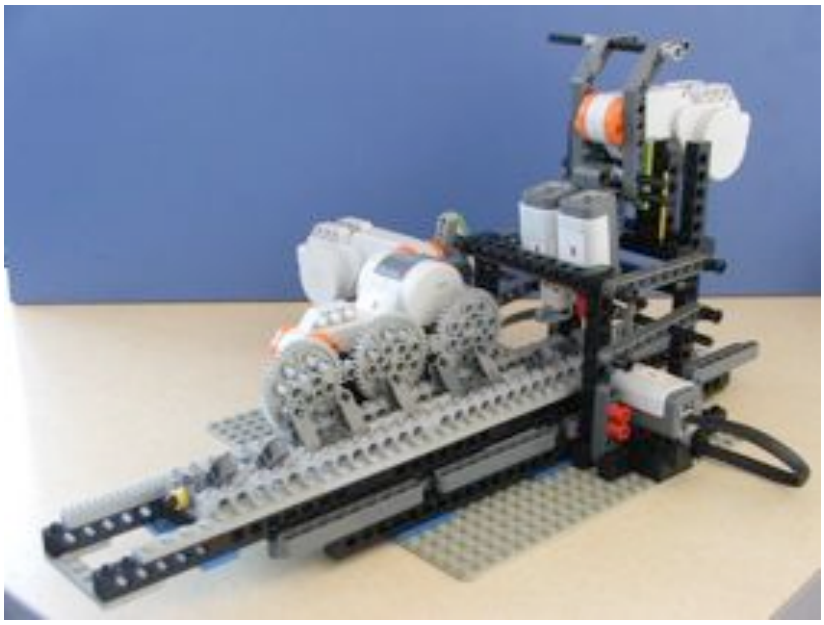
Following are several models to be exhibited in the showcase:

Poly-alphabetic 2-Rotor Enigma Machine

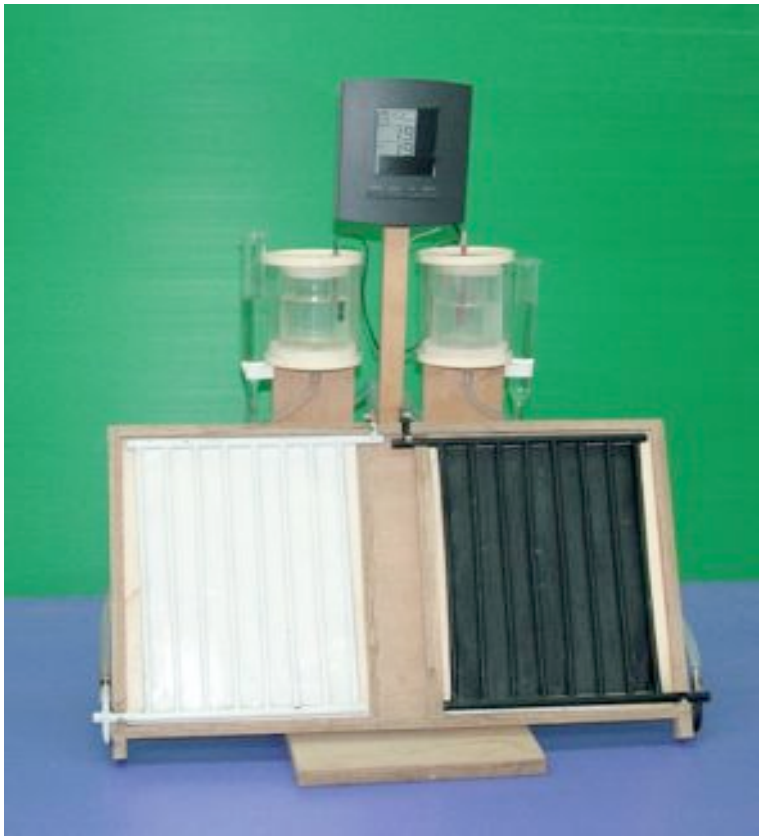
Pulley setup used for the mechanical advantage activity



