

# インターナショナル・サイエンス・スタディに取り組む スーパー・サイエンス・ハイスクールにおける英語での理科授業の実践

Science Lesson Practice in English  
at a Super Science High School Engaging in International Science Study

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## 1. Outline of the Activity

The improvement of science and mathematics education is one of the important issues for international education cooperation. Science and mathematics should be shared and exchanged among different cultures since they handle universal natural phenomena and logics. In the Field of Mathematics and Science Education of Global Education Course of Graduate School of Naruto University of Education, staffs and students have been committed to developing effective teaching materials and methods for improving worldwide science and mathematics education. As part of the educational activities, we performed science classes in English for Japanese 10th- and 11th- grade students on November 13th in 2020 at Tokushima Prefectural Tomioka-nishi High School selected as a Super Science High School (SSH). The SSH school has engaged in “International Science Study” so far to nurture human resources who can act both regional and global fields with an international sense. Through the lesson practice, both we and the SSH school were able to strengthen the win-win relationship each other and to obtain fruitful results contributing to each educational goal. In the following section, we introduce the details of the classes and the exchange activity with the SSH students.

## 2. Chemistry Class for 11th Grade by Bema (4th period, 50 min)

### 2.1. Background

#### 2.1.1. A Necessary Concept of the Individual Skill Development in Chemistry

We convince that the concept of chemical equations was difficult to teach, but also the fundamentals in the construction of students' scientific concepts. Indeed, it allows us to explain questions, to explain everything around us and to glimpse the probable scientific foundations of our environment, chemical species that we use in everyday life, it is an integral part of us. It is therefore a necessary concept to understand our own identity and the world in which we live; I will call it universal because I think it is essential that everyone can take ownership of it in order to build themselves fully. The cognitive construction of the individual cannot be completed without the inevitable passage of understanding of this concept. On the basis of this hypothesis, we immediately show the importance of the construction and the quality of teaching this concept, which begins in college.

#### 2.1.2. The Difficulties for Students and Teachers on the Scientific Concept

The difficulty lies in the fact that chemical equations are conventions between scientists, beyond

the symbol, materializes a chemical experiment during a chemical reaction between chemical species of a different nature, but governs by laws and rules according to their chemical and physical goods. Thus, students and teachers withdraw in the deduction, from the abstract, to obtain the concrete, which reflects the experimental reality. Advanced microscopes only give representations, images, and the teacher has only explanatory models. We would need the equipment of a large laboratory to make these chemical reactions more concrete, but we all know that our schools are not as well equipped.

In Africa, we have only the minimum of equipment, almost no laboratory, or no suitable equipment for chemical experiments. To remedy this, our approach is to make students understand that chemical equations are only mathematical, association of formulas. Is this approach really real?

In a so-called "classic" teaching, the teacher uses experimentation (the experience on which he relies very often) allows students to demonstrate and prove a law or principle. Similarly, through trial and error, students construct an experimental approach that also allows him to achieve the desired results. In any cases, the empirical approach convinces students.

We would be tempted to sum up his position as "I designed, I saw, I am convinced". This wording may seem reductive, but it seems to me to reflect what is really happening in the classroom. This empirical approach can lead students to make conclusions that are too hasty. It deprives itself of a critical mind and a good scientific understanding.

With symbols, university professors rely on models that they cannot demonstrate either through experiments or calculations. They should use the history of science and show the difficulty and contradicted pathways of the reasoning of the various scholars. But very often, the teaching of chemical reaction models is done by rupture. Often at high temperature or at low temperature, in the presence of a catalyst.

At no time is the investigative approach used by scientists described realistically, just an equation with symbols and a lot of explanations to convince students, because it is that of the abstract with these own rules. Linking the relationship between chemistry and everyday life, it is with this approach that we wish to present this activity.

## 2.2. Objectives

The aim of this course is to make Japanese students understand how to solve a chemistry problem theoretically based on a typical African pedagogical style. This style of resolution is very popular in Africa, due to the lack of infrastructure, laboratory in schools. Teachers rely on drawings, photos of experiments to carry out his course and theoretically solve the application exercises related to learning.

