

紀 要

第49卷

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独立行政法人国立高等専門学校機構
鈴 鹿 工 業 高 等 専 門 学 校

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酸化亜鉛存在下におけるポリ塩化ビニルの 低温脱塩素化反応への加熱混練法の応用

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ポリ塩化ビニル廃棄物の処理方法として、酸化物との反応を利用したポリ塩化ビニルの脱塩素化による無害化がある。本研究では、ポリ塩化ビニルと酸化亜鉛の混合物を加熱混練したのち、200℃で加熱処理する方法（加熱混練法）を適用した。加熱混練した混合物をポリ塩化ビニルの熱分解温度（250℃）より低温で反応を行うことで、塩化水素の発生を抑制することができ、また同時に、ポリ塩化ビニルに残留した塩素量を1%以下とすることができた。加熱混練法は、他の化学物質を用いることなく、ポリ塩化ビニルと酸化亜鉛との接触面積を増大させ、脱塩素化反応を促進することができる方法として有意義であることがわかった。

Key Words : ポリ塩化ビニル, 脱塩素化, 酸化亜鉛, 加熱混練

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1. 緒言

ポリ塩化ビニル（以下 PVC と略記）は、広く使用されているプラスチックである。使用後廃棄される PVC は、腐食性の塩化水素およびダイオキシン類などの有害な有機化合物を生じることから、焼却処理が難しい。そのため一部が再利用されている他は、そのほとんどは産業廃棄物として埋め立て処理される。PVC 廃棄物の新たな処理方法として、PVC 中の塩素を除去する方法が研究されている¹⁻¹¹。熱分解により塩化水素が生じないように塩素を除去するためには、PVC の熱分解温度である 250℃より低温で反応を行うことが重要となる。PVC と酸化亜鉛（以下 ZnO と略記）を混合し、200℃で熱処理することで、塩化水素を発生することなく、脱塩素化反応が進行することが報告されており、また PVC 中の塩素は ZnO と反応することで、塩化亜鉛として除去される¹²。PVC と ZnO を混合する方法として、PVC と ZnO を乳鉢混合する方法（粉末法）があり、およそ 70% の塩素を除去することができるが、粉末同士では接触面積が十分でなく、乳鉢混合するだけの前処理では、PVC を完全に脱塩素化することができない。PVC を有機溶媒に溶解させ、その溶液に ZnO を混ぜたのち溶媒を揮発させ、ZnO 表面に PVC をコーティングする方法（薄膜法）では、PVC と ZnO との接触面積がきわめて大きいことに起因して、PVC を完全に脱塩素化できると報告されている¹³。しかしながら、PVC と ZnO との混合に有機溶媒を用いているため、本反応の実用性を高めるためには、新たな混合方

法の開発が必要である。そこで本研究では、PVC と ZnO の接触面積を大きくするために、あらかじめ PVC と ZnO を PVC の熱分解温度未満で加熱しながら混練する方法（加熱混練法）を用いて試料 (PVC-ZnO) を調製し、200℃で脱塩素化反応を試みた。脱塩素化反応の成績を薄膜法と比較することで、有機溶媒を用いることなく PVC を ZnO で完全に低温脱塩素化する技術開発に資することを目的とした。

2. 実験方法

2-1. 試薬

粉末ポリ塩化ビニル (PVC) 和光純薬製

平均重合度 1,100 粒径 50-150μm

酸化亜鉛 (ZnO) 和光純薬製 特級

テトラヒドロフラン (THF) 和光純薬製 特級

2-2. 加熱混練機

東洋精機製作所製卓上用試験ロール機 TC-1 を図 1 に示す。

(学術論文)

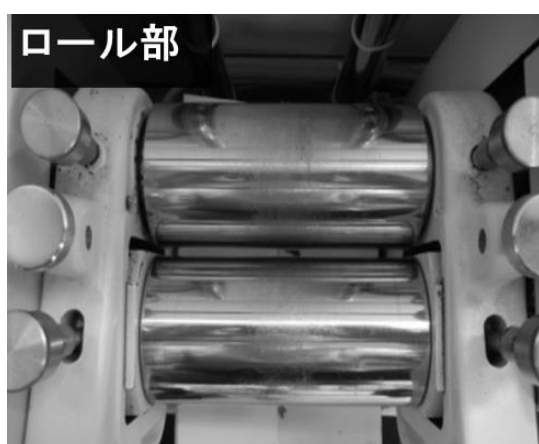
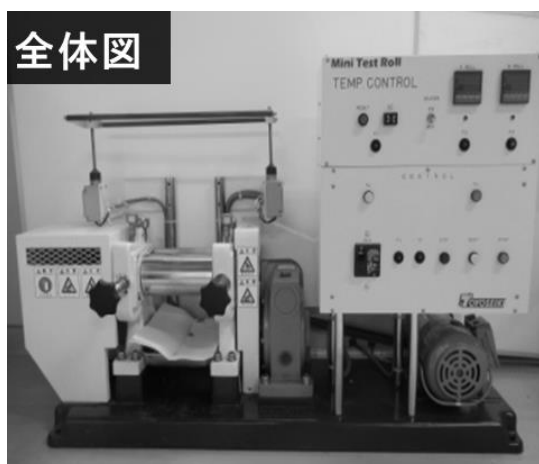


図1 加熱混練機

2-3. PVC-ZnO 調製（薄膜法）¹³

ドラフト内でテトラヒドロフラン（以下 THF と略記）に PVC を加え、超音波洗浄機を用いて攪拌し、PVC を THF に溶解させた（PVC-THF 溶液）。乳鉢に ZnO と PVC-THF 溶液を入れ、ZnO をすり潰すように攪拌しながら THF を揮発させた。PVC と ZnO の混合量は、後述する R 値に従って種々調製した。ドラフト内で 1 時間放乾後、PVC-ZnO（厚さ数 mm のフィルム状）を 50℃で一晩乾燥させた。およそ 1cm² にカットした。薄膜法で調製した PVC-ZnO を図 2 に示す。



図2 薄膜法で調製した PVC-ZnO (R=6)

2-4. PVC-ZnO 調製（加熱混練法）

加熱混練機（図 1）ローレル部の手前側を 170℃に、奥側を 160℃に設定して、少量の滑材を塗ったローラーを回転させながら、PVC と ZnO の混合物を 30 分程度繰り返し加熱混練した。PVC と ZnO の混合量は、後述する R 値に従って種々調製した。混練物は全体が均一の薄茶色となり、加熱混練を繰り返すに従い、混合物は微粉化する傾向にあった。加熱混練法で調製した PVC-ZnO を図 3 に示す。



図3 加熱混練法で調製した PVC-ZnO (R=1.6)

2-5. 脱塩素化反応

調製した PVC-ZnO を粉碎した後、500mL の三角フラスコに入れ、ガスの導入および排出に必要な 2 穴栓を装着した。片方の穴から 60mL/min の窒素を連続的に流通させながら、200℃、2 時間熱処理した。熱処理中に排出されたガスはすべて、水酸化ナトリウム水溶液でトラップした。反応後の試料は、1.0mol/L 希硫酸－エタノール－蒸留水の混合溶液（混合比 2:1:5）で繰り返し洗浄し、乾燥して、脱塩素化した PVC を得た。

(学術論文)

2-6. 塩素量の測定

反応中発生した塩化水素を中和滴定によって、洗浄液中の塩素量および反応後の試料中に残留する塩素量を、Mohr 法によって測定した。

2-7. SEM 観察と FT-IR 分析

脱塩素化した PVC の形状は、走査型電子顕微鏡（日立 S-4100）を用いて観察した。また FT-IR スペクトルは、日本分光 FT/IR-4200 により得た。

3. 結果と考察

3-1. 塩化水素として発生した塩素量

PVC-ZnO を窒素流通下 200℃で加熱すると、容器内で瞬時に多量の水蒸気が発生するため、系内の圧力が上昇し、気体が水酸化ナトリウム水溶液で満たされたトラップに押し出される様子が見られた。表 1 に塩化水素として発生した塩素量（熱処理前 PVC に含有する塩素量に対する百分率）を示す。ZnO 添加量 R は、化学量論的に PVC の塩素を除去するために必要な ZnO を R=1 と定めた値である。薄膜法 PVC-ZnO、加熱混練法 PVC-ZnO ともに塩化水素ガスはほとんど発生しなかったと認められる。したがって、発生したガスの主成分は、ZnO の酸素と PVC の水素が反応して生成した水蒸気であることがわかる¹²。また、ZnO の添加量を増やすことで、塩化水素の発生を抑制できることがわかる。

表 1 発生した塩化水素量

試料	ZnO 添加量	反応温度 (℃)	反応時間 (hr)	塩化水素量 (%)
薄膜法 PVC-ZnO	R=2	200	2	4.5
	R=6			0.8
加熱混練法 PVC-ZnO	R=1.6			5.6
	R=3			0.7
	R=6			0.2

3-2. ZnO と反応した塩素量

表 2 に洗浄液中の塩素量から求めた、ZnO と反応した塩素量を示す。いずれの条件においても、PVC 中の塩素は ZnO と反応し、塩化亜鉛として除去することができた。

表 2 ZnO と反応した塩素量

試料	ZnO 添加量	反応温度 (℃)	反応時間 (hr)	ZnO と反応した塩素量 (%)
薄膜法 PVC-ZnO	R=2	200	2	93
	R=6			91
加熱混練法 PVC-ZnO	R=1.6			96
	R=3			93
	R=6			92

3-3. 反応後試料中に残留した塩素量

表 3 に反応後の試料中に残留した塩素量を示す。薄膜法 PVC-ZnO では ZnO 添加量に関係なく、残留塩素量は 1%以下で、ほぼ完全に脱塩素化できた。加熱混練法で調製した PVC-ZnO では、ZnO 添加量の増加に伴い、若干の塩素が残留した。PVC の低温脱塩素化に対して、試料調製の際に、有機溶媒使用に課題がある薄膜法に比しても、加熱混練法は十分対応できる結果を得た。

