Developmental Research on Early Education in Science through English Taught by Non-Native Speakers to Japanese Students in Preparation for Globalization

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Abstract

Although science education in Japan was evaluated highly in TIMSS and PISA, education for gifted students to foster the next-generation of scientists was considered to be important. An additional issue in Japan was the urgent need for prompt action to meet the needs of a globalized society. Students learn English for a total of six years in junior-high and high school, but they lack sufficient chances to use it in practical situations. In this research, we developed programs for early education in science through English and carried out university-level scientific experiments through English only, under the assumption of the effectiveness of simultaneous learning of both science and English for non-native speakers as part of gifted and talented education. Seven lessons were developed. In the design of the lessons, we included the highly-regarded Content-and-Language-Integrated-Learning (CLIL) approaches. Furthermore, (1) video clips for preparation of individual lessons were uploaded onto a website, (2) many international students were involved in supporting the participants, and (3) some procedures were intentionally carried out in order to encourage students' use of thinking and communication skills. In total 18 lessons were organized in the academic years 2011 to 2014. From the questionnaire and reflection sheets submitted by the student participants in the final lesson, science experiments with English communication were shown to be effective in increasing the participants' desire to learn both science and English, although the range of levels of linguistic skills among the participants was found to be wide. The necessity of cooperative development with science and language educators was discussed.

Key words: gifted education, scientific experiments through non-native language, CLIL approaches

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Introduction

Background to Science Education in Japan

Although science education in Japan was evaluated highly in the latest TIMSS (Martin *et al.* 2011) and PISA (OECD 2012), the intrinsic motivation, pleasure and interest to learn mathematics were reported to be less than the OECD average, although some improvement from the previous reports was observed. They also pointed out that Japanese students have great anxiety towards mathematics and feel less confident in their ability to solve mathematics problems than students in other countries. The Japanese government (Ministry of Education, Culture, Sports, Science and Technology; MEXT) had started to introduce student-centered assessment of learning at that time. Regarding science education, the Japan Science and Technology Agency (JST) had started to encourage educators to foster the next-generation of scientists. Education for gifted students was also an important issue related to student-centered learning.

Although the report of PISA 2012 showed that the reading comprehension of Japanese students received a high score, Japanese students tend to have a serious problem in developing proficiency in English for international communication (MEXT 2011). This may be one of the reasons why the number of students and young researchers who study abroad has been decreasing, although Japanese society in general including the business community had been shifting towards adapting to globalization (MEXT 2012). Many Japanese leaders in various fields have claimed that nurturing global talents for Japan's next generation is a very important issue which requires imminent attention. Thus Japan Business Federation proposed that English and Math/Science education should be enhanced (KEIDANREN, 2014).

It was also proposed that Japanese people, especially young people, should not hesitate to use English whenever they have the opportunity, in order to catch up with the world-wide globalization trend. In particular, many young students with high proficiency in science are not so proficient in English. This can be attributed to the fact that there are very few chances to study the subject they are most interested in, science, through English. Usually they are aware, however, that science is carried out in English in a globalized community from early on, and thus there is a need to create more opportunities for them. In order to improve this situation, it has become an urgent issue to create a sytem of learning science through English, especially for Japanese young people, *i.e.*, the junior-high (grades 7 to 9) and high school (grades10 to 12) students. Here we should take into account the characteristics of Japanese culture, language, and/or features of the educational system.

Previous Developmental Research

The present authors had previously launched early education science programs "Fostering the next generation leaders in science and technology" under the support of JST in academic years 2008 to 2010. In preparation for the implementation of the programs, we set up an association called Science Studio CHIBA in the Faculty of Education, Chiba University. At first we offered the programs only through our mother tongue, Japanese. We established a method for programs of lessons called "Lab on the Desk" for biology, physics, chemistry and technology. Each of them included experiments performed by individual participants using kits called "Personal Desk Lab" (or PDL in short), developed in Chiba University, Japan (Sou 2008) and some of them were adopted in the Royal University of Phnom Penh, Cambodia (Sou *et al.*, 2010).