Thanks to this style of teaching, Japanese students will deduce that science is universal. Using the same chemical symbols, the same formulas, the same physical and chemical properties studied in their laboratory equipped with experimental devices, using the same universal values of molar masses and molar volumes and by different approaches, we achieve the same result, and this in a theoretical way.

### 2.2.1. Topic

We decided to place the topic as "Chemical Reactions and Equations: Application to Chemistry Problems" and key question to be "How to write a Chemical Equation and Theoretically Solve a Chemistry Problem?"

### 2.2.2. Educational Processes and Materials

This chemistry lesson consisted of an introduction to the subject and purpose of teaching this lesson. For activating the knowledge required for the students, the processes of individual research, group work (5 groups of 8 students), group presentation, and summary are provided in the lesson.

In the prior knowledge activity, each group received an exercise where the objective was to present the equation of a reaction as shown in Fig. 1. With this production, the presentation of the group results allowed us to understand together the concept of "Reagents", "Products", and "Mass Conservation".

In the second activity, an exercise in common is assigned to all groups, as shown in Figs. 2 and 3, where we proposed a theoretical resolution of a chemistry problem. By referring to the word list as shown in Fig. 4, students found the same result by different approaches, which proves that the lesson has achieved these goals.

STUDENT INDIVIDUAL WORK SHEET	GROUP : 1
FIRST ACTIVITY	
<p><b>TODAY'S QUESTIONS</b></p> <p>How do you create the balance of equation?</p> <div style="border: 1px solid black; padding: 10px; margin: 10px auto; width: 80%;"> <p><b>Read and write an appropriate Chemical Equation</b></p> <p>Aminata cooks with a gas stove containing <b>butane</b>.</p> <p>This gas burns in <b>oxygen</b> and gives <b>carbon dioxide</b> and <b>water</b>.</p> <p>Write down the reaction balance equation.</p> </div> <div style="margin-top: 20px; text-align: center;"> <div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 5px; width: 20%;">REAGENTS</div> <div style="flex-grow: 1; border-bottom: 1px solid black; position: relative; height: 40px;"> <div style="position: absolute; top: -10px; left: 50%; transform: translateX(-50%);">→</div> </div> <div style="border: 1px solid black; padding: 5px; width: 20%;">PRODUCTS</div> </div> </div>	

Figure 1. An example of worksheets for the first individual and group activities (Group1)

STUDENT INDIVIDUAL WORK SHEET	GROUP : 2
SECOND ACTIVITY	
<p><small>For all:</small></p> <p><b>Exercising:</b> In a laboratory, Mamadou-san pours some diluted <b>sulfuric acid</b> into a test tube containing <b>4.88g of zinc</b>. A reaction has taken place, he observes the complete disappearance of the metal.</p> <ol style="list-style-type: none"> <li>1) Write down the balanced Equation of Reaction,</li> <li>2) Calculates the volume of <b>hydrogen</b> released,</li> <li>3) Calculates the mass of <b>zinc sulfate</b> formed.</li> </ol> <p><b>DATA:</b> Molar mass: <math>M(\text{Zn})=65\text{g/mol}</math>, <math>M(\text{O})=16\text{g/mol}</math>,  <math>M(\text{H})=1\text{g/mol}</math>, <math>M(\text{S})=32\text{g/mol}</math>              Normal Molar Volume <math>V_0=22.4\text{L/mol}</math></p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px; width: 150px;">Draft</div>	<div style="border: 1px solid black; padding: 10px; height: 200px; margin-top: 10px;">Student's answer</div>

Figure 2. An example of worksheets for the second individual and group activities

