# Practical Methods in Teaching CanSat

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# Outline

- Simplified Models in Engineering Education
- What is CanSat?
- Methods in Teaching CanSat Education
  - Collaborative Learning
  - Project Based Learning / Learn-by-doing
- Typical CanSat Syllabus
- Concluding Remarks

# Simplified Models – Fluid Engineering

- Kelvin-Helmholtz instability

- Naiver-Stokes Equations (1822)

**Continuity:**

$$\frac{\partial \rho}{\partial t}+\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0$$

**X – Momentum:**

$$\frac{\partial(\rho u)}{\partial t}+\frac{\partial(\rho u^2)}{\partial x}+\frac{\partial(\rho uv)}{\partial y}+\frac{\partial(\rho uw)}{\partial z}=-\frac{\partial p}{\partial x}+\frac{1}{Re_r}\left[\frac{\partial \tau_{xx}}{\partial x}+\frac{\partial \tau_{xy}}{\partial y}+\frac{\partial \tau_{xz}}{\partial z}\right]$$

**Y – Momentum:**

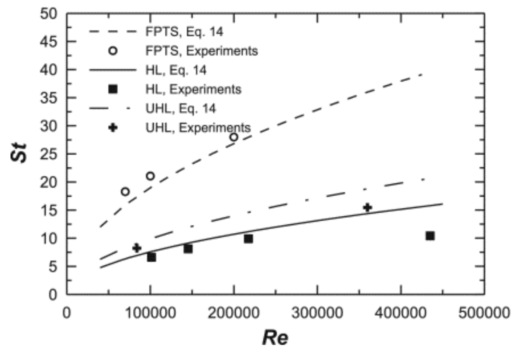
$$\frac{\partial(\rho v)}{\partial t}+\frac{\partial(\rho uv)}{\partial x}+\frac{\partial(\rho v^2)}{\partial y}+\frac{\partial(\rho vw)}{\partial z}=-\frac{\partial p}{\partial y}+\frac{1}{Re_r}\left[\frac{\partial \tau_{xy}}{\partial x}+\frac{\partial \tau_{yy}}{\partial y}+\frac{\partial \tau_{yz}}{\partial z}\right]$$

**Z – Momentum**

$$\frac{\partial(\rho w)}{\partial t}+\frac{\partial(\rho uw)}{\partial x}+\frac{\partial(\rho vw)}{\partial y}+\frac{\partial(\rho w^2)}{\partial z}=-\frac{\partial p}{\partial z}+\frac{1}{Re_r}\left[\frac{\partial \tau_{xz}}{\partial x}+\frac{\partial \tau_{yz}}{\partial y}+\frac{\partial \tau_{zz}}{\partial z}\right]$$

**Energy:**

$$\frac{\partial(E_T)}{\partial t}+\frac{\partial(uE_T)}{\partial x}+\frac{\partial(vE_T)}{\partial y}+\frac{\partial(wE_T)}{\partial z}=-\frac{\partial(up)}{\partial x}-\frac{\partial(vp)}{\partial y}-\frac{\partial(wp)}{\partial z}-\frac{1}{Re_r Pr_r}\left[\frac{\partial q_x}{\partial x}+\frac{\partial q_y}{\partial y}+\frac{\partial q_z}{\partial z}\right]$$
$$+\frac{1}{Re_r}\left[\frac{\partial}{\partial x}(u\tau_{xx}+v\tau_{xy}+w\tau_{xz})+\frac{\partial}{\partial y}(u\tau_{xy}+v\tau_{yy}+w\tau_{yz})+\frac{\partial}{\partial z}(u\tau_{xz}+v\tau_{yz}+w\tau_{zz})\right]$$




Mathematical Simplification

$$\nabla^2 \varphi = 0$$

Laplace's Equation

# Simplified Models – Space Engineering

- 1998
  - Egyptian Space Program was launched (Egypt-Sat1)
    - Complex System
    - Expensive System
    - Long Development Time
    - Space Agency
  - CanSat was proposed by Prof. Robert Twiggs