Our early education courses consist of two types. One is a one-day experience of university-level experiments to develop the basic skills necessary for experimental research. We call it a "step-up course". The participants in this course listened to an introductory lecture and performed experiments in a laboratory in our university. The other is called a "master course", where the selected participants, who were all of high ability, carried out self-directed research under the supervision of our university researchers. The participants visited our university and carried out experiments and had discussions with their supervisors at mutually convenient times.

Contents of the Present Paper

In the subsequent academic years 2011 to 2013 we developed programs through English, focusing on meeting the needs of globalization with support from the Japan Society for the Promotion of Science (JSPS). In the present paper, first we describe the theoretical aspects of delivering early education of science through English. We determined our policy of development after consultation with science education researchers in Singapore, where science education is carried out in English in multilingual circumstances. Next, we developed lesson materials referring to a method called "Content and Language Integrated Learning (CLIL)". We will introduce the characteristics of CLIL in the theoretical aspects section. Second, in the methodology section, the lesson preparations and implementation are explained. Here we include a new theme to enhance students' thinking and communication skills. In the results section, the answers of a questionnaire by the participants in a lesson are tabulated and free writings of them are exemplified in a list. Then in the discussion section, we take up the issue of how to enhance those skills for science enthusiasts. Lastly, the effectiveness of our current project and the scope of future developments are discussed.

Before presenting these aspects, we will offer a simple hypothesis of our present educational activities.

Hypothesis

In Japan, junior-high and high school students who hope to become scientists but often hesitate to use English have a strong desire for opportunities to use English in scientific research situations. They find that their English knowledge learned in schools are *sufficient* but their skills acquired are *insufficient* to carry out experiments and to discuss the procedure or results with international students, although they need some ice-breaking English conversation prior to putting their skills to use.

Theoretical Aspects

Investigation of the Singapore Case

As is well-known, Singapore is a country of different ethnic groups with their own languages but the official language is English. The English proficiency of the students in the science classes in Singapore will be the most appropriate target for Japanese in the future. Thus some of the present authors visited the Natural Science & Science Education (NSSE) division of the National Institute of Education (NIE), Singapore and held a meeting with professors there. They provided us with useful suggestions for carrying out our program. From their experience, switching between English and other languages is sometimes used in classrooms to bring about a particular concept. However, doing so might not be easy as it required high level cognitive skills and can cause language interference. Nonetheless, we decided to accept their suggestions. They offered to cooperate further with our project to improve our lessons. We visited their university and some schools, where we observed some lessons for their undergraduate and graduate students who were studying to be future teachers of science. We found that there had been swift developments in the educational revision in Singapore reflecting the results of recent world-wide research.

Contents and Language Integrated Learning (CLIL)

At the very beginning of our research, our main task was to develop teaching material by translating and modifying materials created by ourselves in Japanese and already shown to be effective. Here, developing students' English proficiency was postponed to a later stage. However, our developmental research is taking the same direction as the simultaneous learning of English and science, *i.e.*, language and content. There are several methods for this kind of learning. In some methods the students in the classes are only allowed to use the target language, English. In the other methods they are allowed to use both the target language and their mother tongue, in this case Japanese. The scope of this paper does not allow us to describe the advantages and disadvantages in detail. In English learning in Japan, the Contents-and-Language-Integrated-Learning (CLIL) approach has become more popular recently. The theoretical background of this method includes recent developments in cognitive research. CLIL was developed and is utilized mainly in Europe and includes some features which are of particular significance for us; the lecturer need not be a native speaker of the language being taught (in this case English). Another method, in frequent use in the United States, is Immersion Program or Content-Based Instruction (CBI), where the lecturer is usually (or in some cases required) to be a native speaker who teaches language devotedly. In our case, the lecturer is expected to have considerable experience in science. Consequently, the lack of native English speaking scientists in Japan makes it difficult to adopt the Immersion or CBI method. Therefore, we decided to apply the methodology of CLIL to our program.

