EXPERIMENTS IN THE "HUNVEYOR ON THE TESTYARD" PLANETARY SCIENCE EDUCATION PROGRAM: HUSAR-18 ROVER MEASURES THE SOIL MOISTURE. Z. Horváth[1], Sz. Kárpáti[2,7], Gy. Hudoba[3], I. Ságodi[4], Sz. Bérczi[5], H. Hargitai[6], A. Gucsik[7,8], P.G. Vizi[9], [1]Budai Ciszterci Szent Imre High School, H-1114 Budapest, Villányi út 27. Hungary (hozoli.mail@gmail.com) [2]Petőfi Sándor Roman Catholic Elementary and High School of Vecsés, H-2220, Vecsés, Petőfi tér 1, Hungary (nyuliszilvia@gmail.com), [3]Óbuda University, Faculty of Electrical Engineering, Inst.Computer Technology, Székesfehérvár, Hungary (hudoba.gyorgy@amk.uni-obuda.hu), [4]Szekszárdi Garay János High School, H-7100 Szekszárd, Szent István tér 7-9. Hungary, (ibolyasagodi5@gmail.com), [5]Eötvös University, Faculty of Science, Institute of Physics, Cosmic Materials Space Res. Group, H-1117 Budapest, Pázmány P. s. 1/a. Hungary, (bercziszani@staff.elte.hu), [6]Eötvös University, Budapest H-1088 Múzeum krt. 6-8. Hungary, (hargitaih@caesar.elte.hu), [7]Eszterházy Károly Catholic University, Fac. of Science, H-3300 Eger, Leányka str. 6, Hungary, [8] Institute of Low Temperature Science, Hokkaido University; Kita-19, Nishi-8, Kita-ku Sapporo 060-0819, Japan (sopronianglicus@gmail.com), [9]MTA Wigner RCP H-1121 Budapest, Konkoly Th. 29-33. (vizi.pal.gabor@ek-cer.hu)

Introduction: In our work last year, we expanded the Hunveyor educational space probe model with a field table (testyard). Thus, the experiments could be planned for two types of units that can be used to perform surface measurements on the planetary body. The active spacecraft models, the Hunveyor (stationary unit) and the Husar (moving unit), on one side and the field table, you can set planetary body surface conditions (now only at ground dimensions) on the other side. You can simultaneously shape the planetary body surface soil conditions and the measurement directed at them.

This the two-sidedness is also beneficial from the viewpoint of education, because the students' attention can be focused both on the operation of the instruments during the measurements, and the soil conditions. All attention of running parallel threads: planning, soil-arrangement, measurements and final evaluation.

The possibilities for variation in the new series of experiments are expanded by application of changing terrain soil units on the testyard, where the landing unit may operate [1] among, for example in a specific layout of soil mosaic field [3], with, which can result in differences in the ability of the soil to retain moisture, or producing differences in drying due to porosity. In our Hunveyor in the testyard program we designed and built experiments in the following topics:

Soil moisture measuring – ideas and models: Here are some ideas considered for measuring soil moisture.

By pressing (squeezing water out of the soil/rock with very high mechanical pressure)

By centrifugation

By testing conductivity (by measuring the resistance between two electrodes inserted into the ground and using reference data)

By evaporation from a soil sample (at appropriate temperature and pressure)

By measuring humidity

By measuring the weight loss of the sample

Selected: The focus of the soil testing experiment should be the examination of soil moisture by measuring conductivity.

Conductivity test by measuring the resistance between two electrodes inserted into the ground and using reference data, so that the measurements are performed in the points of a matrix one row at a time, one after the other. Maturation table. (It looks like this: (A) columns: soil water content (set), this is one of the variables, (B) lines: one of the parameters of the two electrodes inserted into the soil, which was changed (another variable). Conductivity data is included in the matrix cubes. Preparation experiments with the 'sponge'-model (Fig. 2.).

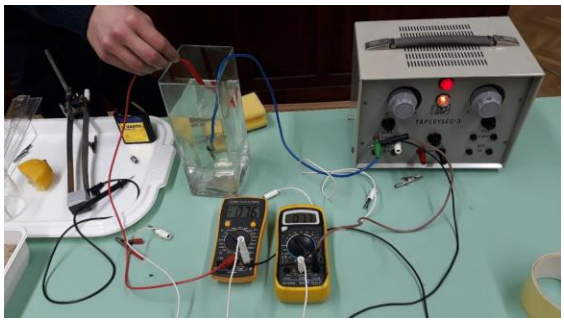

Fig. 1. Soil moisture measurement – Simple devices

Fig. 2. Soil moisture measurement - 'Sponge' model

Permeation profile measurement

Arduino measurements:
Resistance measurement with Voltage Divider Bridge
Modeling of voltage source and voltage meter
Calculation with Kirchhoff's laws
System of equations with 7 unknowns with multiple sampling solving (developing mathematical skills)
The chosen sensor is SEN0114 Soil moisture meter.