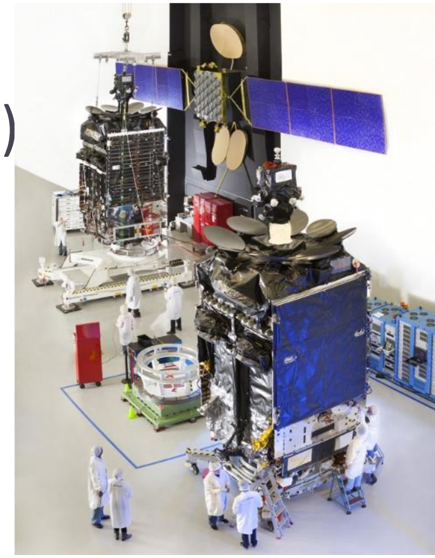
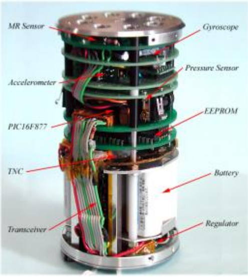


Image Courtesy of Boeing

Robert Twiggs

Sayed Dessoki Hassan

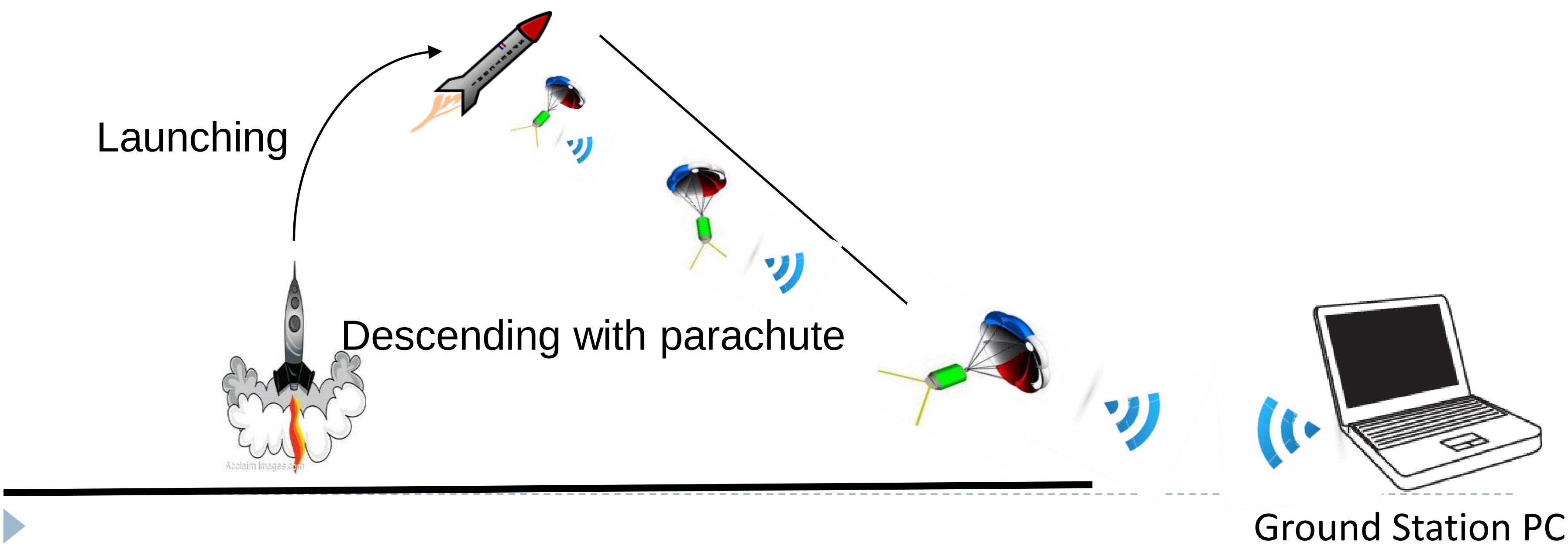
Physical Simplification




CanSat

# What is the CanSat?

The CanSat provides an affordable way to acquire the students with the basic knowledge to many challenges in building a satellite. Students will be able to design and build a small electronic payload that can fit inside a coke can. The CanSat is launched and ejected from a rocket or a balloon. By the use of a parachute, the CanSat slowly descends back to earth performing its mission while transmitting telemetry. Post launch and recovery data acquisition will allow the students to analyze the cause of success and/or failure.



