E-LEARNING SYSTEM TO FUSE PLANETARY SCIENCE AND ENGINEERING ISSUES. S. Hegyi[1], A. Kereszturi[2,3] ([1]Faculty of Science, University of Pecs [2]Nagy Karoly Astronomical Foundation, [3]Polaris Observatory of the Hungarian Astronomical Association, e-mail: Hegyis@ttk.pte.hu).

Introduction: An online sytem was developed using the open source Moodle eLearning management system, and used for education of planetary sciences at Pecs University as part of the ongoing educational activity connected to Hunveyor student space probe series [1]. Earlier results on the integration of planetary science and astrobiology to the Univeristy education are summarized in the corresponding references [2-5], just like the background of this e-learning system [6]. Below we summarize new results from the course in the first semester of 2011/2012 focusing on the connections between engineering and planetary sciences. The aim here was to identify how and where could planetary science be integrated those topics, where engineering related subjects learnt at this University have connections with planetary science. The course was open for all natural science students at Pecs University.

The structure, topics of the course are listed below:

1. Introduction	7. Landing site selection
2. Oribiters	8. Geographical information systems
3. Landers	9. Virtual presence beyond the Earth
4. Missions to asteroids and comets	10. Trends in astrobiology
5. Space technologies in general	11. Equipments and methods in SETI research
6. Mars analog research	12. Summary

Each lesson has modular structure starting with an up.to two pages song summarizing pdf file, an online video lecature accompanied with the connected ppt as a separate file, few related popular articles and a youtube video or a related image, infographics etc.

Figure 1. Screenshot of the lesson on analog research on Earth: 1. summarizing pdf file, 2. online video lecture on HungaroMars expedition [7], 3. ppt file of this lecture, 4. structure of some DESERT RATS rovers, 4. youtube video on Haughton Mars Project.

Connections between engineering and planetary science are summarized in two tables **(**topic related to space probes / related subject(course) / specific example).

Technology related issues

propulsion methods
- vacuum physics – hot gas release into vacuum
- mechanics – Newton's and Kepler's law, force-counterforce
- thermodynamics – transform heat to mechanical work
- chemistry –energy release from chemical reactions
- hydrodynamics –turbulent motion
- oscillations, waves – electromagnetic data broadcast
- electrical engin. – signal modul., amplification, broadcast
- computer networks – communication channels, inter-computer connections, wireless data broadcast, server centres
- information architect. – data collection, -mining, -analysis
- geoinformatics – data transmission

spacecraft analysis of planetary surfaces
- optics – refraction, CCDs, image processing, lasers
- modelling transport processes – reflection, absoprption
- programming – imaging algorithms
- digital imaging – digital image processing

energy budgets of space probes
- electrical engineering – economic energy usage, solar cells
- electronics – solar cell and energy usage optimization
- nuclear physics – nuclear propulsion
- economics – economic energy usage
- energetic – energy consumption minimization

rocket launch
- mechanics – first cosmic speed issue
- economics – launch costs, influence of the market
- enterprise financing – measure the financial expediency
- meteorology – conditions required for launch
- project management – planning the launch
- applied management – harmonizing operation
- analysis – force, angle computation
- theoretical compilation – launch track computation

landing on planetary surfaces
- mechanics – Kepler problems, trajectory and speed computation, friction heating, atmospheric drag
- discrete mathematics – computation of landing site
- analysis – computation of landing site
- game theory – analysis of optimal decisions
- linear algebra – vector geometry

planetary surface mobility
- electronics – logical circuits
- physics and electronics laboratory work – electromotor
- mechanics – wheels, suspension system
- project management – rover track planning
- electro mechanics – efficiency of electromotor
- mechatronics – synergy of equipments for over mobility
- management controlling – fault compensation

planetary surface sampling
- chemistry – sampling , laboratory equipments, solvation
- nuclear physics – isotopic dating
- laser spectroscopy – inorganic material analysis by ablation
- artificial intelligence – interpretation of material analysis
- geomorphology – sampling site determination
- analysis – sampling, signal interpretation

Data management related issues

<u>in-situ data management of space probes</u>
- database management systems – data organization into matrixes
- informatics – computer based data management
- integrated business info. syst. – data collection, -management, autonomous behaviour of space probes
- programming – structured programming
- knowledge engineering – experience based learning
- methodology of programming – effectiove method selection
- information system architecture – artificial intelligence
- robotic technology – process automatization
- game theory – results of different behaviour of space probes