SECOND ACTIVITY: Theoretical Solving Laboratory Problem	
<p><b>SOLVING STEP</b> (Malian theoretical solving style)</p> <ol style="list-style-type: none"> <li>1. Equation of chemical reaction (Write reagents in Left, and products in Right)  <math>aA + bB \longrightarrow cC + dD</math>                      The <i>stoichiometric coefficients</i>  <math>n(\text{Zn}) = n(\text{H}_2\text{SO}_4) = n(\text{ZnSO}_4) = n(\text{H}_2)</math>                      The value <b>n</b> of mole contained in (mass or volume) of started Reagent (4.88g of zinc)  <math>n(\text{Zn}) = \frac{m(\text{Zn})}{M(\text{Zn})} = \frac{4.88}{65} = ? \text{ mol}</math> </li> <li>2. Volume of hydrogen obtained with 4.88g of zinc  <math>V(\text{H}_2) = n(\text{H}_2) \times V_0 = ? \times 22.4 \text{ liters}</math>      <math>V(\text{H}_2) = ? \times 22.4 = ? \text{ liter}</math> </li> <li>3. Mass of zinc sulphate formed  <math>m(\text{ZnSO}_4) = n(\text{ZnSO}_4) \times M(\text{ZnSO}_4)</math>      and      <math>M(\text{ZnSO}_4) = M(\text{Zn}) + M(\text{S}) + 4M(\text{O})</math>  <math>m(\text{ZnSO}_4) = ? \times 161 = ? \text{ g}</math>      <math>M(\text{ZnSO}_4) = 65 + 32 + (4 \times 16) = 161\text{g/mol}</math> </li> </ol>	<div style="border: 1px solid black; padding: 10px; height: 150px; margin-top: 10px; text-align: center;">DRAFT</div>
<p><b>SYNTHESIS</b></p> <ul style="list-style-type: none"> <li>- Chemical reaction is a transformation where the chemical species involved disappear and given birth to new chemical species.</li> <li>- The Chemical Species that disappear are called <b>Reagents</b>; the Chemical Species that appear after reaction are called <b>Products</b>.</li> <li>- The equation of the reaction is the following: <math>aA + bB \longrightarrow cC + dD</math></li> <li>- Reagents and Products formed are proportional to the <i>stoichiometric coefficients</i> as follows: <math>\frac{n(A)}{a} = \frac{n(B)}{b} = \frac{n(C)}{c} = \frac{n(D)}{d}</math></li> </ul>	

Figure 3. Solving steps for the second activity

Title: CHEMICAL REACTIONS AND EQUATIONS: APPLICATION TO CHEMISTRY PROBLEMS				
Problematic: How to write a chemical equation and theoretically solve a chemistry problem?				
WORDS		CHEMICAL SPECIES		
ENGLISH	JAPANESE	NAME	SYMBOL	JAPANESE
balance of equation	(化学)反応式の平衡 (両辺の係数が揃い、質量保存則が成立した状態にある反応式)	aluminum	Al	アルミニウム
burn	燃焼する	aluminum oxide	Al <sub>2</sub> O <sub>3</sub>	酸化アルミニウム
chemical reaction	化学反応	butane	C <sub>4</sub> H <sub>10</sub>	ブタン
chemical species	化学種	carbon dioxide	CO <sub>2</sub>	二酸化炭素
dazzling light	閃光、まぶしい光	hydrochloric acid	HCl	塩酸
disappear	消失する	hydrogen molecule	H <sub>2</sub>	水素分子
powder of the complete disappearance theoretically	理論的に完全に消失する粉末	iron	Fe	鉄
products	生成物	iron sulfate	FeSO <sub>4</sub>	硫酸鉄 (II)
qualitatively	定性的に	methane	CH <sub>4</sub>	メタン
quantitatively	定量的に	nitric acid	HNO <sub>3</sub>	硝酸
reagents	反応物	oxygen molecule	O <sub>2</sub>	酸素分子
stoichiometric coefficients	化学量論係数 (化学反応式の各化学種に付ける係数)	potassium hydroxide	KOH	水酸化カリウム
		potassium nitrate	KNO <sub>3</sub>	硝酸カリウム
		sodium chloride	NaCl	塩化ナトリウム
		sodium hydroxide	NaOH	水酸化ナトリウム
		sodium sulfate	Na <sub>2</sub> SO <sub>4</sub>	硫酸ナトリウム
		sulfuric acid	H <sub>2</sub> SO <sub>4</sub>	硫酸
		water	H <sub>2</sub> O	水
		zinc	Zn	亜鉛
		zinc chloride	ZnCl <sub>2</sub>	塩化亜鉛
		zinc sulfate	ZnSO <sub>4</sub>	硫酸亜鉛

Figure 4. Words list and symbols used in the lesson



Figure 5. Several scenes of the lesson for 11th grade

In the group activity, the students were very committed to sharing understanding collectively and collaboratively. Although, language was an issue that made it difficult to exchange. Thanks to the advice of the teachers and in particular their peers, the students were able to finalize their results. Presenting their results was a bit difficult because it was in English.