表 3 反応後の試料中に残留した塩素量

試料	ZnO 添加量	反応温度 (℃)	反応時間 (hr)	残留塩素量 (%)
薄膜法 PVC-ZnO	R=2	200	2	0.5
	R=6			0.6
加熱混練法 PVC-ZnO	R=1.6			0.8
	R=3			1.6
	R=6			1.9

3-4. SEM 観察

脱塩素化した PVC 表面の SEM 画像を図 4（薄膜法 PVC-ZnO）と図 5（加熱混練法 PVC-ZnO）に示す。2 つの SEM 画像ともにマクロ孔が見られ、細孔の大きさは、薄膜法では 0.1~0.7μm、加熱混練法では 0.5~1.5μm であった。ZnO の粒径が 0.1~0.7μm であることから、細孔は、反応で生じた塩化亜鉛および過剰の ZnO が洗浄過程で除去された際に形成されたと考えられる。また細孔の大きさから、加熱混練法に比べ薄膜法の方が、PVC 中に ZnO が広く分散しており、これによって脱塩素化反応が促進される、と考えた。

(学術論文)

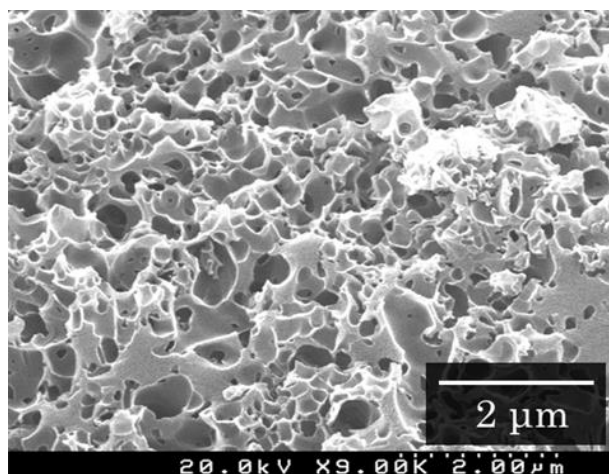


図4 薄膜法により得られた脱塩素化 PVC (R=6) の SEM 像

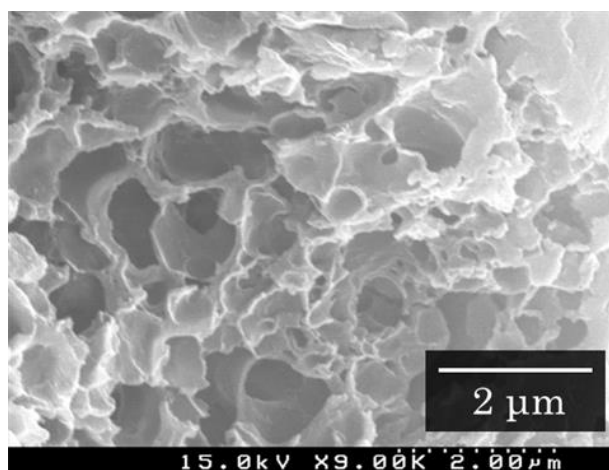


図5 加熱混練法により得られた脱塩素化 PVC (R=1.6) の SEM 像

3-5. FT-IR 分析

脱塩素化した PVC の FT-IR スペクトル分析結果を図6に示す。上から、反応前 PVC、薄膜法による脱塩素化 PVC、加熱混練法による脱塩素化 PVC のものである。反応前 PVC に見られる、C-Cl 結合による $600\sim 700\text{cm}^{-1}$ 付近の吸収帯は、薄膜法、加熱混練法ともに見られなかったことから、いずれも PVC から塩素が除去されたことを裏付けている。

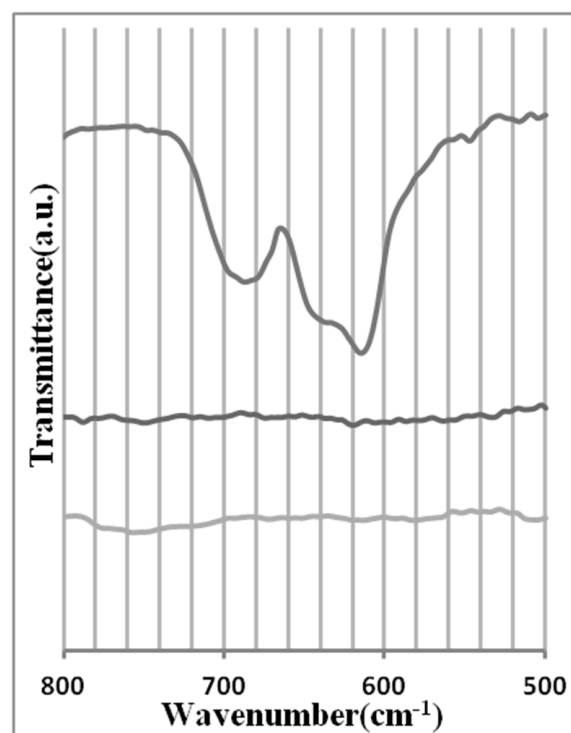


図6 脱塩化水素 PVC の FT-IR スペクトル
(薄膜法 R=6、加熱混練法 R=1.6)

4. 結論

酸化亜鉛存在下におけるポリ塩化ビニルの低温脱塩素化反応への加熱混練法の応用性について検討した。その結果、

- (1) ポリ塩化ビニルの脱塩素化反応中に発生した塩化水素はきわめて少なく、塩化水素ガスの発生を抑制できた。
- (2) ポリ塩化ビニル中の塩素は、酸化亜鉛と反応することで塩化亜鉛として除去された。
- (3) 200°C 、2時間の脱塩素化反応で、反応後の試料中に残留した塩素は、1%以下となった。
- (4) 加熱混練法は、有機溶媒を用いることなくポリ塩化ビニルに酸化亜鉛を広く分散することを可能とし、結果、ポリ塩化ビニルを 99.2%脱塩素化できた。

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(学術論文)

Application of a heat-kneading process to the low temperature Dechlorination of PVC in the presence of zinc(II) oxide

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Dechlorination of poly (vinyl chloride) (PVC) in the presence of zinc(II) oxide (ZnO) has been recognized as one of the environmentally benign recycling processes for waste PVC. In this study, we developed a heat-kneading process, which is simultaneous heating and kneading to provide a homogeneous mixture of PVC with ZnO, as a pre-treatment of the dechlorination. Negligible quantity of HCl gas evolved upon the heat-treatment of the PVC-ZnO mixture at a lower temperature (200 °C) than the thermal decomposition temperature of the PVC (250 °C). Only a slight content of the residual chlorine in PVC was achieved after the dechlorination reaction to be 1% or less. Highly dispersed ZnO fine particles in PVC matrix were observed, showing large contact area of ZnO to PVC. The increase in the contact area by the heat-kneading is a possible reason to the observed thorough dechlorination. Thus, we conclude that the heat-kneading is a simple and useful process to facilitate the dechlorination reaction without any chemicals.

Key Words: Poly (vinyl chloride), Dechlorination, Zinc(II) oxide, Heat-kneading process

Cognitive Acquisition of English-Language Structure and Process Skills: Study Material and an Examination

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At National Institute of Technology, Suzuka College, there is an ongoing attempt to improve students' English-oral communication proficiency ^{1, 2, 3, 4}. Since 2009, an English oral presentation and script creation course has been offered to Advanced Course students and there is a continuing effort to improve the class. Consequently, the following research examines the effect that study material had on students' ability to understand the structures and processes entailed in an expanding series of English-language speech outlines and culminating English-language oral-presentation scripts. This research also focuses on the effect of an examination on students' motivation to learn the study material. Results are based on qualitative data derived from nine 1st year Advanced Course students, during the Zenki 2015 term.

KEY WORDS: English communicative skill, oral communication, oral speech, small-group learning, motivation for English learning

1. Introduction

National Institute of Technology, Suzuka College (NITSC), places emphasis on improving students' international competence. One area in which this emphasis is realized is in a focus on improving students' English-oral communication ability. Since 2009, an Advanced Course English oral presentation and script creation (ACEOPSC) class has been offered to students each semester and has continually undergone pedagogical changes based on teaching experience and the results of student surveys ^{1, 2, 3}. One area of the course that has received scant attention is the script creation technique (SCT).

To help students write scripts, since 2013, an SCT that has students complete a series of increasing structurally and procedurally detailed outline forms culminating in script forms containing the students' final presentation scripts, has been used. Prior to the first semester of 2015, students were taught the SCT based solely on a classroom lecture during the second week of the course. As of Zenki 2015, the first week of class, students are given SCT hardcopy study material covering the structures and corresponding processes entailed in the outline-to-script progression and an exam (worth 33% of their final course scores) covering the study material the second week of class.

The current research consists of three main foci: 1) did the study material help the students understand the structure of each outline form and the script form; 2) did the study material help the students understand the corresponding processes of each outline form and the script form; and 3) did having to take the exam motivate the students to learn the structures and corresponding processes covered in the study material?

2. Course Background

The ACEOPSC class has been taught to first-year Advanced Course students during the first semester and to second-year Advanced Course students during the second semester since 2009. The first-year course is taught by three native-English speaking teachers, consisting of one permanent faculty member (PFM) and the other two guest teachers. Each teacher is responsible for one-third of the class and is free to conduct the course according to their own methods (within general guidelines). The second-year course is taught only by the PFM. In both classes, students in groups of four, select presentation topics, create presentation scripts, create corresponding presentation PowerPoint files, and practice their presentations for a contest which, prior to the first semester of 2015 ^{note 1}, was the sole basis of the students' course scores.

3. Script Creation Technique

From the first semester of 2013 until the first semester of 2015, students were given a lecture on the SCT during the second week of class. The purpose was to discuss a process whereby students would complete three progressively detailed outline forms and a final script form (see Tables 1-4) which, upon finalization, would have them advance from a general outline (the first-step outline) to a fully developed, eight-paragraph English-language presentation script (the script form). The students were told that the first-step outline would provide a minimal framework for their general ideas and that with the second- and third-step outlines, they would develop their general ideas into full scripts through structural and procedural changes.