<u>analysis of magnetospheres</u>
- electrical engineering – analysis of planetary magnetic field, effect of magnetic fields on moving charged particles
- electrodynamics – measuring magnetic fields
- geophysics – analysis of magnetic field, interplanet. dust
- astrophysics – applied spectroscopy
- chemistry – composition of dust particles
- mineralogy and petrology – composition of dust particles
- optics – spectroscopy

<u>remote planetary surface observations</u>
- oprics – refraction, CCD imaging, laser reflexion
- transport process modelling – reflection
- programming – imaging algorythms
- digital imagin – digital image acquisition

<u>Earth attendant staff of space missions</u>
- informatics – project management
- project management – coordination of tasks

<u>manned space missions</u>
- human-machine interaction – robot + human Mars exploration
- philosophy – importance of human is space flight
- athletics – fitness and physiology
- economics – economize on human resources
- human biology – effect of environmental conditions on the human body, effect of centrifugal forces,
- foods and microbiology – conservation methods
- psychology – effect of weightlessness
- biomechanics – muscle mass loss in weightlessness

Tests written by the students: during the course we made the students to write tests with questions related to the givel lecture. The tests were written by 40 university students. At least half of students were right in the following issues: 1. the largest cost is required by the launch, 2. more orbiters were launched than landers, 3. they estimated the average lifetime of a planetarymission around 10 years, 4. and they estimated the touch down speed of landers around 1 m/s properly. Most of them think it is more difficult to design landers than orbiters, and the more effective probe types between landers and orbiters depends on the target olanetary body. Some other interesting results from the tests are below: They estimated the probable travel distance that Curiosity will pass on the surface of Mars around 50 km. For the question: which planetary body has never been visited (Mercury, Titan, asteroids, Pluto) all the students replyed properly. But a general mistake is that they usually overestimated the distance that Sojourner gone from the Pathfinder lander.

Grades: The students were given grades based on two sport tests during the first part of the course, one homework and the final test.

Figure 2. Screenshots of example lessons: landing site selection, analog probe field tests, orbit simulators

Monitoring the students' activity: during the course the students' activity could be monitored by various logging functions, and the more and less popular topics could be separated, as well as the tasks they found more easy or difficult.

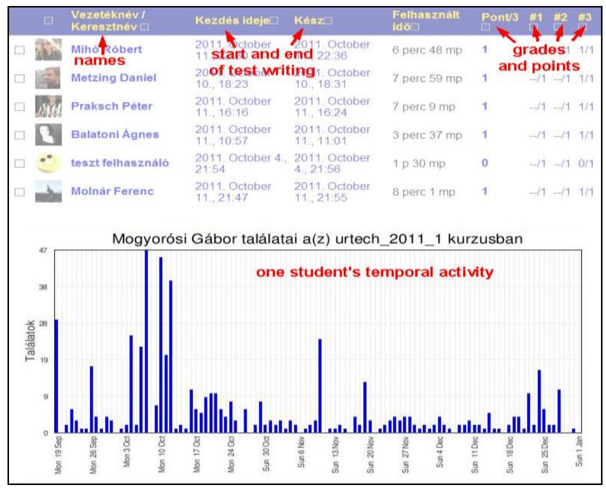

Figure . Example screenshots on the monitoring of stdents' activity: periods and results of test writing (top), and one student's login axctivity (bottom)

For international partners: In the next years we are going to develop this course toward a wider and possible international course that helps to orient students toward planetary science from engineering domain. Any foreign institutes/universities who are interested in the change of educational materials, or would like to have an online version of their classical course, or even interested in developing a joint international online course in planetary science or astrobiology are welcomed. Our e-learning system is ready to support more students and institutes in the future.

References: [1] http://moodle.org [2] Berczi et al. (1999) *30th LPSC* #1332. [3] Kereszturi, chapter in *Astrobio. Phys. Orig. Biol. Evol. Spatial Distrib.*, ed. Hegedűs and Csonka 2010. Nova Publishers, 131-141. [4] Hargitai, 2006 *Cartographica* 41. 149-167. [5] Hargitai et al. 2007, *Cartographica* 42. 179-187. [6] Berczi et al. *32th LPSC* #1332. [7] Hegyi et al. 2011 *42th LPSC* #1990. [8] Boros-Olah et al. 2009, *40th LPSC* #1492.