Turing machine using the NXT controller

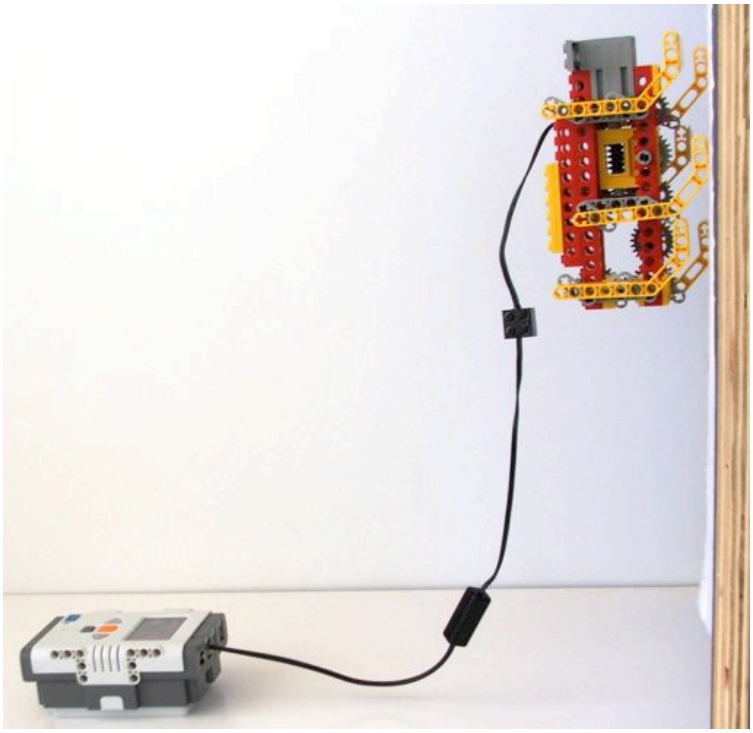


White and black solar water heaters

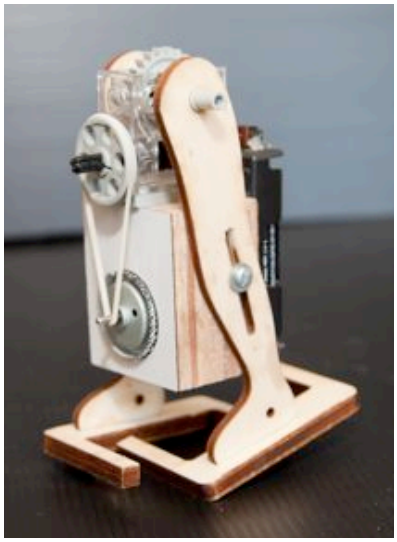


Tower crane

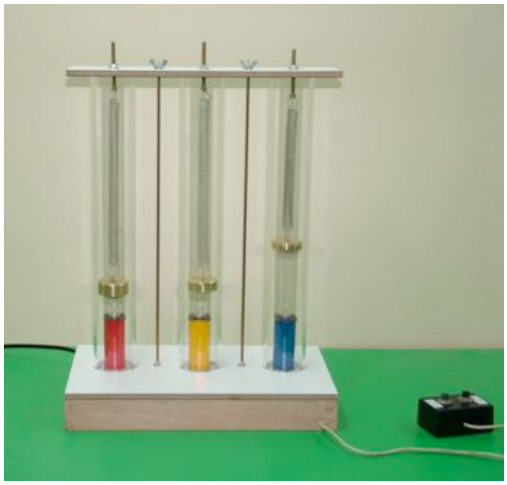
Wall Climbing Robot



Two-legged robot



Spring-mass system demonstrating resonance



How machines work: forklift & excavator mechanisms

IV. Presentations on Gelfand Center Robotics Programs at International Forums

1. Verner I., Polishuk A. et al. "How children grasp the concept of system through constructing robots and exploring behaviors", 22nd IEEE International Symposium on Robot and Human Interactive Communication (IEEE RO-MAN), Korea, August 2013.
2. Verner I., Polishuk A. et al. “Elementary science lesson delivered by robot", *8th International Conference on Human-Robot Interaction*, Tokyo, March, 2013.
3. Polishuk A. 2013. "Children-robot learning interactions in science museum workshops", *4th Israeli Conference on Robotics (ICR)*, Tel-Aviv, September 2013.

V. The Gelfand Center Staff

1. **Center Director** - Alex Polishuk, BSc & MSc in Automation, Faculty of Mechanics, St. Petersburg State University of Technology, currently in the process of completing his doctoral thesis on Children-Robot Learning Interactions in Science Museum Workshops, at the Technion's Department of Education in Science and Technology;