Table 1. First-Step Outline Form ^{note 2}

MASTER INTRODUCTION											
¶ 1	{	A.									
		B.									
		C.									
BODY											
A. ¶ 2				B. ¶ 4				C. ¶ 6			
¶ 3	{	1.		¶ 5	{	1.		¶ 7	{	1.	
		2.				2.				2.	
		3.				3.				3.	
CONCLUSION											
¶ 8	{	A.									
		B.									
		C.									

Table 2. Second-Step Outline Form ^{note 3}

¶ 1 MASTER INTRODUCTION		
BODY		
A. ¶ 2		
¶ 3	1.	2.
	a.	a.
	b.	b.
B. ¶ 4		
¶ 5	1.	2.
	a.	a.
	b.	b.
C. ¶ 6		
¶ 7	1.	2.
	a.	a.
	b.	b.
¶ 8 CONCLUSION		

Table 3. Third-Step Outline Form ^{note 4}

¶ 1 MASTER INTRODUCTION		
BODY A. ¶ 2		
¶ 3	1.	2.
	a.	a.
	1.	1.
	2.	2.
	3.	3.
	b.	b.
	1.	1.
	2.	2.
	3.	3.
	c.	c.
	1.	1.
	2.	2.
BODY B. ¶ 4		
¶ 5	1.	2.
	a.	a.
	1.	1.
	2.	2.
	3.	3.
	b.	b.
	1.	1.
	2.	2.
	3.	3.
	c.	c.
	1.	1.
	2.	2.
BODY C. ¶ 6		
¶ 7	1.	2.
	a.	a.
	1.	1.
	2.	2.
	3.	3.
	b.	b.
	1.	1.
	2.	2.
	3.	3.
	c.	c.
	1.	1.
	2.	2.
¶ 8 CONCLUSION		

4. Previous Findings

At the conclusion of the first semester 2013 first-year Advanced Course class, a survey was administered to students to determine the usefulness of the SCT. In an examination of eight pupils, it was determined that: 1) students understood the process of creating a script based on weekly outline expansion; 2) they felt it was an effective way to develop a topic into a full script; 3) they would use the technique in the future; 4) they developed confidence in their ability to make a script using the technique; and 5) email exchange with the teacher was an effective method to complete the process³. However, a qualitative survey administered in 2014 to nine NIT, Suzuka College, first-year Advanced Course students, revealed both pre-course apprehension regarding the SCT, with one student listing ‘writing an English script’ as their chief concern and another student listing that the teacher helping them to turn their “original sentences into wonderful scripts” as a main source of post-course relief^{note 5}.

Table 4. Script Form

Paragraph 1
Paragraph 2
Paragraph 3
Paragraph 4
Paragraph 5
Paragraph 6
Paragraph 7
Paragraph 8

5. The Current Study

Because receiving a lecture covering the SCT the second week of class, especially a lecture spoken in a foreign language, was likely not the best method to teach students, as of the first semester of 2015, pupils have received SCT hardcopy study material the first week of the course and an exam covering the material the second week of the course. The current study examines whether the study material helped the students understand the structure of each outline form and the script form; whether the study material helped the students understand the corresponding processes of each outline form and the script form; and whether having to take the exam motivated the students to learn the structures and corresponding processes covered in the study material. Tables 5, 7, 9, and 10 show the outline portion of the SCT study material used by students to study for the exam. Due to space limitations, Table 9 shows only the information covered on the exam. The SCT study material, encompassing four A4-sized paper sheets, included the following information on the first page:

Table 5. First-Step Study Material

Structure shaded grey. Process written next to structure.		
STRUCTURE		PROCESS
MASTER INTRODUCTION		
A.	Main idea A	Students should write their first main idea concerning their topic using complete English sentences.
B.	Main idea B	Students should write their second main idea concerning their topic using complete English sentences.
C.	Main idea C	Students should write their third main idea concerning their topic using complete English sentences.
BODY		
A.	Main idea A	Using a complete English sentence, students should write their first main idea concerning their topic.
	1. First-level subpoint	Using a complete English sentence, students should write their first 1 st level supporting example of their first main idea (main idea A) about their topic.
	2. First-level subpoint	Using a distinguishably different complete English sentence, students should write their second 1 st level supporting example of their first main idea (main idea A) about their topic.
	3. First-level subpoint	Using a distinguishably different complete English sentence, students should write their third 1 st level supporting example of their first main idea (main idea A) about their topic.
B.	Main idea B	Using a complete English sentence, students should write their second main idea concerning their topic.
	1. First-level subpoint	Using a complete English sentence, students should write their first 1 st level supporting example of their second main idea (main idea B) about their topic.
	2. First-level subpoint	Using a distinguishably different complete English sentence, students should write their second 1 st level supporting example of their second main idea (main idea B) about their topic.
	3. First-level subpoint	Using a distinguishably different complete English sentence, students should write their third 1 st level supporting example of their second main idea (main idea B) about their topic.
C.	Main idea C	Using a complete English sentence, students should write their third main idea concerning their topic.
	1. First-level subpoint	Using a complete English sentence, students should write their first 1 st level supporting example of their third main idea (main idea C) about their topic.

Table 5. First-Step Study Material (Cont.)

	2.	First-level subpoint	Using a distinguishably different complete English sentence, students should write their second 1 st level supporting example of their third main idea (main idea C) about their topic.
	3.	First-level subpoint	Using a distinguishably different complete English sentence, students should write their third 1 st level supporting example of their third main idea (main idea C) about their topic.
CONCLUSION			
A.	Main idea A		Students should write their first main idea concerning their topic using a complete English sentence.
B.	Main idea B		Students should write their second main idea concerning their topic using a complete English sentence.
C.	Main idea C		Students should write their third main idea concerning their topic using a complete English sentence.

Table 6. First-Step Apita Example

TOPIC: Apita		
MASTER INTRODUCTION		
A.	You can buy almost anything you want at Apita.	
B.	You can socialize at Apita.	
C.	There is plenty of parking space at Apita.	
BODY		
A.	You can buy almost anything you want at Apita.	
	1.	You can buy food at Apita.
	2.	You can buy clothes at Apita.
	3.	You can buy gifts at Apita.
B.	You can socialize at Apita.	
	1.	You can meet people that you haven't seen for a long time.
	2.	You can play games with your friends at the game center.
	3.	You can have a meeting with your friends at Apita.
C.	There is plenty of parking space at Apita.	
	1.	There is a four-level parking garage at Apita
	2.	There are many parking spaces at Apita.
	3.	There are places to park automobiles, motorcycles, and bicycles.
CONCLUSION		
A.	You can buy almost anything you want at Apita.	
B.	You can socialize at Apita.	
C.	There is plenty of parking space at Apita.	

You need to clearly and thoroughly understand HOW TO STRUCTURE the first, second, and third-step outlines and the script form. You need to clearly and thoroughly understand THE PROCESS of each part of the first, second, and third-step outlines and the script form. I want you to learn how to write a script. To do this, you need to learn the structure of the first, second, and third step outlines, as well as how to complete the final script form. You also need to learn the process of writing a script. This means understanding the PROCESS of each outline. In this class we will do this through a series of 3 outlines and a final script form. To write the script we will start with a simple first-step outline. Next, we will add more detail in the second-step outline. Then, we will add more detail in the third-step outline. Finally, we will transfer the third-step outline to a script form.

What kind of sentences should you always write in your outlines? ALWAYS WRITE COMPLETE ENGLISH SENTENCES IN YOUR OUTLINES.

What is a paragraph? A PARAGRAPH IS A GROUP OF RELATED SENTENCES.

For the first- and second-level outline SCT study material, the students were also provided hardcopy handouts of completed outline forms having "Apita" as the topic (see Tables 6 and 8). These outline forms had been completed by the teacher of the course and were to be used as examples to help make the SCT study material more understandable. For the exam, students were provided blank first-, second-, and third-step outline forms and the script form with cells labeled only with bullet points. Some of the cells contained "boxes" for students to input answers. Underneath each corresponding form, the structures and processes of the cells that contained "boxes" were numbered and randomly listed. In each cell of the forms that contained a "box", students had to write the number of the correct process and the number of the correct structure (see Table 11).

Table 7. Second-Step Study Material

Structure shaded grey. Process written next to structure.	
STRUCTURE	PROCESS
MASTER INTRODUCTION	
Master introductory paragraph	Introduce your audience to your presentation topic. Include historical background and why it is important now for the audience to learn about it. Mention the 1 st , 2 nd , and 3 rd main ideas about your topic from the first-step outline.

Table 7. Second-Step Study Material (Cont.)

BODY				
A.	Main idea “A” introductory paragraph		Write a paragraph to introduce the first main idea (main idea A) about your topic from the first-step outline. In this paragraph, mention the three 1 st level supporting examples you gave for main idea A.	
	1.	First-level subpoint	Write the first 1 st level supporting example you gave for the first main idea (main idea A) about your topic from the first-step outline.	
		a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the first 1 st level supporting example of the first main idea (main idea A) about your topic.
		b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the first 1 st level supporting example of main idea A.
		c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the first 1 st level supporting example of main idea A.
	2.	First-level subpoint	Write the second 1 st level supporting example you gave for main idea A.	
		a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the second 1 st level supporting example of the first main idea about your topic.
		b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the second 1 st level supporting example of main idea A.
		c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the second 1 st level supporting example of main idea A.
	3.	First-level subpoint	Write the third 1 st level supporting example you gave for main idea A.	
		a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the third 1 st level supporting example of the first main idea about your topic.