# Main features of CanSat

- Very Simple Satellite System
- Short Development time (few days – one year)
- Low Life Cycle cost.
- Excellent Educational tool for many engineering disciplines

# CLTP Syllabus and Methods: CLTP-1

- Date: Feb 11 – March 11, 2011
- Hosting institute: Wakayama University
- Host Professor: Hiroaki Akiyama
- Teaching Method: "Animal Sprit"

- Orientation
- Introductory Lecture about Space Engineering
Prof. Hiroaki Akiyama

Build and Launch Basic CanSat

Start an Advanced CanSat Mission Project

PDR

CDR

Launch

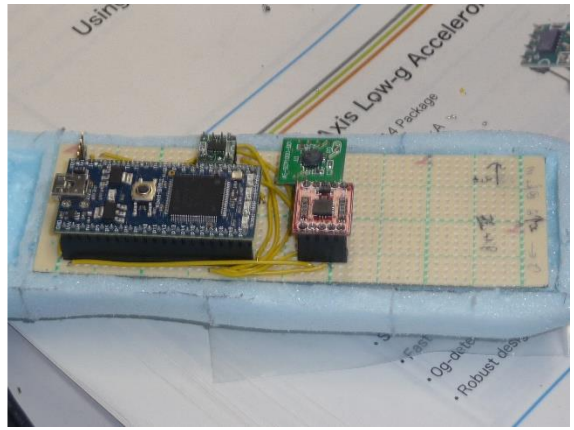
Week 1 | Week 2 | Week 3 | Week 4

Micro-Controller Programing
By SENIO Co.

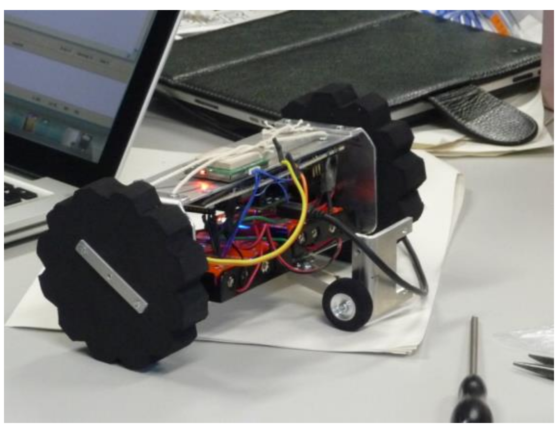
System Design Lecture
Prof. Seiko Shirasaka

General CanSat Lecture
Prof. Twiggs

# Basic / Advanced CanSats: CLTP-1



Basic CanSat



Rover-Back CanSat

Fly-Back CanSat

# CLTP-1 Participants

- 12 Participants
- 9 countries (Algeria, Australia, Bangladesh, Egypt, Guantanamo, Mexico, Nigeria, Peru, Turkey)

# Learning Approach

- “Animal Sprit” = Collaborative Learning
  - Small groups work with peer interaction leads to better learning outcomes
    - Increase the depth of learning
  - Group size and composition matters
    - 2-10 members
    - Set the goal, e.g. productivity, maximize performance of low performance participants.
  - Peer feedback and support can be as useful as instructor feedback and support.