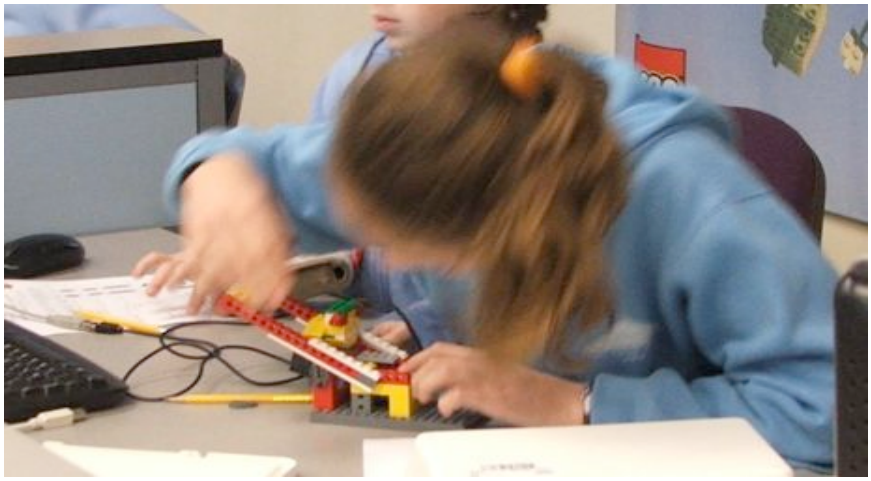
2. **MadaTech Instructors** - Sasha Tabak (MSc in Industrial Engineering, St.Petersburg State Marine Technical University), Dima Ferhat (BSc in Science Education, Technion), Mohammed Mahammed (BSc in Geodesy and Technology Education, Technion); Omri Lifshitz (BSc in Aerospace Engineering, Technion); Niv Kreiner (BSc in Mechanical Engineering); Dmitry Filler (BSc in Technology Education, Technion).

3. **Student Instructors** in the process of completing their undergraduate degrees - Roman Veltman (Computer Science & Mathematics, Technion), Katya Klimovich *(*Architecture, Technion), Alexey Bolembah.

APPENDIX A
Children's Reactions to Robotics Programs at the Gelfand Center

1. **7th & 8th graders from the Girls to the Technion program, following a one-day workshop entitled Mobile Robots in Labyrinths:**

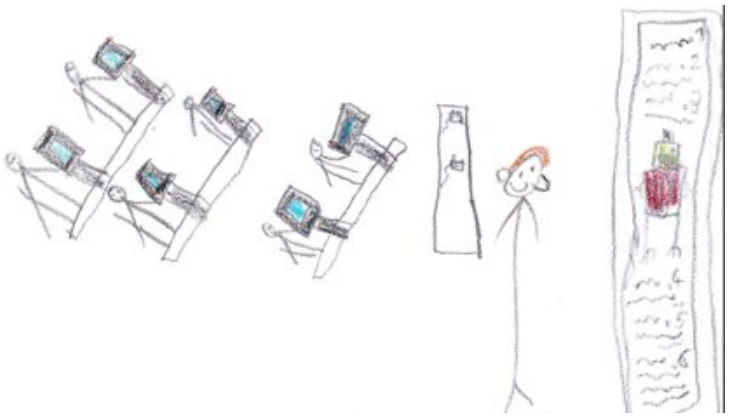
   - "It was amazing to watch smart robots like RoboDog, and learn how to operate and program robots through the computer."
   - "It was great fun ☺ We watched a Robot Show and learned how to program a robot. That was really cool!"
   - "It was fun seeing and trying out things you don't usually find in your everyday life."
   - "I learned the basics for programming robots, and that's cool. I recommend it to everybody."
   - "I like robotics because it shows you that processes take time, until you get the final results. It's exciting to see how the robot does what I tell him to do."
   - "It was very interesting and amazing. It shows what you can do with today's technology."
   - "The topic was very interesting. I found a connection between the workshop and computer studies (giving commands)."
   - "It was great to understand how robots work. I'd love to do it again!"
   - "The session was interesting. Robots are really cute…"



2. **Thanks from 2nd graders following an Animal-Like Robots program:**

   - *Hi Dima, I hope you enjoyed teaching me robotics and I was very happy to learn from you.*

   - *Dear Dima! I want you to teach us robotics here at our school.*



   - *To Dima!!! Thank you for explaining to us things we didn't understand. Now we know more than we did before. It was great fun learning with you. I'll miss you!!!*

   - *Dear Dima, You were wonderful and you taught us robotics very very well.*

   - *To Dima, 1. Robotics was fun with you. 2. It was very interesting with you. 3. Thank you for teaching us about robotics.*

- *Dear Niv, thank you for teaching me about RoboCroc. I'll miss you.*
- *Dear Niv, MadaTech's robots are very interesting. I loved the dog robot. I also liked the experiments we did. It was fun with you because I think you are the best instructor in the world!*
- *Hi Niv. Thank you for teaching us robotics and the part with the dog and its engine was the most fun. The crocodile and its engine were also fun. Maybe because I like dogs and crocodiles.*

- *Dear Niv, You were great. Thank you for the knowledge on robotics.*
- *Dear Niv, thank you for teaching us robotics.*