Table 7. Second-Step Study Material (Cont.)

		b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the third 1 st level supporting example of main idea A.
		c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the third 1 st level supporting example of main idea A.
B.	Main idea “B” introductory paragraph		Write a paragraph to introduce the second main idea (main idea B) about your topic from the first-step outline. In this paragraph, mention the three 1 st level supporting examples you gave for main idea B.	
	1.	First-level subpoint	Write the first 1 st level supporting example you gave for the second main idea (main idea B) about your topic from the first-step outline.	
		a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the first 1 st level supporting example of the second main idea (main idea B) about your topic.
		b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the first 1 st level supporting example of main idea B.
		c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the first 1 st level supporting example of main idea B.
	2.	First-level subpoint	Write the second 1 st level supporting example you gave for main idea B.	
		a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the second 1 st level supporting example of main idea B.
		b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the second 1 st level supporting example of main idea B.
		c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the second 1 st level supporting example of main idea B.

Table 7. Second-Step Study Material (Cont.)

	3.	First-level subpoint	Write the third 1 st level supporting example you gave for main idea B.
	a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the third 1 st level supporting example of main idea B.
	b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the third 1 st level supporting example of main idea B.
	c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the third 1 st level supporting example of main idea B.
C.	Main idea “C” introductory paragraph		Write a paragraph to introduce the third main idea (main idea C) about your topic from the first-step outline. In this paragraph, mention the three 1 st level supporting examples you gave for main idea C.
	1.	First-level subpoint	Write the first 1 st level supporting example you gave for the third main idea (main idea C) about your topic from the first-step outline.
	a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the third main idea (main idea C) about your topic.
	b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the first 1 st level supporting example of main idea C.
	c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the first 1 st level supporting example of main idea C.
	2.	First-level subpoint	Write the second 1 st level supporting example you gave for main idea C.
	a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the second 1 st level supporting example of main idea C.

Table 7. Second-Step Study Material (Cont.)

	b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the second 1 st level supporting example of main idea C.
	c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the second 1 st level supporting example of main idea C.
	3.	First-level subpoint	Write the third 1 st level supporting example you gave for main idea C.
	a.	Second-level subpoint	Using a distinguishably different complete English sentence, write the first 2 nd level supporting example of the third 1 st level supporting example of main idea C.
	b.	Second-level subpoint	Using a distinguishably different complete English sentence, write the second 2 nd level supporting example of the third 1 st level supporting example of main idea C.
	c.	Second-level subpoint	Using a distinguishably different complete English sentence, write the third 2 nd level supporting example of the third 1 st level supporting example of main idea C.
CONCLUSION			
Concluding paragraph		Sum up the important points made in your presentation.	

Table 8. Second-Step Apita Example

TOPIC: Apita			
MASTER INTRODUCTION			
Good morning. Today, we would like to tell you about Apita. Apita is a large-scale retail store located throughout Japan. It is a popular store which provides its customers with a wide variety of goods and services. An Apita opened up right next to Suzuka Kosen about 11 years ago. It has made the lives of NITSC's students and faculty much more convenient. We feel it is important for us to tell you about the Suzuka Apita because it has provided so much benefit to our lives and it is a great place to visit. Specifically, today, we would like to tell you about Apita in terms of how you can buy almost anything you want there, how it is a great place to socialize, and how easy it is to find parking.			
BODY			
A.	At the Suzuka Apita, you can buy almost anything you want. For example, you can buy food, clothes, and even gifts.		
	1.	You can buy food at Apita.	
	a.	For example, you can buy apples.	
	b.	Also, you can buy dog food.	

Table 8. Second-Step Apita Example (Cont.)

	c.	Finally, you can buy gum.
2.		You can buy clothes at Apita.
	a.	For example, you can buy socks.
	b.	You can buy shoes.
	c.	Also, you can buy shirts.
3.		You can buy gifts at Apita.
	a.	For example, you can buy flowers for your mother.
	b.	You can get candy for your girlfriend.
	c.	You can buy ice cream for a friend.
B.		Furthermore, when you go to Apita, you can socialize. For example, you can meet people that you haven't seen for a long time, you can play games with your friends at the game center, and you can have a meeting with your friends.
	1.	You can meet people that you haven't seen for a long time.
	a.	You might run into an old friend.
	b.	Maybe you will see your long-lost teacher at Apita.
	c.	Or, you might even meet your old boy friend from high school.
	2.	You can play games with your friends at the game center.
	a.	For example, you can play space invaders with your friends.
	b.	Also, if you like, you can play a game of Donkey Kong.
	c.	Finally, you can even play a game of air hockey at the game center.
	3.	You can have a meeting with your friends at Apita.
	a.	After school, it is nice to relax with friends at Apita.
	b.	You can talk about what happened that day at school.
	c.	You can even just sit with your friends and eat ice cream at Third-One.
C.		Finally, there is plenty of parking space at Apita. They have a four-level parking garage, many parking spaces, and places to park automobiles, motorcycles, and bicycles.
	1.	There is a four-level parking garage at Apita
	a.	You can park on the first floor.
	b.	If the first floor is full, you can park on the second floor.
	c.	If the first and second floors are full, you can try the third or fourth floors.
	2.	There are many parking spaces at Apita.
	a.	The parking floors are very spacious.
	b.	You almost never have to wait for a space to park.
	c.	There are so many spaces, often, many go to waste.

Table 8. Second-Step Apita Example (Cont.)

	3.	There are places to park automobiles, motorcycles, and bicycles.
	a.	If you take a car, you can park with no problem.
	b.	Or, if you want to, you can ride a motorcycle and park there.
	c.	Finally, they also have many places for you to park your bicycle.
CONCLUSION		
Today, we have discussed the Suzuka Apita in terms of how you can buy almost anything you want there, how it is a great place to socialize, and how easy it is to find parking. Of course, there are many other great aspects about Apita than those we've discussed today, so, why don't you visit today and find out for yourself all of the wonderful adventures you can have at Apita?		

Table 9. Third-Step Study Material

Structure shaded grey . Process written next to structure.				
STRUCTURE			PROCESS	
MASTER INTRODUCTION				
Master introductory paragraph			Cut and paste from the second-step outline	
BODY				
A.	Main idea A			Cut and paste from the second-step outline
	1.	First-level subpoint	Cut and paste from the second-step outline	
		a.	Second-level subpoint	Cut and paste from the second-step outline
			1.	Third-level subpoint Continue development of your discussion of your 1st, second-level subpoint for your first, first-level subpoint for main idea A
			2.	Third-level subpoint. Continue development of your discussion of your 1st, second-level subpoint for your first, first-level subpoint for main idea A
			3.	Third-level subpoint. Continue development of your discussion of your 1st, second-level subpoint for your first, first-level subpoint for main idea A

Table 10. Script Form Study Material

STRUCTURE		PROCESS
Structure shaded grey. Process written next to structure.		
¶1	Master introduction paragraph	Cut and paste from the third-step outline
¶2	Main idea A introductory paragraph	Cut and paste from the third-step outline
¶3	Main idea A main paragraph	Remove bullet points from the first-, second- and third-level subpoints in the main idea A section of your third-step outline, combine the sentences into a paragraph and cut and paste them
¶4	Main idea B introductory paragraph	Cut and paste from the third-step outline
¶5	Main idea B main paragraph	Remove bullet points from the first-, second- and third-level subpoints in the main idea B section of your third-step outline, combine the sentences into a paragraph and cut and paste them
¶6	Main idea C introductory paragraph	Cut and paste from the third-step outline
¶7	Main idea C main paragraph	Remove bullet points from the first-, second- and third-level subpoints in the main idea C section of your third-step outline, combine the sentences into a paragraph and cut and paste them
¶8	Concluding paragraph	Cut and paste from your third-step outline

Table 11. Exam: Second-Step Outline Form

STRUCTURE		PROCESS
MASTERINTRODUCTION		
□		□
BODY		
A.	□	□
1.	□	□
	a.	□
	b.	
	c.	
2.	□	□
	a.	
	b.	□

Table 11. Exam: Second-Step Outline Form (Cont.)

	c.		
	3.	□	□
	a.		
	b.		
	c.	□	□
B.	□		□
	1.	□	□
	a.		
	b.		
	c.		
	2.	□	□
	a.		
	b.		
	c.		
	3.	□	□
	a.		
	b.		
	c.		
C.	□		□
	1.	□	□
	a.		
	b.		
	c.		
	2.	□	□
	a.		
	b.		
	c.		
	3.	□	□
	a.		
	b.		
	c.		
CONCLUSION			
□		□	
1. Write the second 1st level supporting example you gave for main idea B.			
2. Using a distinguishably different complete English sentence, write the third 2nd level supporting example of the third 1st level supporting example of main idea A.			
3. Write the first 1st level supporting example you gave for the first main idea (main idea A) about your topic from the first-step outline.			
4. Write a paragraph to introduce the third main idea (main idea C) about your topic from the first-step outline. In this paragraph, mention the three 1st level supporting examples you gave for main idea C.			
5. Concluding paragraph			
6. Write a paragraph to introduce the second main idea (main idea B) about your topic from the first-step outline. In this paragraph, mention the three 1st level supporting examples you gave for main idea B.			
7. Write the third 1st level supporting example you gave for main idea C.			

Table 11. Exam: Second-Step Outline Form (Cont.)

8. Using a distinguishably different complete English sentence, write the first 2nd level supporting example of the first 1st level supporting example of the first main idea (main idea A) about your topic.
9. Using a distinguishably different complete English sentence, write the second 2nd level supporting example of the second 1st level supporting example of main idea A.
10. Main idea "B" introductory paragraph
11. Main idea "C" introductory paragraph
12. Introduce your presentation topic to your audience. Include historical background and the reason why it is important now for the audience to learn about it. Mention the 1st, 2nd, and 3rd main ideas about your topic from the first-step outline.
13. First-level subpoint
14. Write the second 1st level supporting example you gave for main idea C.
15. Main idea "A" introductory paragraph
16. Write the first 1st level supporting example you gave for the third main idea (main idea C) about your topic from the first-step outline.
17. Write the third 1st level supporting example you gave for main idea A.
18. Master introductory paragraph
19. Write a paragraph to introduce the first main idea (main idea A) about your topic from the first-step outline. In this paragraph, mention the three 1st level supporting examples you gave for main idea A.
20. Second-level subpoint
21. Sum up the important points made in your presentation.
22. Write the third 1st level supporting example you gave for main idea B.
23. Write the second 1st level supporting example you gave for main idea A.
24. Write the first 1st level supporting example you gave for the second main idea (main idea B) about your topic from the first-step outline.