At the beginning of a compact textbook for the Teaching Knowledge Test (TKT) course CLIL module, its author indicated that CLIL has many definitions. However, she described its characteristics that "CLIL is an approach or method which integrates the teaching of content from the curriculum with teaching of a non-native language. It is increasingly important in our global, technological society, where knowledge of another language helps learners to develop skills in their first language and also helps them develop skills to communicate ideas about science, arts and technology to people around the world" (Bentley, 2010, p.5).

The concept of integration of content and language learning in CLIL is given in a prominent work in this area by Coyle, Hood, and Marsh (2010). Its 4Cs framework integrates "four contextualized building blocks", *i.e.*, Content (subject matter), Communication (language learning and using), Cognition (learning and thinking process) and Culture (developing intercultural understanding and global citizenship). Their perspective is that "it takes account of integrating content learning and language learning within specific contexts and acknowledges the symbiotic relationship that exists between these elements." (Coyle *et al.*, 2010, p.41).

They introduced Bloom's taxonomy which shows that in the cognitive process dimension, remembering, understanding and applying belong to Lower-Order Thinking Skills (LOTS), whereas analyzing, evaluating and creating belong to the Higher-Order Thinking Skills (HOTS). In the knowledge dimension, four types of knowledge (factual, conceptual, procedural and metacognitive knowledge) are listed. In order to activate the students' cognitive skills, it is considered to be valuable to introduce some authentic materials in the class.

They also discussed the relationship between language learning (grammar) and language using (communication), and as a result, they advocated the Language Triptych for CLIL linguistic progression with three interrelated perspectives: Language *of* learning, Language *for* learning, and, Language *through* learning (*ibid.* pp.36-38). Language *of* learning is an analysis of language needed for learners to access basic concepts and skills relating to the subject (scientific) theme or topic. Language *for* learning focuses on the kind of language needed to plan and carry out teaching in a foreign language learning environment. Language *through* learning is to do with capturing language as it is needed by individual learners during the actively learning process, and encourages the teacher to find ways of grasping emerging language *in situ*.

One remark should be added here. The CLIL lesson does not, in general, mean learning the contents again after learning them through the students' first language. Because the students meet the contents for the first time in the CLIL lesson, the teacher or lecturer should deliberately prepare some scaffolding for their students. This should consist of rewriting texts, explaining key words, adding comments about vocabulary and grammar regarding the students' linguistic difficulty, and raising students' interest, explaining the background, and elicting students' experiences regarding the difficulty of the content.

CLIL Approach Adopted to the Designing Lessons

The lecturer in CLIL in higher education is expected to be professionally qualified in teaching the subject and be a non-native speaker of English who is partly supported by language specialists. For the scientists who will conduct CLIL lesson, it is helpful for planning the lesson to read Chapter 4 of the book of Coyle *et al.* where "The CLIL Tool Kit to Transforming Theory into Practice" is precisely described (*ibid.* pp.48-85). Here we show an example of the syllabus for our lesson created for a physics experiment below (Appendix) which is created by following the Appendix "Creating a Tool Kit" in the above mentioned book, especially "CLIL lesson plan" (*ibid.* pp.80-85).

Methodology

Lesson Preparations and Implementations

We developed seven lessons as shown in Table 1. In each lesson, we placed great emphasis on communication activities compared with the previous lessons with similar experiments carried out in Japanese. Related manuals for the lesson through English, including video clips made from slides and voices, are available on our website (Science Studio CHIBA, 2014). The amount of time required for each lesson is fixed as three hours, including an ice-breaking talk and communication activity conducted by one of the international students for thirty minutes at the beginning. Then explanation of the procedure was conducted by the author of the manuals (one of the present authors), who is a science researcher in the corresponding field. The ratio of the numbers of participants (junior-high and high school students) and assisting international students was designed to be three to one. It means that some small-group activities for three participants and one international student were included in the lesson in order to encourage the participants to communicate with each other or with the international students. During the experiment, all the assistants including Japanese university students, all of whom were students of Faculty of Education or Graduate School of Education of Chiba University, always watched and checked the progress of the participants' experiments and supported them by talking with them in English. Although all the talks from the lecturer and international students were conducted in English, sometimes the participants spoke to the other participants in Japanese. It was necessary for us to strongly request the international students not to use Japanese, because all of them were learning Japanese and willing to use it. In each lesson, the participants made a simple report for the experiments in English, partly filling in some blanks for vocabulary used in the experiments and partly composing sentences to explain what they found and what they did. In the academic years 2011 to 2014, 18 lessons in total were held in laboratories in Chiba University (Table 2). For each lesson, we assigned the assistant university students earlier but did not clarify their participation until the day before the lesson, with the result that the ratios in some lessons differed from the ideal ratio of three to one.