# Learning Cycle

- Systematic approach to skill building

# CLTP Syllabus and Methods: CLTP 5-7

1. Online Lecture Series Portion
   - Four Segments
   - One month
   - Total of 13 hours
   - Assessment with 50% passing grade

Professor Shinichi Nakasuka
The University of Tokyo
**CanSat - Its Educational Significance**

Professor Hironori Sahara
Tokyo Metropolitan University
**Mission Subsystem**

Professor Shinichi Kimura
Tokyo University of Science
**C&DH and Power Systems**

Professor Hiraku Sakamoto
Tokyo Institute of Technology
**Structures & Deployables**

Professor Masahiko Yamazaki
Nihon University
- **Communication and Ground Station**
- **Sensors and Actuators**

Professor Yasuyuki Miyazaki
Nihon University
- **Ground Test and How to Feedback**
- **Field Experiment and Safety Standard**

Week 1 → Week 2 → Week 3 → Week 4

# CLTP Syllabus and Methods: CLTP 5-7

2. Hands-on Training Portion
   - Date: Sep.21 – Oct. 2, 2016
   - Hosting institute: Hokkaido University
   - Host Professor: Tsuyoshi Totani
   - Teaching Method: Project Based Education

Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 | Day 11

**Day 1**

- Orientation
- i-CanSat Assembly

**Day 2**


- Orientation
- Introductory Presentation
- i-CanSat Assembly

**Day 3**

- Continuity test
- GPS Configuration
- Xbee Configuration

**Day 4**

- Cancam operation
- General operation
- Google Map & GPS data
- Parachute fabrication
- Drop test