6. Methodology

The results presented in tables 12-15 are based on qualitative data derived from nine, first-year Advanced Course students, during the first semester of 2015. The nine students were given surveys following the second week of class during which they had taken the exam covering the SCT study material. Although there were ten students in the class being surveyed for the current report, responses from only nine students are included in the current report because one student was absent from the first class session and therefore did not receive the lecture concerning the SCT study material or the exam. The survey included the following questions: 1) did the study

material help you learn the structure of each cell of the outline forms and the script form? 2) did the study material help you learn the process of each cell of the outline forms and the script form? 3) did having to take the exam motivate you to learn the structure of each cell of the outline forms and the script form? and 4) did having to take the exam motivate you to learn the process of each cell of the outline forms and the script form? Survey questions were first written in English and then translated into Japanese. The students' responses were written in Japanese and then translated into English.

7. Results

Tables 12 and 13 show the students' opinions of the SCT study material in terms of its efficacy in helping them to understand the structures and processes of each outline form and script form, respectively. Tables 14 and 15 show the students' opinions of the SCT study material examination in terms of its usefulness in motivating them to learn the structures and processes of each cell of the outline forms and the script form, respectively.

Table 12. SCT Study Material and Structure

Survey question 1. Did the study material help you learn the structure of each cell of the outline forms and the script form?	
Students	
1.	Yes. It did help me to figure it out.
2.	It helped me to understand. Thanks to the very detailed study material, it helped me tremendously, since I am bad at English. However, I had to say that since I am so bad, I realized I would need to study much harder to understand better.
3.	It was good. Since there was instruction on each level, such as first level, second level, third...it was very helpful and easy to understand what I was supposed to do on each level.
4.	The study material was helpful because it explains what should be written.
5.	The SM was helpful because the APITA examples were not enough for me to understand each structure.
6.	Yes. Each line had an explanation, so it was helpful.
7.	It was helpful because each line had a detailed explanation. I like the chart-looking style
8.	Yes, it was helpful because at first sight, I thought I had to write a long essay, but with the SM, I realized that I just need to take care of each stage....I felt that I could do that!
9.	Using the headline "Main point A" was good. Each headline was very helpful to understand the structure.

Table 13. SCT Study Material and Process

Survey question 2. Did the study material help you learn the process of each cell of the outline forms and the script form?	
Students	
1.	Yes. It did help me to arrange my thoughts and express them clearly and make my points understandable.
2.	I guess that it was helpful. Since the “process” was very long, without the study material, I could not have understood a bit! Even with it, I could not understand completely. Thus, I need to study harder.
3.	In the instructions, there was some overlap, but it was helpful because of it.
4.	The study material was helpful because there was a clear instruction of what should be stated.
5.	The study material made me understand what the process is, and what to write, so, it was helpful.
6.	With just an Apita example, I could only understand the big picture of the outline. As for the SM, I could understand the complete picture of the process.
7.	As in the “structure”, it was helpful since each headline had an explanation.
8.	Apita’s example was useful.
9.	Yes, because, there are many students who are not good at English so they could learn with the detailed material.

Table 14. Exam and Structure

Survey question 3. Did having to take the exam motivate you to learn the structure of each cell of the outline forms and the script form?	
Students	
1.	Yes. Without the exam, I may not study.
2.	My drive went up! Frankly speaking, I guessed that there would be many questions in the exams that are from the study material, I studied hard with it, because, I wanted to get a higher score. Also, since I knew that studying the material could help me understand what Lawson was trying to teach, my study was not wasted.
3.	As Mr. Lawson said, the exam made us read the instructions carefully. We got motivated.
4.	The motivation went way up since there was an exam, and the understanding of the structure went up too.
5.	Because we had an exam, I had to read every sentence in the study material, so it was a good why of learning what the structure is etc. Of course, my motivation went up because of the exam.
6.	No answer was stated.
7.	I could understand the structure because I had to study that for the exam.
8.	The SM helped me understand and got me motivated because it covered the whole structure.
9.	Without the exam, I don’t think I would look at the material, and I would not pay enough attention to each headline.

Table 15. Exam and Process

Survey question 4. Did having to take the exam motivate you to learn the process of each cell of the outline forms and the script form?	
Students	
1.	Yes. Without the exam, I may not even read the study material.
2.	My motivation got stronger. As I stated above, knowing that the material in the study material will appear in the exam, I got motivated. Also, if I understand the process, I knew that my effort would pay off for the group study later. So, I worked hard for the exam.
3.	I was glad to have an exam, because I read and understood the “process” and the exam gave me a chance to think about what to present, etc.
4.	The “process” part was more difficult than the structure, so I spent more time studying that part and I was motivated.
5.	Without the exam, I would have just browsed the material. With the exam, I studied the meaning of the process, the purpose, what to write. I read each word of it! And my motivation increased.
6.	Without the exam, I do not think we would have tried to understand each process. Since we had the exam, I was forced to study and I learned.
7.	I could understand the process as I studied for the exam.
8.	Knowing that the exam score would affect the grade, I studied well and because of that, I could understand it better.
9.	Without the exam, I would not have studied or understood the process.

8. Discussion

Improving the ACEOPSC instructional pedagogy is an ongoing concern. Improving the teaching method regarding the script-creation segment of the course could help reduce students’ stress and make the class a more enjoyable and meaningful learning experience. While always reflected upon seriously, prior to the first semester of 2015, the SCT was communicated to students through only one lecture during the second week of class ^{note 6)}. It was hoped that the addition of SCT hardcopy study material as of the first semester of 2015 would help students’ gain a better understanding of the differing structural and procedural requirements as they transition through each progressively more detailed outline form and the script form—and in doing so, progressed from a basic outline to a completed script. It was also hoped that including an exam would motivate students to actually read and hopefully learn the study material. Based on the findings, it looks as if including the SCT hardcopy study material as part of the class is a good idea that probably should have been done long ago. The detailed information

included in the SCT study material makes it very clear how students will develop their topic into a script. It provides a “road map” that is easy to follow once learned. It is also very clear that including an exam covering the material is a must in order to increase the students’ motivation to actually learn the SCT study material.

9. Conclusion

Refining the ACEOPSC class continues each year, as any step that can be taken to increase students’ English-language capability is important. In terms of the script creation portion of the ACEOPSC, it seems that the addition of SCT study material is effective in helping students understand how to develop a topic into a script. It also appears that an exam covering the material is effective in motivating the students to learn the SCT material. These two facets will remain as part of the course instruction.

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Notes

1. As of the first semester of 2015, students’ course scores are based on two exams—one covering the SCT, and the other covering script memorization—and a final presentation contest.
- 2-4. All bullet points are listed vertically in the forms that students complete.
5. This research is currently being developed for possible publication.

6. In subsequent weeks, it was necessary to spend class time repeating information from the lecture as students developed their scripts.

(学術論文)

英語言語構造と処理能力の認知習得について：学習材料と試験

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本校はこれまで英語のオーラル・コミュニケーション能力の向上に努め、2009年以来、専攻科では英語の口頭プレゼン発表とその原稿作りの講義が行われてきた。本論は、その講義で使用される学習材料が一連の英語スピーチのアウトライン作り、ひいてはプレゼンの最終原稿作りにおいてどのくらい効果的に学生の構造上やプロセスの理解に繋がっているのかを考察した。更に、試験の有無が彼らが学習材料を学ぶことへの動機付けとなり得ているのかも調べた。研究に使われたデータは2015年前期の専攻科1年生9名による質的調査によるものである。

KEY WORDS: 英語コミュニケーション能力、オーラル・コミュニケーション、口頭スピーチ、少人数教育、英語学習の動機付け

Preparation for the Annual English Presentation Contest for Students of Colleges of Technology and Comments on the Present State and Future Direction of English Oral Communication Pedagogy

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National Institute of Technology, Suzuka College (NITSC), has recently increased focus on improving students' English-oral communication skill ^{1, 2, 3, 4}. Participating in the Annual English Presentation Contest for Students of Colleges of Technology (AEPCST) is one way in which this focus has been realized. The current research offers a qualitative examination of three students' feelings regarding the merit of the AEPCST in terms of its usefulness in motivating them to improve their English oral communication ability and seeks to understand if these students desire more English oral communication opportunities at NITSC. Additionally, there is an attempt to gain practical pedagogical information regarding the students' preparation for the 2015 AEPCST. Results are based on a 15-question qualitative survey administered to three Advanced Course students who plan on participating in the 2015 contest.

KEY WORDS: Oral communication, oral speech, motivation for English learning

1. Introduction

At National Institute of Technology, Suzuka College (NITSC), there has been increased effort to improve students' English oral communication ability ^{1, 2, 3, 4}. Having students participate in the Annual English Presentation Contest for Students of Colleges of Technology (AEPCST) is one way this effort is focused. The AEPCST has entailed a two-step process. First, over the past 8 years, each November, groups of three students from Kosens throughout Japan have recorded themselves engaging in English oral presentations and submitted these recordings to a committee of AEPCST judges. Second, those groups deemed best based on the recordings have been invited to the final round of the presentation contest held in Tokyo.

At the time of this writing (February 2015), three NITSC Advanced Course students are planning on submitting a recording in November 2015 in the hope of being selected to participate in the final round of the contest. The current research attempts to determine these students' opinions regarding the motivational value

of the contest in terms of its usefulness in inspiring them to improve their English oral communication ability, if they wish for more such opportunities at NITSC, and to understand some specific ideas regarding the best way for the supervising teacher (ST) to help prepare the students for the contest.