In the final lesson on August 4th, 2014, we arranged a full-day activity. In the morning, a lesson for English communication "Communication English for Science Experiments" and a lesson of scientific report writing "How to Write a Scientific Report" were done in English by two of the present authors (Horne and Oi, respectively, both of whom are specialists in language education). In the afternoon two short versions of physics experiments (A and B) were carried out. In the lunch break and a tea break in the afternoon sessions, the participants had the opportunity to talk with international master-and doctor-course students and to play some authentic instruments (acoustic and electric guitars and violins) which are closely related to the experiment theme.

New Theme Designed to Include More Thinking & Communication Skills

All of the lessons except for (C) were prepared from the translation of the lessons originally developed by Japanese scientists through Japanese. We decided that we should develop a lesson unaffected by any characteristics of thinking in Japanese. With the partnership of one of the present authors (Yeo), we created a novel theme, *Induction of Electricity* (C), where we intentionally included occasions using more thinking and communication skills by engaging students in scientific modeling (Gilbert, 2004). Here we show the synopsis of this as an example.

At the beginning of a 30-minutes ice-breaking activity, some generic phenomena of the electric, magnetic and electromagnetic induction were reviewed using Power Point slides and video clips. Next, the instructor carried out a discussion on a simple demonstration experiment on electrostatic induction. The participants were asked what would happen when a charged plastic bar approached an aluminum can which had no charge. They watched, and then reproduced by themselves the phenomenon that the can started to rotate due to a pulling electrostatic force. They were asked to think about the reason why this occured using a free-electron model in the can. Some magnets on a whiteboard were regarded as free electrons and the can was drawn on the whiteboard. The participants considered the displacement of free electrons with the other participants or assisting international students in a small group in a trial-and-error manner. The instructor gave hints whenever the discussion in the group stopped. When the students constructed their own theory, one of the participants was asked to explain it using the whiteboard in front of the whole group.

After this group activity, the instructor explained the theoretical relationship between the activity and the next experiment. The experiment was not an electrostatic phenomenon but a steady-current phenomenon with a time-independent distribution of electric current in a two-dimensional conductive sheet. The experimental task for the participants was to find many equipotential points, to draw the equipotential lines, and then to inspect the current lines. Because the shape of the conductive sheet and the electrodes were changed as the students liked, the drawings of those lines became different for each group. The participants explained their results with their drawings of those lines which were projected onto a screen. Such experiments using "equipotential lines" can be found in some approved textbooks for high-school physics in Japan, so we reshaped the experiment by use of a large conductor to be put on the sheet. This had a strong effect on the shapes of the lines due to the electrostatic shielding.

Results

Participants' Response to the Questionnaire

In order to assess the session from the participants' perspective, we asked them to answer the questionnaires on a sheet. We show here the results of the final class of the extended lesson (A and B) held on August 4, 2014. A pre-session questionnaire was summarized in Tables 3 and 4. Table 3 is the result which shows the reason why they wanted to join the session. Table 4 shows the extent of their anxiety before the session. After the session, we asked the participants to answer another questionnaire, *i.e.*, a post-session questionnaire which included a space for free writing of their reflections. We will present the free writing in the next subsection. The results of the option-type questionnaires are summarized Table 5. Here students' impressions of such activities are exhibited. All of these option-type questions have five options. The options [1] to [5] correspond to the degree of desirability for each question item with [5] being the best suited to the participants.