Despite this challenge, the students were able to present their results for discussion. Several scenes of the lesson are shown in Fig. 5.

### 2.3. Evaluation and Limitation

Language is the first obstacle that limited the effectiveness of this lesson, and it was difficult to

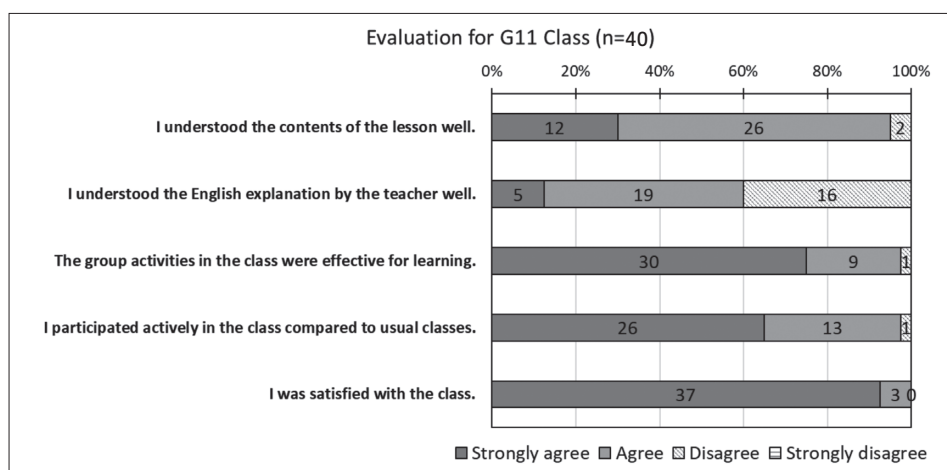


Figure 6. Results of questionnaire conducted for 11th grade students

interact proactively. The purpose of the group work was to increase collaboration and to ensure that everyone worked together; the teacher had essential elements to assess this learning. The key is to challenge the work of individual students to realize that they were working together. Therefore, because of the language barrier that may have led to the use of more time, this crucial part was eliminated. Students managed to solve the problem, and to achieve the goal set using the materials for groups work. Figure 6 shows the results of the questionnaire conducted for the students after this class. Most of students were able to realize a good learning performance and were well-satisfied with this lesson.

## 2.4. Conclusions

When we started this lesson, we weren't sure we would succeed with the students at Tomioka-Nishi High School. Our primary objective was to introduce the African method of teaching science, theoretically based on the fundamental laws of modern chemistry. Certainly, the language barrier is a handicap. The teacher is French speaking, the students speak Japanese, and the course is in English. Nevertheless, the goal is achieved.

## 3. Chemistry Class for 10th Grade by Wiliame (5th Period, 50 min)

### 3.1. Theme & Objectives

The theme of this lesson is "Properties of Metals and Non-metals" with a key-question for students, "What or How is the Difference between Metals and Non-metals?". The objectives of the class are as follows:

- 1) At the end of the lesson, the student should be able to discover their findings by using an electric circuit to experiment and investigate the elements of metals and non-metals.

- 2) The student should be able to interpret their findings by expressing them in worksheets, group discussions and on the board by presenting whether the different elements a good or bad conductors of electricity.
- 3) Students will be able to identify and distinguish its physical properties, related to concepts learned with the periodic table with its symbolic value and its uses in our daily lives.