2. Student Selection

Another way that NITSC has increased focus on improving students' English-oral communication ability is through the creation of an Advanced Course English oral presentation and script development class (ACEOPSD). First-year Advanced Course students receive the class during the Zenki term, and second-year students during the Koki term. In the class, groups of 3 or 4 (and sometimes 5) students select topics, create English-language scripts, create English-language PowerPoint presentation files, and compete against each other in a presentation contest as the culminating experience of the course. Generally, six groups compete in the ACEOPSD presentation contest each term. The contest is the sole basis of the students' course scores. In addition, based on the scoring

of the presentations, three students from the Zenki class are selected to participate in the AEPCSCCT.

The judging of the ACEOPSD contest is based on the group performance as a whole. However, each individual student receives a score for their speaking ability. After the students' course scores are totaled, the three top-scoring speaking students, irrespective of group membership, are selected to participate in the AEPCSCCT and will use the PowerPoint file and corresponding script of the group that received the highest score on those criteria in the ACEOPSD presentation contest.

Thus, for example, a student from group 1, a student from group 4, and a student from group 5, each having received the highest scores in the speaking category of the ACEOPSD contest, could be selected to use the PowerPoint file presentation and corresponding script from group 6, which had received the highest group score on organization of content and visual aids in the ACEOPSD contest, in recording an English oral presentation and submitting the recording in November in an attempt to be selected for the final round of the AEPCSCCT held in Tokyo ^{note 1}. The Zenki semester ends in July, giving students approximately four months to practice their presentation before submitting the recording to the committee of AEPCSCCT judges in November.

In Zenki 2014, the three NITSC students who were selected to submit an English oral presentation recording, failed to be chosen to participate in the final round of the eighth AEPCSCCT. Because the three students had just finished the ACEOPSD class, it was thought that they had sufficient experience and material (the script and PowerPoint file from another group) to afford them a good chance. The students were left alone to prepare for the contest as they saw fit. However, the AEPCSCCT presentations are of a very high quality and the students were disappointed to learn that they were not chosen to advance to the final round in Tokyo. Thus, it was decided that for the 2015 AEPCSCCT contest, the usual method of selecting students would be suspended and the three 2014 contestants would be allowed to try again.

3. New Plan

In January 2015, a plan was developed by the ST in an attempt to better prepare the students for the 2015 contest. Remembering that for their 2014 attempt, the students used a script and PowerPoint presentation file that was created by other students from the first-year ACEOPSD class, the new plan called for the students to create a new PowerPoint file and corresponding script based on their own interests.

Beginning in March 2015, the students were to work closely with the ST in deciding upon a topic, writing the script, and creating the corresponding PowerPoint presentation file. This was to be accomplished primarily through email exchange. Then, the students would be asked to memorize their portions of the script and would receive intermittent memorization "tests". Next, the students would practice giving their presentation a minimum of five times each week with the ST in attendance. Some of these practice sessions would be recorded and shown to the students to help improve their performance. Finally, in November 2015, a recording of the students giving their presentation would be submitted to the committee of judges to be considered for acceptance to the final round of the ninth AEPCSCCT.

Before imposing this plan on the students, the ST thought that it would be helpful to understand their feelings regarding the merit of the contest in terms of its usefulness in motivating them to improve their English oral communication ability, their desire for more English oral communication opportunities at NITSC, and some of their practical pedagogical preferences. It was thought that an understanding of such feelings may help the ST provide the appropriate type and amount of assistance to the students. Consequently, a survey covering the students' thoughts on these criteria was administered prior to the planned March 2015 commencement of the AEPCSCCT contest preparation.

4. Methodology

The results of the current study are based on a 15-question qualitative survey administered in February 2015 to the three second-year Advanced Course students who are planning on participating in the 2015 AEPCSCCT. The questions were designed to gain an understanding of students' opinions regarding the usefulness of the AEPCSCCT as an English-language motivational tool, if the students desire more opportunities within the NITSC curriculum to improve their English-oral communication ability, what the teacher's mindset should be in terms of the AEPCSCCT contest preparation, what they most anticipated and were anxious about, and some specific pedagogical concerns. The survey questions were written in English and Japanese. The students' answers were written in Japanese and translated to English by a Japanese English-language teacher.

5. Results

5.1 Motivation

Presented in Table 1 are the results of one survey question asked of the three contestants. The question was asked to gain an

understanding if the students feel that the AEPCST is a good way to motivate them to learn English (see Table 1).

Table 1. Usefulness in Motivating Students

Question	
In general, is the presentation contest (PC) a good way to motivate you to learn English?	
1	I have always liked English, and by participating in the PC, I am motivated to learn English more.
2	It is good motivation for speaking English, because you must speak with confidence in the PC.
3	Since there are not many occasions to speak English in the Kosen, it is good because if I want to learn those things, I always have to do it on my own.

5.2 More Opportunities

Table 2 lists results of two survey questions asked to understand if the students desire more opportunities to improve their English oral communication competence at NITSC (see Table 2).

Table 2. More Communication Opportunities

Question 1	
Do you think there should be more effort by NITSC to promote students' English oral communication skills through activities such as the Kosen PC?	
1	Having the Advanced Course English oral presentation class is a great way to improve students' communication skills. We should have that type of class in our pre-Senko-Ka years.
2	Yes, because preparing for the presentation improves your English level. I hoped the Kosen would offer more opportunities like this to use English.
3	We should have an English presentation contest during our pre-Senko-Ka years, and should have more listening and speaking classes.
Question 2	
Do you wish there were more opportunities at NITSC to improve your English oral communication skill?	
1	The majority of the Kosen classes teach grammar and reading comprehension. We need many more communication classes.
2	Yes, because if we want English communication training, we must use money to find it outside the Kosen. For example, we can try some online English conversation learning.
3	It should be important to learn grammar and reading, but there are not enough classes with a native-English teacher, such as communication classes. I want more of that.

5.3 Preparation

To gain information to help prepare the students for participation in the AEPCST, questions were asked to help determine the proper mindset of the ST, the students' sources of anticipation/anxiety, and specific pedagogical preferences.

5.3.1 Teacher's Mindset

Presented in Table 3 are the results of five survey questions asked of the three contestants. The questions were asked to gain an understanding of what the mindset of the supervising teacher should be (see Table 3).

Table 3. Teacher's Mindset

Survey Question 1	
Should the teacher be, serious or relaxed?	
1	Usually, relaxed is good, but when we are bad, please give us a serious manner.
2	Both and in turns, please.
3	Either way is okay.
Survey Question 2	
In specific, why will you participate in the presentation contest (PC)?	
1	To tell the truth, I am not the kind of person who is willing to attend the PC, but since I was chosen as one of the best speakers, I started to feel like attending.
2	I want to try anything I can to improve my English.
3	I want to improve my English ability, using presentation and communication skills that I learned in the Advanced Course presentation class. Plus, I want to make a good memory during my school years.
Survey Question 3	
What is the priority of the PC for you?	
1	This year, I have to job-hunt and I have to finish my research. I want to be able to coordinate the presentation practice with these two.
2	Precision in pronunciation, because even if you make a correct English sentence, if your pronunciation is bad, it is hard to carry a conversation.
3	It is third behind finding a job and doing my research.
Survey Question 4	
How important is the PC to you?	
1	Since I do not get many opportunities to speak English, attending the PC would offer a good experience.
2	It is important because I get to use English in a practical manner.

Table 3. Teacher's Mindset (Cont.)

3	I have to say that it is less important compared with research for graduation and job hunting because these two are the most important reasons I chose the Kosen in the first place. But, besides these two, the contest is the most important, and I want to win!
Survey Question 5	
What is a good way for the native-English speaking teacher and the Japanese students to communicate to avoid cultural misunderstandings?	
1	Both parties should understand each other. It might be a good idea to have a mediator who understands both cultures.
2	Other than the lecture topics, it is important to exchange our culture through broader topics.
3	I have never felt the difference in ideas, so don't know the answer.

5.3.2 Student Anticipation and Anxiety

Presented in Table 4 are the results of four survey questions asked to gain an understanding of what the students were looking forward to and what they were worried about in terms of participating in the AEPCSCCT (see Table 4).

Table 4. Student Anticipation/Anxiety

Survey Question 1	
What are you excited about?	
1	I am excited just because I have almost never had the chance to improve my English oral communication.
2	I am excited by the challenge to do something difficult for me. If I conquer this hard task, I think I can step forward.
3	I am looking forward to practicing the speech with the other two students. I am looking forward to listening to other presentations.
Survey Question 2	
What do you hope to learn?	
1	I want to continue to learn how to develop a presentation and how to communicate through interaction with the teacher, and through the making-process.
2	How to better develop a presentation and what to care about in terms of planning—because I am sure that I need that knowledge in my future academic life.
3	I want to learn and how to prepare, practice and answer the questions.

Table 4. Student Anticipation/Anxiety (Cont.)

Survey Question 3	
What do you hope to achieve by participating in the PC?	
1	First, I want to advance to the Tokyo contest. And in Tokyo, I want to do my best. I need more practice in learning a basic method of presenting a good speech. I want to start that.
2	I want to advance to the Tokyo contest. I want to raise the degree of perfection by practicing with other students.
3	Of course, I want to attend the Tokyo contest. So I want to take much time to prepare.
Survey Question 4:	
What are you worried about?	
1	It is not impossible to deliver the perfect presentation if you memorize the draft well, but wondering if I can answer the judges' questions is worrisome.
2	Pronunciation and questioning, because I acknowledge my low level of English usage.
3	First, whether I will make mistakes in front of the big audience—since I tend to get nervous in public. Second, whether I will be able to answer the judges' questions, because I am anxious about being able to say what I want to say.

5.3.3 Pedagogy

Presented in Table 5 are the results of three survey questions asked to gain a specific understanding of certain pedagogical issues (see Table 5).

Table 5. Pedagogy

Survey Question 1	
How do you want to control the practice?	
1	It would be ideal to be able to do it by ourselves, but we need the teacher with flexibility.
2	I want to come up with my own practice way, because in that way, even if I fail, it is more fun. Also, I want to consult and discuss with other students.
3	Having the teacher is better.
Survey Question 2	
How much time should you spend practicing each week?	
1	Three times a week after class would be ideal.
2	After the PowerPoint file is completed, 3 hours a week is enough for the delivery-practice.
3	More than once a week, since language learning needs continuance

Table 5. Pedagogy (Cont.)