The data in Table 3 show that the most frequent reason why the students attended the class was that they were interested in science itself. They also considered that scientific activity through English would be important for their future carrier. Table 4 indicates that almost all the participants came to the lesson with deep anxiety about their ability to use English. Table 5 shows that they were satisfied with the class, even though they felt their ability to use English was insufficient.

Reflections of Participants from Their Free Writing

From the free writings of the post-session questionnaire, we selected some of their writings here. All the writings here were translated from Japanese with some compensation to make the meaning clear by the author.

I could hardly wait to join today. I hoped to feel the closeness of music and science. Writing a report on the experiment in English seemed to be difficult. It was such long time after I joined the English-only class. So happy today. I found physics is related to music rather than what I expected. Sometimes I cannot find the terms for experiments.

This is the first time to talk with international students. So it's a new experience.

I wish I had had a word list or something. It's better for me if there is also an explanation in Japanese. I found that the sounds can be reproduced by a machine. I found we have oscilloscopes!

I understood that English is important, but I hope to get Japanese a translation for the explanations.

Now I know communication is quite important. It's better to have more knowledge, for example, about the use of tools.

My school has some all-English classes, so it is not new for me. I hope to have more chances of communication with others. It is OK to use English only in the class "Communication English" and the experiment, but in the class "How to Write a Scientific Report" partly I would have liked to have Japanese.

I found some words in the class "How to Write a Scientific Report" difficult. I have experience of joining all-English classes, but such an experiment through English is the first time for me. It's so fresh. The university students were very kind. I understood the relation between frequencies and tone heights. Now I have moments of reflections that I could not say "I want to do something" or "How can I do for something" in English.

I am just a beginner of learning English. The teacher in the class "How to Write a Scientific Report" used some Japanese words, which were quite helpful. Some assistant speak Japanese so I enjoyed the experiment. What I could not say but wanted to say in English was that I did not understand.

Table 1. Lesson titles and its fields and lectures.

(A)	Sound Creation Using an Electric Signal Generator	(Physics)	Kato, T.
(B)	String Vibration Observed through Oscilloscope	(Physics)	Kato, T.
(C)	*Induction of Electricity*	(Physics)	Kato, T.
(D)	The Basic Technique for Protein Analysis	(Life Science)	Nomura, J.
(E)	Lipid and Fat in Food	(Life Science)	Yoneda, C.
(F)	Chemical Experiments with Soap	(Chemistry)	Hayashi, H.
(G)	Temperature and Electric Resistance	(Technology)	Iizuka, M.

Table 2. Numbers of participants and assistants for individual lessons in the present project. A mark * indicates an elementary school returnee child (who has lived abroad before).

Year	Date	Lesson	Numbers			
			Participant Students		Assistant Students	
			Junior-high	High School	International	Japanese

			(K-7 to 9)	(K-10 to 12)		
2011	Nov 23	(A)	4 +1*	0	3	4
	Dec 18	(D)	0	5	2	4
	Dec 23	(E)	0 +1*	2	3	5
(2012)	Jan 28	(B)	4	8	5	5
2012	July 15	(E)	5	5	4	5
	July 22	(A)	6	8	4	4
	Dec 2	(D)	1	1	3	2
	Dec 26	(B)	3	2	4	3
(2013)	Jan 13	(F)	1	3	2	2
	Jan 27	(G)	3	2	3	2
2013	June 16	(A)	3	3	6	3
	July 21	(C)	2	3	4	3
	Nov 17	(A)	3	3	5	2
	Nov 30	(E)	1	1	3	2
(2014)	Dec 1	(C)	1	1	3	2
	Dec 8	(G)	2	0	3	5
	Dec 15	(B)	4	0	5	2
2014	Aug 4	(A and B)	22	3	9	9
	Total		67	50		

Table 3. The reason for participation (August 4, 2014)

	[5] applies	[4]	[3]	[2]	[1] hardly applies
(1) I myself wanted to attend it	10	7	3	4	1
(2) Upon someone's suggestion	9	6	4	3	3
(3) I am interested in scientific experiments	12	8	3	1	1
(4) I wanted to do scientific experiments through English	9	7	7	1	1
(5) The learning materials looked interesting	4	6	9	1	5
(6) Expected to improve my English skills	8	9	4	1	3
(7) Helpful for entrance examination	5	3	9	1	7
(8) Hoping this experience will help my future plan	11	8	4	2	0
(9) I only wanted to visit Chiba University	7	6	9	2	1
(10) It was free of charge	5	4	9	5	2

Table 4. Anxiety before participation (August 4, 2014).