**Day 5**

User board Assembly

**Day 6**

Sapporo Sightseeing

**Day 7**

- Testing
- User board Development

**Day 8**

- Move to Akabira
- Paper rocket Fabrication

**Day 9**

- Paper rocket Fabrication
- First Launch

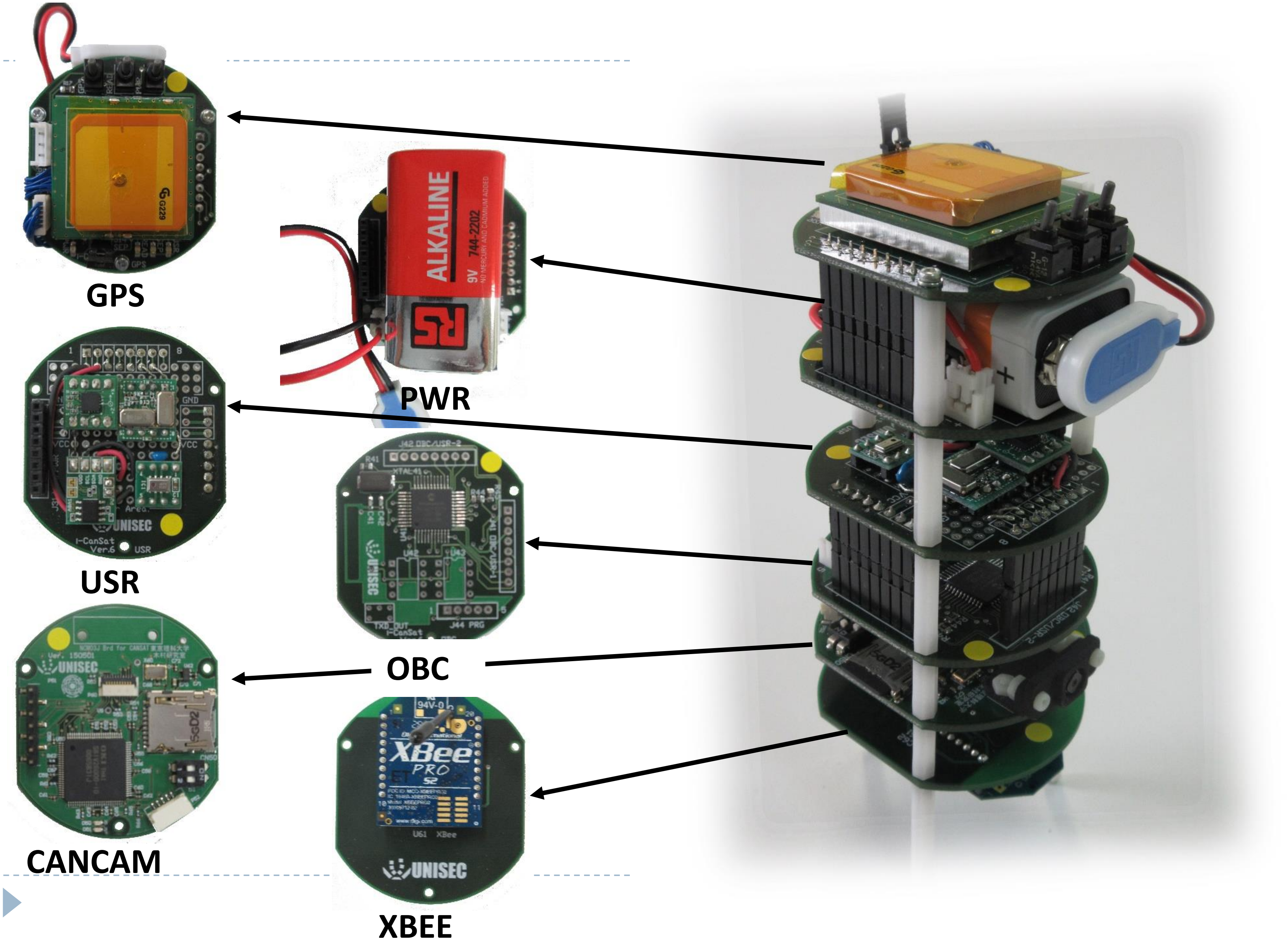