Survey Question 3	
The PC is in November—when is the best time to start practicing?	
1	I think the April start is enough.
2	We should start during the summer vacation.
3	I want to finish the PowerPoint file and script by the summer vacation and practice during and after the vacation.

6. Discussion

6.1 Motivation and Opportunities

When looking at responses from Table 1, it seems that the AEPCSCCT does a good job of motivating students to develop their English oral communication skills. The contest likely motivates students to improve their English oral communication ability by providing them with a valuable opportunity to showcase their competence and a situation in which their competence will *clearly be tested*. It also appears that a scarcity of opportunities to improve English oral communication at NITSC increases the value of the AEPCSCCT, helping it to become a special event that students believe should be taken full advantage of.

According to the results presented in Table 2, the students wish for more activities such as the AEPCSCCT ^{note 2}, and they hunger for more opportunities to improve their English oral communication ability at NITSC. However, a potential problem with the former is that contests do nothing to help the *general student population*, as only a tiny fraction of the student body can participate each year. Further, contests may give the appearance that great effort is being taken by Kosen to improve students' English oral communication ability when in fact contests are largely ineffective and may mask what is truly needed (to be discussed in section 8.3). For the latter, while there are many off-campus English speech contests for Kosen students, there are few large-scale, systematic opportunities for the average student to work on their English oral communication skills at NITSC on a daily, or even a weekly basis, due to curriculum and staff constraints. Students may need to resort to using their own money in seeking outside opportunities to develop their skill. This is unfortunate as it may create unequal access to English oral communication learning programs, giving students of a certain financial position or familial leaning an advantage over their peers. Students appreciate NITSC's ACEOPSD class and they want more speaking courses during their pre Senko-Ka years, but to provide this to students on a high-volume, wide-spread basis under existing

conditions is difficult.

6.2 Preparation

What should the ST's mindset be? What are the students most looking forward to? What are the main sources of their anxiety? An attempt to understand these questions, as well as specific pedagogical preferences, may be helpful in deciding how to prepare the three NITSC 2015 AEPCSCCT student contestants.

6.2.1 Teacher's Mindset

Because the ST is not a Japanese native, one exacerbated challenge faced is understanding what level of teacher intensity, or pressure, is appropriate and how to overcome culturally-induced communication barriers. For example, American students may respond best to a relaxed manner. However, Japanese students may want a more seriously-mannered teacher. When the students were asked directly, Table 3 data indicate that they are receptive to both styles—in fact, two students indicated that they prefer both styles— noting that seriousness is useful when correcting weak performance.

Other than asking directly, one way to attempt to determine the appropriate level of teacher intensity is by trying to gain an understanding of the students' level of motivation—how much do they want to participate in the contest? If the students are highly motivated, it *may* be a sign that the teacher can worry less about pushing too hard. Of course, students can be very motivated and also wish to do the majority of the planning and work themselves. But, it is certainly likely that unmotivated students would resent a pressured environment. Survey question 2 in Table 3 provides mixed results with one student being highly motivated, one student being averagely motivated, and one student not being very motivated. However, the priority of the contest seems to be high for all of the students. Question 3 in Table 3 shows that for two of the students the contest is only surpassed by two obligations—graduate research and finding a job.

Responses to question 4 in Table 3 lend support to the feeling that the students' level of motivation to participate in the contest is high with statements such as “it would be a good experience,” that “...it is important to use English in a practical manner,” and that “I want to win!” Finally, cultural barriers to communication may decrease the ST's ability to provide students with sufficient help in their preparation. Based on the students' responses to the question, “What is a good way for the native-English speaking teacher and the Japanese students to communicate to avoid cultural misunderstandings?” it appears that special effort should be taken to patiently listen to each other, to develop cultural understanding

through discussions of broader topics, and to have a third-party mediator attend some practice sessions—one who has a good understanding of both cultures.

6.2.2 Student Anticipation and Anxiety

Another challenge for any teacher when considering how to best help prepare students for an event, is understanding what students are especially excited about and conversely, what they most fear. The question presented in Table 4, “What are you excited about?” seems to indicate that the students are most anticipating the opportunity, the challenge, and the comradery. Data presented in Table 4 also show that the students are looking forward to the process of developing the presentation, interacting with the teacher, and practicing the presentation. Finally, the students’ responses to the question, “What do you hope to achieve by participating in the PC?” provides some evidence of interest in learning a process that will enable them to make a good presentation, in seeing their presentation improve through practice, and in devoting enough time to practicing to have their presentation accepted for the final round of the contest held in Tokyo. On the other hand, when asked, “What are you worried about?” all three students mentioned that they were most concerned about answering the judges’ questions.

6.2.3 Pedagogy

Several questions were asked to gain a practical understanding of how the students wanted to conduct the contest preparation. Students have busy schedules and their own ideas about such matters. Responses to the first question presented in Table 5 show variability in the students’ preferences regarding the extent of teacher involvement. One student wants to take total control of the contest preparation; one student wishes for total control but prefers teacher involvement of a flexible nature; and one student wants the teacher to take control of the preparation.

Considering these responses, it appears that a somewhat passive teacher presence would be best. It would likely be proper to unobtrusively observe how the students advance in their preparation, while letting it be known that help is always available. Data presented in Table 5 also show that the students prefer a three-hour, or three times a week, practice schedule. Finally, when asked when the best time to start the contest preparation is, one student said April, one said summer vacation, and one said he wanted to finish the script and PowerPoint file by the summer vacation and begin practicing after that.

7. Moving Forward

Before the survey was administered to the students, the ST’s plan

was to closely supervise the pupils as they began in March 2015 to create a fresh script and corresponding PowerPoint file (not based on the Advanced Course class). Fortunately, it is now understood that the students prefer a later starting date and that passive supervision is likely most appropriate. This is not to say that the students are unmotivated. To the contrary, the students are motivated and just seem to want to be independent. It is useful to know that the students feel comfortable beginning at what the ST would have considered to be a late date. It certainly would have caused trouble had a preparation schedule been forced upon the students in March.

Also, understanding that the students want to be independent in the preparation, tells the teacher not to impose a weekly email exchange system of script and PowerPoint file creation, where the teacher performs scheduled editing and provides comments. Instead, the ST should allow the students to freely write their script and create their PowerPoint file based on their own time schedules and without interference. When they are completely finished, then the teacher can provide editing and comments.

Previously, it was assumed that the students would appreciate a “hands-on” effort, but now it is understood that the students want more control. The students do not want the teacher to “do it for them”. This is encouraging. It does appear that the students enjoy interacting with the teacher, suggesting engaging in discussions of broader topics to break cultural barriers to communication. It is likely that these students enjoy engaging in “small-talk” with the ST, but they want to be free in terms of serious preparation.

The suggestion for a third-party mediator is also an excellent idea. From time-to-time, a Japanese English teacher who has spent much time abroad will be invited to assist. But, the ST will no longer pressure the students to, for example, memorize their scripts. Of course the scripts must be memorized in order for the presentation practice to be at its best. But the students will be allowed to accomplish that without being given intermittent memorization tests.

A key idea gained is that the students want to take control and be responsible for their performance. However, students anticipating the challenge of the contest indicates that they are motivated to do well and therefore are also receptive to some instruction. Before surveying the students, it was assumed that they would appreciate close monitoring of every step. It is now believed that such a stance would likely prove to be overbearing and would ruin the experience for the students. It does appear, however, that they will be particularly receptive to instruction regarding how to answer judges’ questions about their presentation.

Further, through their development of the script, PowerPoint file, and practice, the students should supplement what they learned in the Advanced Course class, helping them to better learn a process of making a good presentation. This is something they anticipate. A sense is gained that the students have experienced the ground-work for creating and giving a presentation in the Advanced Course class with closely monitored supervision and instruction and that for the AEPCST, they look forward to facing the challenge generally by themselves. While it was originally thought that a five-day a week practice schedule would be best, the students opt for three-days a week. The teacher should be available to provide support if asked, but should not take a leadership role. This can be difficult, as the ST may feel pressure to have contestants perform well as a reflection of his or her teaching ability. Due to confines which result in an English language learning paradigm that limits formal opportunities for native-English speaking English teachers to demonstrate teaching competence (Japanese English language teachers have the TOEIC test, which students sit for at various scheduled times throughout the year), contests such as the AEPCST become an outlet. However, approaching contest preparation with an ego-based attitude should be constrained with an understanding that it is the students' contest, not the teacher's. This should be coupled with an awareness that a teacher can have the best intentions and plan for students but if they are not interested in carrying out the plan, the teacher cannot and should not force the issue.

Based on the findings presented in the current research the approach to the 2015 AEPCST practice will be as follows: 1) the teacher will be passive, allowing the students to direct the procedure; 2) the students will likely begin around the time of summer vacation; 3) from time-to-time, a Japanese teacher will be invited to join the practice sessions to serve as a mediator; 4) the teacher will make time for three, one-hour sessions per week as soon as the students have finished preparing their script and PowerPoint file; 5) to help improve their performance the teacher will video the students giving their presentation if the students agree to that step; and 6) the students' final presentation video will be taken in November 2015 and submitted to the AEPCST judges to be considered for acceptance in the final round of the 2015 contest.