	[5]	[4]	[3]	[2]	[1]
	applies ←→ hardly applies				
(1) What if I cannot understand explanation	14	5	5	0	1
(2) What if I cannot discuss or explain something	13	7	4	0	1
(3) What if the contents look difficult	8	11	4	1	1
(4) What if my preparation is insufficient	8	10	4	1	2
(5) What if I am the only person who do not follow	10	8	5	1	1

Table 5. Post-session questionnaire (August 4, 2014).

	[5]	[4]	[3]	[2]	[1]
	applies ←→ hardly applies				
(1) I was satisfied with the class	19	5	0	1	0
(2) I had been well-prepared for the class	6	9	5	3	2
(3) I was able to understand instructions given in English	6	8	7	3	1
(4) I understood almost all the content of experiments	9	9	5	1	1
(5) I did well on the experiment	10	6	7	1	1
(6) I discussed with others and explained what I knew	5	8	7	4	1
(7) I became acutely aware of the necessity of English skills	19	5	0	1	0
(8) I will attend another session provided in English	13	7	3	1	1

Discussion

Before the implementation of the lesson *Induction of Electricity* (C), we had expected that such a thinking activity would be enjoyable for our participants. In the science classes in Japanese schools, such activities in small groups are common, especially in elementary schools. So the participants should realize what they should do at any moment even if they have difficulties with the language. This seemed to be true because they kept struggling with the tasks until they found the solution. They realised that their language skills were often inadequate, but some of them were not concerned about this. In the beginning, many of them wanted to ascertain that they completely understood everything, so they used Japanese, and then they needed time to switch languages. This showed that they did not have enough experience to think about science in English from the beginning. Some of them were able to find a good explanation for the phenomena, and all of them did experiments with the help of international students. Then, a set of two lessons with the first half (or shorter) in Japanese and the second (maybe as a review exercise) through English would be more appropriately to fit their demand, especially younger students.

The participants sometimes lacked the very basic vocabulary of discussion that belongs to "Language *through* learning". This was apparent in lesson (C) more explicitly than in others. In other lessons, for example, in the lesson *Sound Creation Using an Electric Signal Generato*r (A), a group of participants was asked to produce a harmony with three or four tones. There each tone was created by one participant so that it was necessary for them to discuss how to allocate one tone for one participant. There seemed to be no problem for them to carry out such a task which must be solvable by use of only LOTS. The HOTS tasks, which were incorporated in the discussion and positive representation of experimental results as the essential requirements, seemed to be rather difficult for them, so it is important for us to consider the degree of difficulty for the latter tasks. Nevertheless, because non-native scientists have a tendency to avoid linguistic and thinking confusion on the part of the students, they must develop strategies for preventing any possible pitfalls. This means that consultation with specialists in language education and/or the cooperation with them is quite effective when thinking and communication skills are to be successfully incorporated in higher-level science education.

The degree of positive responses in many of the answers to the post-session questionnaire in Table 5 showed a narrower distribution than that in the pre-session questionnaires in Tables 3 and 4. This indicates that the participants were influenced considerably by our lesson. The result of question (7) in Table 5 as well as their free writing showed that our lesson was effective in encouraging them to be aware of the necessity of developing English skills. Even though most of participants were satisfied with the class (question (1) in Table 5), there was a discernible difference in the degree of understanding the instruction and content of the experiments (questions (3) and (4)). This suggests that we should teach in a manner that matches the learning stage of the individual participants.