**Day 10**

- Second Launch
- Presentation Preparation

**Day 11**

Data Analysis & Final Presentation

# i-CanSat



# i-CanSat

# Participants

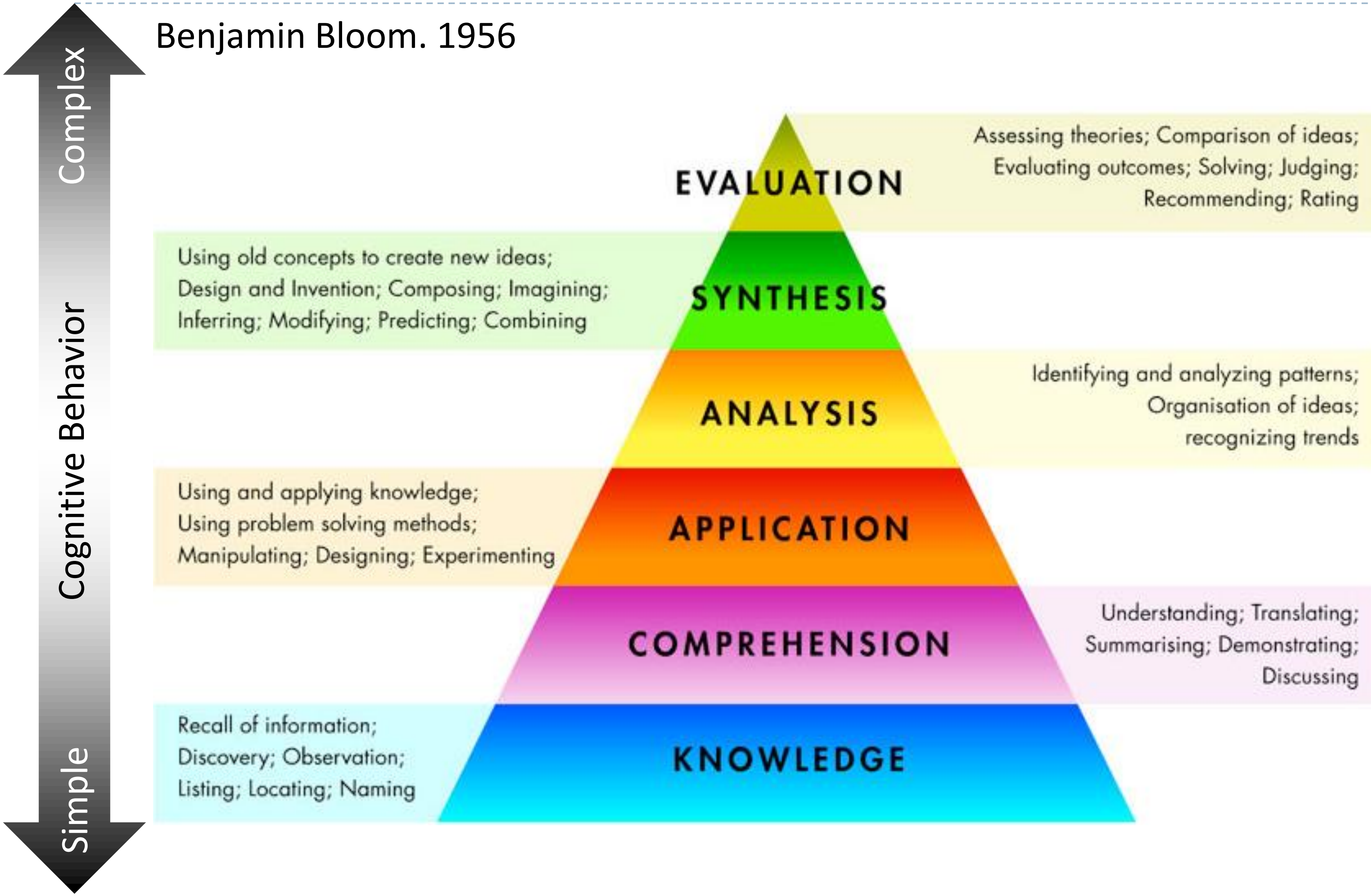
- 8 Participants
- 7 countries (Dominican Republic, Egypt,, Magnolia, Myanmar, Nepal, Peru, Serbia)

