Developing a Hands-On STEM English Course for Japanese University Students

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Purpose

- Develop an English CLIL STEM course
- Use hands-on activities while engaging with authentic English materials
- Encourage higher-order thinking while practicing L2 skills

Participants

1st and 2nd year Japanese university from a range of engineering, architecture, media informatics and science majors

Course Structure

- 14 week course (Half face-to-face, half distance learning)
- 5 units introduced in 3-week blocks
- Hands-on experiments and reporting allows for standards based assessment

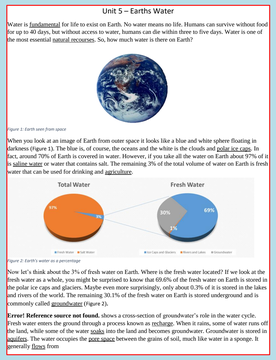
Unit/Topic	Lesson Structure	Time
STEM Fundamentals	1) Reading STEM nomenclature 2) Reading graphs, table, charts etc.	2 Weeks
Scientific Method	1) Introduce Content/Reading 2) Conduct Experiment 3) Presentation/Reporting	3 Weeks
Bernoulli's Principle		3 Weeks
Parabolic Motion		3 Weeks
Global Water		3 Weeks

Material Development

- The main focus was to introduce STEM content in English and provide students with an opportunity to apply HOTs in the English classroom
- Materials and Experiments were developed by the presenter

Reading Materials

- Five original texts were created for each unit
- Used to introduce the topic, key vocabulary, practice reading/comprehension skills
- Average 580 words per text


Unit 5 – Earths Water

Water is fundamental for life to exist on Earth. No water means no life. Humans can survive without food for up to 40 days, but without access to water, humans can die within three to five days. Water is one of the most essential natural recourses. So, how much water is there on Earth?

Figure 1: Earth seen from space

When you look at an image of Earth from outer space it looks like a blue and white sphere floating in darkness (Figure 1). The blue is, of course, the oceans and the white is the clouds and polar ice caps. In fact, around 70% of Earth is covered in water. However, if you take all the water on Earth about 97% of it is saline water or water that contains salt. The remaining 3% of the total volume of water on Earth is fresh water that can be used for drinking and agriculture.

Figure 2: Earth's water as a percentage

Now let's think about the 3% of fresh water on Earth. Where is the fresh water located? If we look at the fresh water as a whole, you might be surprised to know that 69.6% of the fresh water on Earth is stored in the polar ice caps and glaciers. Maybe even more surprisingly, only about 0.3% of it is stored in the lakes and rivers of the world. The remaining 30.1% of the fresh water on Earth is stored underground and is commonly called groundwater (Figure 2).

Error! Reference source not found. shows a cross-section of groundwater's role in the water cycle. Fresh water enters the ground through a process known as recharge. When it rains, some of water runs off the land, while some of the water soaks into the land and becomes groundwater. Groundwater is stored in aquifers. The water occupies the pore space between the grains of soil, much like water in a sponge. It generally flows from

Figure 1: Sample Text

Hands-On Experiments

- Experiments (conducted in teams of 3-4 students) allowed students to i) apply content knowledge to conduct simple experiments, ii) solve simple problems in teams, iii) collect and analyse data and iv) evaluate experiment outputs and report findings.
- Experiments required very little to no additional materials

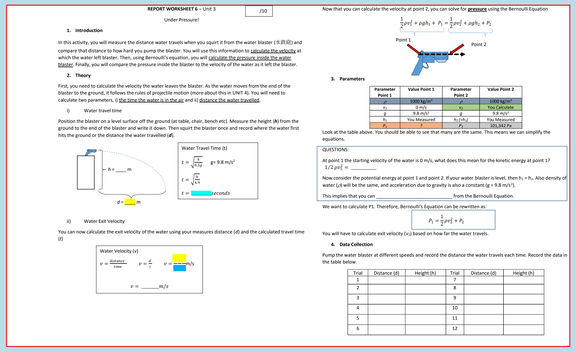
Experiments included:

Scientific Method – Paper plane/Ball Drop/Step Length

Bernoulli's Principle – Relate pressure and fluid velocity using water blasters

Parabolic Motion – Use handmade catapults to evaluate the curve of a parabola

Global Water – Estimate individual Direct and Indirect water budgets


REPORT WORKSHEET 6 – Unit 3 /10

Under Pressure!