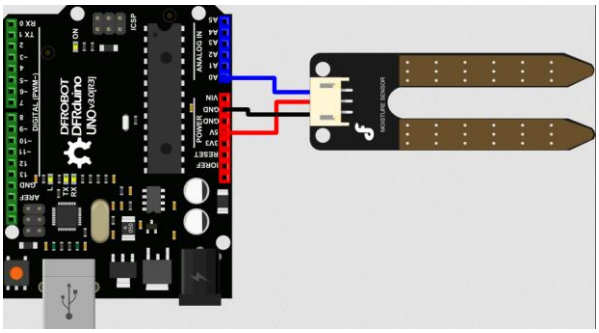

Figure 3. Arduino SEN0114 Soil moisture meter

We give pocket computers (exists on Android phones also [2]) with program which is part of a teaching helper software system to show a simple solution for students to earn quick results from the repeated measures after they understood the mathematical idea itself.

```
400 "G":CLEAR :INPUT "R(A)R(C)N=";N:DIM W(N-1,N):WAIT
10:DIM V(N-1,N)
  402 FOR I=0TO N-1:FOR J=0TO N
  403 PRINT I+1;J+1:INPUT W(I,J):V(I,J)=W(I,J):NEXT J:NEXT I
  405 "H":INPUT "W:";Q:WAIT Q:FOR I=0TO N-1:FOR J=0TO N
  407 PRINT I+1;J+1;" ";V(I,J):W(I,J)=V(I,J):NEXT J:NEXT I
  410 FOR I=0TO N-1
  415 FOR K=I+1TO N
  418 IF W(I,I)=0THEN WAIT :PAUSE "Inconsistent, no
solution":GOTO 418
  420 W(I,K)=W(I,K)/W(I,I)
  425 NEXT K
  430 FOR J=I+1TO N-1
  431 IF J>N-1THEN 446
  435 FOR K=I+1TO N
  440 W(J,K)=W(J,K)-W(J,I)*W(I,K)
  445 NEXT K
  446 NEXT J
  447 NEXT I
  450 FOR I=N-1TO 0STEP -1
  455 FOR K=I+1TO N-1
  456 IF K>N-1THEN 465
  460 W(I,N)=W(I,N)-W(I,K)*W(K,N)
  465 NEXT K
  466 NEXT I
  474 PAUSE "M:":WAIT :FOR I=0TO N-1:PRINT
W(I,N);":(";I+1;")":NEXT I:GOTO 474
```

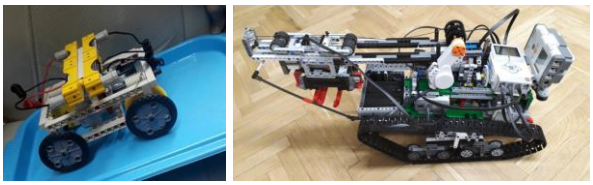

Figure 4. Versions of rovers (The most evolved rover which can deploy and apply Soil Moisture Meter and serials of them is the Husar-18 – right).

Figure 5. Husar-18 robotics and the and the team at the Szent Imre High School.

Summary of the work: With the help of the 3 types of variable units: Hunveryor, Husar, and testyard, students together with teachers develop a new research style of planetary surface testing. When planning the measurements, the students gain knowledge in the joint work and become motivated to think through their own developments. Cooperation between students and researchers, in the form of robot-building and measurement-building, is one of the most interesting educational areas, for which students always prepare with great enthusiasm and participate in the works. By connecting the fields of planetary science and environmental physics, students are expected to be even more open to other natural sciences, too. The method can also be successfully used in talent management [4].

References: [1] Sz. Bérczi, V. Cech, S. Hegyi, T. Borbola, T. Diósy, Z. Köllő, M, Sz. Tóth (1998): Planetary geology education via construction of a planetary lander probe. *29th LPSC*, #1267, LPI, Houston (CD-ROM);
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