# Project Based Education (Learn-by-doing)

- Relevance improve retention
  - Allow to retain more information/concepts
- Practice allows integration of knowledge
  - Software/Hardware integration.
- Application leads to generalization
  - CubeSat and Large Spacecraft
- Depth of understanding improves with synthesis and integrations

# Blooms Taxonomy (Different level of Knowledge)

Benjamin Bloom. 1956



# Knowledge Verbs


| | |
|---|---|
| Evaluation | Appraise, assess, choose, compare, criticize, estimate, evaluate, judge, measure, rate, rank, revise, score, select. |
| Synthesis | Arrange, assemble, collect, compose, construct, create, design, formulate, integrate, manage, organize, plan, prescribe, propose. |
| Analysis | Analyze, appraise, calculate, categorize, compare, contrast, debate, diagram, differentiate, examine, inventory, question, test |
| Application | Apply, calculate, demonstrate, employ, examine, illustrate, interpret, operate, practice, schedule, sketch, solve, use. |
| Comprehension | Compute, describe, discuss, explain, identify, locate, report, review, tell, translate. |
| Knowledge | Define, repeat, record, list, cite, name, relate, review. |

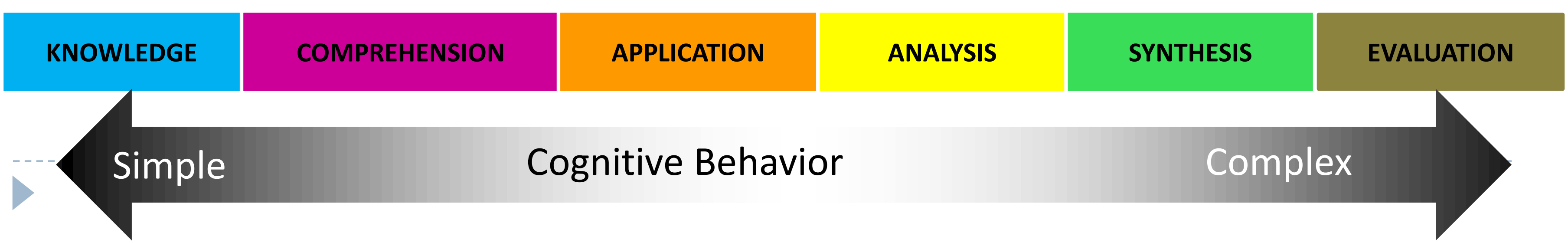
# CanSat Training Course Syllabus

- **Description**:
  - In this training course the participants will have the opportunity to learn different aspects of satellite subsystems through introductory set of lectures followed by hands-on training that cover the following topics:
    - Microcontroller Programing
    - Sensor and Actuators Interfaces
    - GPS Interface, configuration, and data extraction.
    - Communication Subsystem (Xbee)
    - PCB Fabrication Technique
    - Soldering Technique
    - Rapid Prototyping (Laser Cut, 3D printer, CNC)
    - Parachute Design and Fabrication
    - Ground Station Software (Processing and Labview)
    - Project Management
    - System Engineering
    - Drop test, data analysis and presentation.

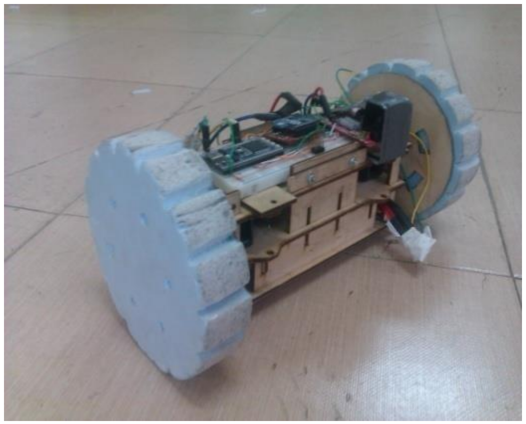
- **Target participants**: Undergraduate Engineering Students
- **Duration**: two weeks, Project: one week

# Course Learning Outcomes

- Understand the satellite systems
- Develop software to Acquire data from sensors and send commends to actuators.
- Design the CanSat's Structure and main PCBs.
- Design and Fabricate of Parachute.
- Practice the Project Management (time, HR, cost, risk)
- Practice the  System Engineering (PDR, CDR)
- Analyze the acquired sensors' data/source of failure.
- Evaluate and Criticize their peers CanSats.



# Advanced CanSat - Capstone Projects



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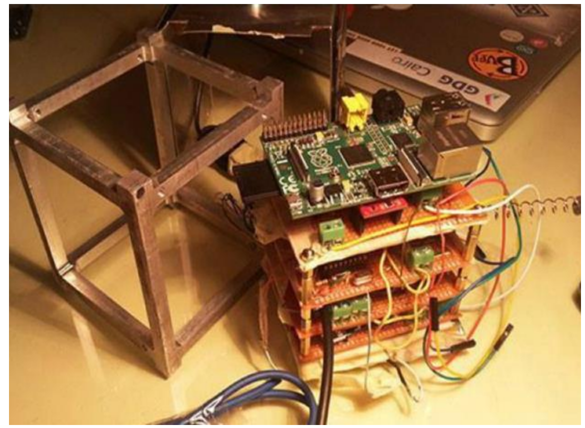
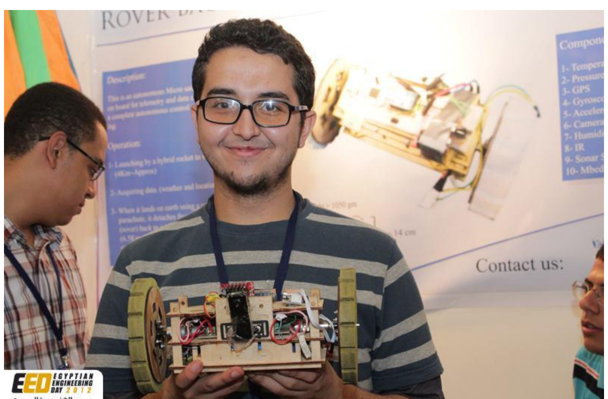


CUBESAT

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# Concluding Remarks

- Project based learning is the most proper method to teach CanSat.
- CanSat proved to be a versatile and customizable educational tool in Space Engineering as well as in Computer, Robotics, Software, and Communication Engineering.
- CanSat deepen the understanding and the retention curriculum related knowledge.