### 3.2. Teaching Process and Materials

This lesson was conducted for 40 students of 10th grade to allow them to investigate the differences in the properties and uses between metals and non-metals in relation to the periodic table. The lesson plan is represented in Table 1. The lesson was designed using the Inquiry Based Learning Approach which is the 5E method of instruction to ensure maximum comprehension by the students. The Inquiry Based Learning consists of Engagement, Explore, Explanation, Elaboration, and Evaluation processes. We provided each student with the two kinds of worksheets as in Tables 2 and 3 in addition to a periodic table and the word list used for the lesson. The students were separated into 10 groups of 4, and each group compared metals and non-metals by investigating its physical properties such as luster, conductivity, and malleability. For the students' activities, we prepared and used the following materials: electric circuit device (batteries, bulbs, and connecting wires), aluminum foils, metal plates of iron, zinc, copper and magnesium, plastics (polypropylene containers), silicon (silicon rubber caps), graphite (pencils), phosphorus (match sticks heads).

Figure 7 shows several scenes of the lesson. The results of the questionnaire conducted for the students after this lesson are shown in Fig. 8. Most of students were able to realize a good learning performance and were well-satisfied with this lesson.

Table 1. Lesson plan

Stages/Time	Contents	Teacher's activities	Students' activities	Remarks & Support Questions
Introduction 10 mins  Step 1	<u>Review-Engage</u>  Show a periodic table (PT) and identify the metals, non-metals, and metalloids.	-Ask the students to place a variety of elements (identities not revealed) out for students to investigate metals and non-metals -Give the students a variety of different things they can test various physical properties (luster, electrical conductivity) and make predictions beforehand of which are metals, non-metals or metalloids.	-Students will then define what a metal, non-metal, and metalloid are and compare/contrast the basic physical properties that they all share.  Fill in the worksheets	<u>Questions</u> a) Explain how the PT is organized? -Distinguished between metals, non-metal and metalloids.
Lesson Development 35 mins  Step 2	<u>Experiment-Question Explore</u> <u>Activity 1</u> -Fill the students' worksheets by clasifying metals and non-metals  <u>Activity 2</u> Investigate & Record (Electrical device) Experiment on the metals, non-metals, metalloids Construct- Properties&Uses Express- Presentation	-Students will use a foldable (graphic organizer) to compare/ contrast properties of each type. -Then we will incorporate knowledge of how the organization of the periodic table fits into this schema.  -Demonstrate the experiments. -Also identify the symbols.	<u>Explain</u> -Students have a very brief introduction of the periodic table and how the "staircase" separates the metals from the non-metals will be introduced. -Additionally, students will identify the 7 metalloids that border the "staircase" on the PT. -Perform the experiments using electric circuit. Fill the worksheets	<u>Elaborate</u> b) List properties of metals, non-metals, and metalloids? c) Categorize an substance as an metal, non-metal, or metalloid based on its properties?  d) How can an element be classified as a metal, non-metal, or metalloid based on its chemical and physical properties?
Conclusion 5 mins  Step 3	<u>Evaluate</u> What characteristics do non-metals have in common? (Possible answers : dull/lacks luster, poor conductors of heat/electricity	Feedback, Evaluation Compare and contrast metals or non-metals by testing it using the circuit.	Student ask themselves: What characteristics do metalloids have in common? (Possible answers : have properties of both metals and non-metals)	e) What characteristics do metals have in common ? (Possible answers: shiny/luster, conducts heat/electricity

Table 2. Worksheet of Activity 1

Materials/Properties	Metals	Non-Metals
Malleable		
Foil		
Copper		
Silver		
Aluminum		
Gold		
Steel		
Iron		
Wood		
Pencil		
Carbon (diamond)		
Neon gas		
Chlorine		
Phosphorus		
Boron		
Silicon		
Arsenic		
Lead		
Carbon (graphite)		



Table 3. Worksheet of Activity 2

Materials	Symbol	Properties (Place a tick)						Uses
		Conductor		Shiny	Dull	Bend	Brittle	
		Good	Bad					
a.Aluminum	-----							Example: Suitable for the bodies of plane and cars, for making sauce pans, for cooking foil and milk tops.
b. Plastic	-----							
c. Iron	-----							
d. Silicon	-----							
e. Zinc	-----							
f. Pure graphite (Pencils)	-----							
g. Phosphorus (Match sticks head)	-----							
h. Magnesium	-----							



