Practical Methods in Teaching CanSat

Mohammed Khalil Ibrahim, Ph.D.
Aerospace Engineering – Faculty of Engineering - Cairo University – Egypt.
Aerospace Engineering – College of Science and Technology – Nihon University, Japan
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)

\[
\begin{align*}
\text{Continuity:} & \quad \frac{\partial p}{\partial t} + \frac{\partial (p u)}{\partial x} + \frac{\partial (p v)}{\partial y} + \frac{\partial (p w)}{\partial z} = 0 \\
\text{X – Momentum:} & \quad \frac{\partial (p u)}{\partial t} + \frac{\partial (p u^2)}{\partial x} + \frac{\partial (p uv)}{\partial y} + \frac{\partial (p vw)}{\partial z} = -\frac{\partial p}{\partial x} + \frac{1}{Re} \left( \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} \right) \\
\text{Y – Momentum:} & \quad \frac{\partial (p v)}{\partial t} + \frac{\partial (p uv)}{\partial x} + \frac{\partial (p v^2)}{\partial y} + \frac{\partial (p vw)}{\partial z} = -\frac{\partial p}{\partial y} + \frac{1}{Re} \left( \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} \right) \\
\text{Z – Momentum} & \quad \frac{\partial (p w)}{\partial t} + \frac{\partial (p uw)}{\partial x} + \frac{\partial (p vw)}{\partial y} + \frac{\partial (p w^2)}{\partial z} = -\frac{\partial p}{\partial z} + \frac{1}{Re} \left( \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} \right) \\
\text{Energy:} & \quad \frac{\partial (E_t)}{\partial t} + \frac{\partial (u E_t)}{\partial x} + \frac{\partial (v E_t)}{\partial y} + \frac{\partial (w E_t)}{\partial z} = -\frac{\partial (u p)}{\partial x} - \frac{\partial (v p)}{\partial y} - \frac{\partial (w p)}{\partial z} - \frac{1}{Re,Pr} \left( \frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + \frac{\partial q_z}{\partial z} \right) \\
& \quad + \frac{1}{Re} \left( \frac{\partial}{\partial x}(u \tau_{xx} + v \tau_{xy} + w \tau_{xz}) + \frac{\partial}{\partial y}(u \tau_{xy} + v \tau_{yy} + w \tau_{yz}) + \frac{\partial}{\partial z}(u \tau_{xz} + v \tau_{yz} + w \tau_{zz}) \right)
\end{align*}
\]

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 of CanSat](image-courtesy-of-boeing)

*Robert Twiggs*

*Sayed Dessoki Hassan*
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”

Week 1
- Orientation
- Introductory Lecture about Space Engineering
  Prof. Hiroaki Akiyama

Week 2
- Build and Launch Basic CanSat
- Start an Advanced CanSat Mission Project

Week 3
- General CanSat Lecture
  Prof. Twiggs

Week 4
- PDR
- CDR
- Launch
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

- Goal Setting
- Feedback and Reinforcement
- Tracking (Assessment)
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
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
- Orientation
- Introductory Presentation
- i-CanSat Assembly

Day 2
- Continuity test
- GPS Configuration
- Xbee Configuration

Day 3
- User board Assembly

Day 4
- Testing
- User board Development

Day 5
- User board Development

Day 6
- Paper rocket Fabrication
- First Launch

Day 7
- Day 8
- Move to Akabira
- Paper rocket Fabrication

Day 9
- Data Analysis &
- Final Presentation

Day 10
- Second Launch
- Presentation Preparation

Day 11
- Sapporo Sightseeing
- - Move to Akabira
- - Paper rocket Fabrication
i-CanSat

GPS
USR
PWR
OBC
CANCAM
XBEE
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**: Recall of information; Discovery; Observation; Listing; Locating; Naming
- **Comprehension**: Understanding; Translating; Summarising; Demonstrating; Discussing
- **Application**: Using and applying knowledge; Using problem solving methods; Manipulating; Designing; Experimenting
- **Analysis**: Identifying and analyzing patterns; Organisation of ideas; recognizing trends
- **Synthesis**: Using old concepts to create new ideas; Design and Invention; Composing; Imagining; Inferring; Modifying; Predicting; Combining
- **Evaluation**: Assessing theories; Comparison of ideas; Evaluating outcomes; Solving; Judging; Recommending; Rating
# Knowledge Verbs

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

ARLISS 2014

CUBESAT

ARLISS 2015

QUADCOPTER

ARLISS 2016
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.