After our project was launched, the Japanese government accelerated its support of reforms of higher education for globalization. Some plans of Chiba University oriented towards globalization were adopted. The Twin College Envoys Program, (known as TWINCLE), was launched in 2012. Through this program many university professors and school teachers from ASEAN countries were invited to Chiba (TWINCLE 2012). We arranged for the junior-high and high school students, especially the master course students of Science Studio CHIBA, to have a chance to join to the TWINCLE international exchange meeting and to give their research presentations in English. As a result, some Indonesian science teachers from top-level high schools were impressed that such young students carried out advanced research so well.

Conclusions

Our hypothesis that the junior-high and high school students in Japan who are good at science desire chances to use English in scientific circumstances was proved by implementation of the present developmental research. We prepared some lessons with experiments of physics, biology, chemistry and technology that were designed to encourage students to use thinking and communication skills on the base of CLIL strategies. The participating students were satisfied with the knowledge-related LOTS tasks in our lessons, although we need to take into consideration the variety of their proficiency in HOTS and for "Language *through* learning" to a greater extent in future lessons.

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Appendix: An Example Curriculum for a Physics Lesson (A)

GLOBAL GOAL: Develop scientific & language skills for experiments of science through English

UNIT TITLE: Sound Creation Using an Electric Signal Generator (PHYSICS)

Level of English: 2nd or 3rd grade of junior-high school students

Aim:

To get accustomed to experiments through English, from understanding

To realize the relation of sound and rational numbers, or the relations between music and physics

To understand how to produce sounds with definite frequencies using a signal generator and tools of frequency display

To feel the lowest or highest sounds

To recognize the relation between ratios of frequencies of sounds and musical intervals or harmonies

To recognize the relation between nearness in frequencies and beating produced by two sounds of definite tones

To tackle tasks which will motivate learners to write a paper or make an oral presentation in English

Teaching Objectives (What I plan to teach):

Content (1st C):

Vocabulary for talking/writing about related daily-life issues

Vocabulary for talking/writing about the backgrounds, meaning of experiments and theories

Cognition (2nd C):

(1) Lower-Order Thinking Skill (LOTS):

To operate instruments according to a procedure manual, if necessary, only recalling memory

To take notes on results with configurations smartly

To report operations and results orally or in writing

(2) Higher-Order Thinking Skill (HOTS):

To make sure of settings and readings from comparison of results with expectations, or find errors

To proceed with experiments with a new configuration complementary with results

To compare his(her) results with collaborators, find the difference and consider the reasons

Culture (3rd C):

To understand the meaning of the experiments in the science-historical context

To use expressions under a global standard, and try to find the connection to world-wide research and education

Communication (4th C):

(1) Language of learning:

Obligatory vocabulary in the field of theme science (*e.g.*, pitch, loudness, timbre of sounds, audible frequency range, ultrasound/ultrasonic sound)

Related-field or daily-life vocabulary for enrichment of understanding (*e.g.*, music terms as tones, tone name, scale, harmony, interval)

Vocabulary for calling names of instruments and their parts, reading operational guides and taking notes of results

(2) Language for learning:

Vocabulary of procedures in operation protocol

Language of confirmation of procedures and results with collaborators and make corrections if necessary

Vocabulary of precaution of possible troubles and hazards, and directions in emergency

(3) Language through learning:

To explain to the teacher what is unclear in the procedure and ask him/her to support

To discuss with collaborators on an apparent mistakes or misunderstanding in notes

To write a discussion scientifically and describe personal reflections about the activities

Learning Outcomes (What learners will be able to do by the end of the lessons): Learners will be able to:

describe the pitch of sounds in terms of frequencies quantitatively

explain the frequency range of audible sounds

produce a sound with definite frequency using instruments like signal generators and digital multi-meters

expect relation between an interval of two tones and a ratio of those frequencies

expect a ratio of frequencies for tones which consist of a scale or a harmony

expect a beating if two tones are near in frequencies

Criteria of Assessment: Teacher, peer- and self-assessment process will be used to assess how well learners:

understand science related to the theme of experiment

understand English description related to the theme of the experiment

have sufficient English communication experience

have motivation to know world-wide standard or to join to global activities

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