Figure 7. Examples of students' experimental lessons using the 5Es Inquiry Based Learning Pedagogy

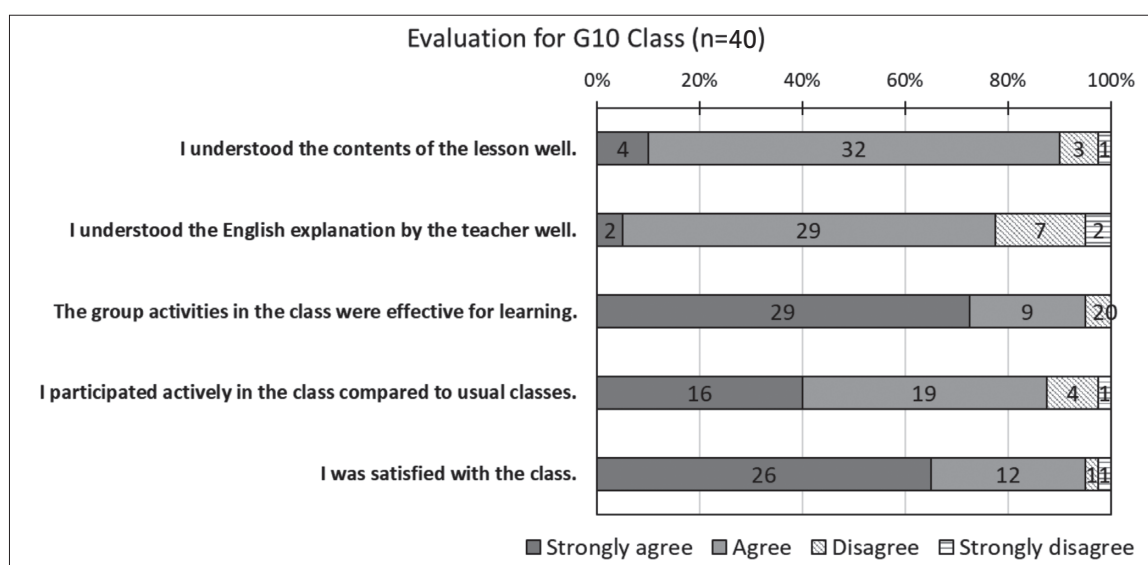


Figure 8. Results of questionnaire conducted for 10th grade students

### 3.3. Conclusions

Altogether, the lesson was smoothly transmitted through hands-on activity due to the inclusion of certain Japanese words which makes it easier for the students to grasp the concepts faster during the post lesson. The preparations for these lessons was challenging and also quite satisfactory given the unwavering support from our team. Giving instructions for both experiments takes much time, and also the students' presentation as well.

Overall, the students not only learn about what are good conductors and bad conductors but they also enjoyed lessons through cooperative learning by discussing and working together as a group likewise understand the deep meaning of the uses of each element, symbols and how it relates to the periodic table.

### 4. Exchange Activity with 10th and 11th Graders of the SSH School (6th Period, 50 min)

After the Science Classes in English, the teachers, trainees and students continued to an exchange activity as shown in Fig. 9. In this activity the 1st and 2nd year students demonstrated their English skills by informing the audience about different types of

activities they have at school, naming their teachers and favorite food, which is “Karaage Don”. Then, we were delighted with a demonstration of Japanese martial arts, such as: Kyudo (archery) and Kendo (swordsmanship).

We were also able to witness the great skills of Japanese Calligraphy done by a student. Moreover, as the activities were displayed by the students, we enjoyed some Japanese sweets and drank green tea. Furthermore, each of the trainees from the Naruto University of Education explained to the students the interesting facts about the culture, gastronomy, language and different aspects of the countries of Honduras, Fiji and Mali. This exchange activity has been highly rewarding for all of us, for the reason that we got to teach and share more about the High School students, and also, the students were able to know about our countries. We hope someday they will visit one of them.

### Acknowledgements

We would like to thank students and teachers of Tokushima Prefectural Tomioka-nishi Senior High School for their kind cooperation.



Figure 9. Scenes of the exchange activity