1. Introduction

In this activity, you will measure the distance water travels when you squirt it from the water blaster (-0.05:00) and compare that distance to how hard you pump the blaster. You will use this information to calculate the velocity at which the water left blaster. Then, using Bernoulli's equation, you will calculate the pressure inside the water blaster. Finally, you will compare the pressure inside the blaster to the velocity of the water as it left the blaster.

2. Theory

First, you need to calculate the velocity the water leaves the blaster. As the water moves from the end of the blaster to the ground, it follows the rules of projectile motion (more about this in UNIT 4). You will need to calculate two parameters, i) the time the water is in the air and ii) distance the water travelled.

i) Water travel time

Position the blaster on a level surface off the ground (at table, chair, bench etc). Measure the height (h) from the ground to the end of the blaster and write it down. Then squirt the blaster once and record where the water first hits the ground or the distance the water travelled (d).

ii) Water Exit Velocity

You can now calculate the exit velocity of the water using your measures distance (d) and the calculated travel time (t)

Now that you can calculate the velocity at point 2, you can solve for pressure using the Bernoulli Equation

3. Parameters

Parameter Point 1	Value Point 1	Parameter Point 2	Value Point 2
ρ	1000 kg/m³	P₂	1000 kg/m³
h₁	0 m	h₂	0.05 (-0.05:00) m
v₁	9.8 m/s	v₂	9.8 m/s
P₁	You Measured	P₂-P₁	You Measured
g	9.8 m/s²	P₂	101,942 Pa

Look at the table above. You should be able to see that many are the same. This means we can simplify the equations.

QUESTIONS:

At point 2 the starting velocity of the water is 0 m/s, what does this mean for the kinetic energy at point 1?

$1/2\rho v_2^2 =$ _____

Now consider the potential energy at point 1 and point 2. If your water blaster is level, then $h_1 = h_2$. Also density of water (ρ) will be the same, and acceleration due to gravity is also a constant (g = 9.8 m/s²).

This implies that you can _____ from the Bernoulli Equation.

We want to calculate P1. Therefore, Bernoulli's Equation can be rewritten as:

$$P_1 = \frac{1}{2}\rho v_1^2 + P_2$$

You will have to calculate exit velocity (v1) based on how far the water travels.

4. Data Collection

Pump the water blaster at different speeds and record the distance the water travels each time. Record the data in the table below.

Trial	Distance (d)	Height (h)	Trial	Distance (d)	Height (h)
1			7		
2			8		
3			9		
4			10		
5			11		
6			12		

Figure 2: Sample Experiment Worksheet

Presentations and Reporting

- Information and data collected through the experiments was evaluated by the students and presented to peers via PowerPoint or poster presentation
- Students were assessed based on their ability to relate experimental results to underlying principles of each unit.

Student Impressions

Quantitative and Qualitative data was collected at the end of the course (n=66)

Survey Results

Students overall impression was positive. Comments included (translated from Japanese):

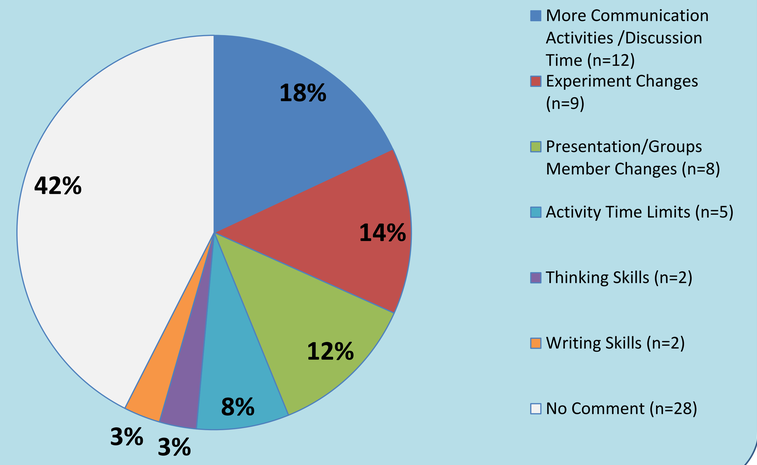
"The assignments and tests were difficult. But I think I have acquired a lot of knowledge about STEM."

"It's not just about learning English, it's content that can be used somewhere, and there is a perspective for what you've learned."

"By experimenting, I was able to deepen my understanding."

"Points that can be calculated from experimental data help to deepen scientific thinking"

Student Feedback - Points for Improvement



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