8. Conclusion

8.1 The AEPCST

The students are motivated to participate in the AEPCST, appreciate the opportunity and wish for more English-speaking classes within the NITSC curriculum. Effectively providing this type

of educational offering is currently difficult due to a lack of enough courses, a lack of enough full-time, permanent native-English speaking English teachers, and curriculum constraints which may pressure teachers to employ methods simply to meet the requirements of bureaucracy without regard to the reality that teaching oral communication to 40 plus students requires different teaching and evaluation methods than that which might work well when teaching listening, reading and/or grammar, making contests such as the AEPCST all the more valuable (yet, woefully lacking). The students are rather self-directed and it is important for the teacher to recognize that an ego-based mindset would likely be counter-productive. Being sensitive to the degree and type of help the students want will likely improve their motivation and performance. In terms of helping the *general Kosen student population* develop English-speaking competence, contests such as the AEPCST are ineffective. At best, contests can help only a few students each year and despite efforts by the teacher to encourage all students to participate, seem only to help those few students who are already adequately proficient English speakers (as they are the only ones who dare to participate). Contests may actually have a negative effect, as they may divert attention away from steps which Kosens might otherwise take to address students' English oral communication education. This invokes the question of what Kosens can do to improve the English oral ability of the *general student population*.

8.2 Present State

Teaching effective English oral communication courses to the general student population (albeit in a limited fashion due to a limited number of teachers and courses) that focus on speaking ability in class sizes of over 40 students (the typical Kosen class) can be accomplished when there is acceptance of innovative pedagogies and exams that only measure secondary foci (see *Lawson and Hirai [b] 2015*)^{note 3}. As of this moment, for the teacher of English oral communication courses attempting to provide students, such as the three surveyed in the current report, with interesting classes that develop speaking ability, being able to independently create courses fitted to his or her specific training and goals, and being able to apply ingenuity in offering experimental pedagogy is very helpful. For instance, following a textbook is often not necessary and can actually be a hindrance. While, for example, following a textbook may be useful for some and comfortable for many, speaking activities included in textbooks might sometimes be too limiting for teachers who hope to combine speaking within a more substantive

professional context better suited to that teacher's particular goals, training and interests, and are fundamentally no better than a teacher's own material as the basis for developing courses and exams in English oral communication classes. Teachers should be encouraged to employ vision in the creation of their courses and not rely solely (or at all) on textbooks.

Further, class sizes of at least 40 pupils make giving anything other than traditional, paper-based exams within the normal Kosen system difficult. Traditional paper exams based on textbooks or a teacher's own material, the kind that Kosen students receive twice per semester, do not measure students' speaking ability, but rather measure secondary foci, such as situational selection (students' ability to select the correct words to say given a certain situation) or speech outlining techniques. Thus, if the purpose of a course taught to a typical Kosen-sized class is to expose students to live native-English speaking and to improve students' speaking ability, its value cannot be reliably judged based on traditional paper exams stemming from either textbooks or a teacher's own material. This should not stand in the way of teaching English oral communication courses, taught to normal Kosen-sized classes. Rather, the importance of exams in such classes should be deemphasized with an understanding that they cannot measure the main pedagogical focus of the course, *to wit*, improving students' English speaking ability.

8.3 Future Direction

The following suggestions regarding the future of English oral communication pedagogy are unlikely to occur due to budget constraints. However, if viewed as an "ideal-type"—something to strive for—they may have some use in generating more workable ideas. With that said, preferably, students would receive English oral communication courses during all five years of their matriculation and English oral communication would be treated with the same weight as teaching English grammar and reading/listening comprehension. More English speaking courses would need to be added to the regular curriculum, along with different standards or expectations for accepted pedagogy and student evaluation. More full-time, permanent, native-English speaking teachers would be needed to teach the classes, as their native intuition, pronunciation, enunciation, intonation, etc., would be invaluable. Just as Kosen require more than one full-time, permanent, highly-skilled Japanese-English language teacher to handle the daunting task of improving the English grammar and reading/listening of over 1,000 students, so too would they require more than one full-time, permanent,

native-English speaking English teacher to handle the daunting task of improving the English speaking ability of more than 1,000 students. Further, full-time, permanent, native-English speaking English teachers would have more power, influence, and investment than part-time workers, better enabling them to help expand the English-language learning environment by creating new norms of pedagogical and student evaluation standards. Japanese-English language teachers, having far too many duties, responsibilities, students, and mandated curriculum guidelines to be fairly asked to also take on the monumental task of improving pupils' English oral communication skill, might welcome the creation of two English departments based on a separation of focus, as a clear delineation of duties and expectations would clear up confusion and provide the structure and goals that allow all to flourish. Ideally, NITSC's current Department of Foreign Languages would have a name more accurately reflecting its mission, such as, The Department of English Grammar, Reading and Listening, and would be headed by a teacher chosen **based on merit** rather than seniority, with an emphasis on his or her international experience, historically demonstrated ability to help NITSC with English-language duties such as serving as interpreter for foreign guests and supervisor of students on international excursions, TOEIC score, academic sophistication and academic interest.

A new department, The Department of English Oral Communication, would be created and staffed by five full-time, permanent native-English speaking teachers. At least one of these five teachers would be highly proficient at Japanese and would serve as the Head of the department. Creating such a department could result in a more *thoroughly established*, formally recognized, systemic need for native-English speaking teachers and an *appropriate vehicle*—that is, one specifically designed to target students' English oral communication ability—for the fulfillment of that need. This could be helpful to both students, who would receive intensive English oral communication instruction based on pedagogy *created by a number of native-English speaking teachers* and the addition of required courses equal in volume to that which focus on grammar, reading, and listening, as well as be helpful to native-English speaking, English language teachers, who would have *native-English speaking teacher created, institutionally-backed, high-volume, curriculum-level goals* to strive for. Under the current English-language paradigm at NITSC, the teaching of English grammar, reading and listening, is well-supported institutionally through a mandated high-volume curriculum and

students that sit for scheduled TOEIC tests throughout the year. This gives Japanese-English language teachers formal professional credibility, great motivation, and feedback on their classroom efforts. For the native-English speaking, English teacher, whose main contribution is oral communication, there are no such institutionally supported, curriculum-based, sanctioned and deified methods in which teaching competence and *general student population performance* can be verified. With the creation of an English Oral Communication department staffed by five native-English speaking English teachers and headed by a native-English speaking English teacher proficient in Japanese, and working with administrators, a formalized approach could be established to improve students' English oral communication ability with *more appropriate* institutionally-backed curriculum standards, "innovative" pedagogical approaches and methods of evaluation ^{note}

⁴. This expansion to the English language education paradigm could help integrate native-English speaking English teachers into the Kosen system and bring about immediate positive results for students.

Fortunately, NITSC's bureaucratic flexibility, coupled with support from senior administrators and key faculty members, demonstrates a healthy and much appreciated progression in NITSC's commitment to improve students' English-language learning experience. The future is bright.

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Notes

1. Due to concerns of plagiarism, as of 2015, the three highest ranking students in terms of speaking create original scripts and corresponding PowerPoint presentations. For the 2015 November submittal, two of the highest ranking speaking students from the ACEOPSD class also were members of the group with the highest ranking PowerPoint presentation and corresponding script.
2. There are already many off-campus contests for English oral communication but most students decline to participate despite being strongly encouraged to do so by the ST. This is likely due to most students lacking the confidence to participate in high-pressure contests. More contests are not needed. What is needed are more curriculum-based courses and native-English speaking English teachers to teach the courses.
3. With the creation of a Department of English Oral Communication, as outlined in section 8.3, innovative pedagogies and methods of evaluation would no longer be innovative—as that distinction is justified only when teaching English oral communication under the current NITSC system.
4. Again, innovative pedagogies and methods of evaluation are only distinguished as such under the existing English language learning paradigm.

(学術論文)

全国高等専門学校英語プレゼンテーションコンテストに向けての準備 と英語オーラルコミュニケーション教授法の現状と未来について

マイケル・ローソン¹

1: 教養教育科

本論は鈴鹿工業高等専門学校で英語のオーラル・コミュニケーションの重要性が高まる中で始まった学生対抗の英語プレゼンテーションコンテスト（年1度）について考察した。コンテストに参加した3名の学生への質的調査結果を基に、このコンテストが英語コミュニケーション能力向上への動機付けになっているのか、学生がカリキュラムとしての英語オーラルコミュニケーションの更なる機会を求めているのかを調査した。加えて、2015年に行われる予定のコンテストにおいてより効果的な実践的教授法を見つけるべく、次年度のコンテスト参加予定の学生3名への15項目による質的調査しまとめた。

KEY WORDS: オーラル・コミュニケーション、英語スピーチ、英語学習の動機付け

半経験的分子軌道計算ソフトウェア「Scigress MO Compact」を利用した e-learning 教材の作成と教育効果

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半経験的分子軌道計算ソフトウェア「Scigress MO Compact」を利用し、シクロヘキサンの立体配変換に伴うエネルギーの変化が分子内に生じる立体障害に起因することを説明するための e-learning 教材を作成した。受講者に対するアンケートの結果より、作成した教材にはポジティブな教育効果が認められた。また、教材の作成に携わった学生に対しても、授業で学んだものよりも深い知識を自発的に学ぶことを促す効果が見出された。

Key Words : 半経験的分子軌道計算ソフトウェア, 有機化学, e-learning 教材

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1. 緒言

波動方程式のハミルトニアンに経験的なパラメータを代入して分子軌道をもとめる半経験的分子軌道計算は、物理定数以外の実験値を用いることなく波動方程式を解く *ab initio* 法に比べて数学的な厳密さでは劣るものの、量子化学の専門家でなくとも容易に計算を行えることや計算速度が速いという利点をもっている。近年のコンピュータの処理能力の向上により一般的なパーソナルコンピュータでも半経験的分子軌道計算を行うためのソフトウェアを利用できる状況より、鈴鹿工業高等専門学校生物応用化学科でも半経験的分子軌道計算ソフトウェア「Scigress MO Compact」(富士通社製)を導入し、学科 4 年生から専攻科 1 年にかけての座学・実習で使用してきた¹。本ソフトウェアは有機化合物の生成熱や分子軌道、極限的反応座標を手軽に計算できることに加え、原子の Van der Waals 半径を反映させた有機化合物の 3D モデルを表示することが可能である。すなわちこれらの特徴をうまく利用することにより、必ずしも量子化学を専門としない高等専門学校の教員や学生にも、原子間の立体反発に起因する有機化学反応の選択性や有機化合物の立体配座の安定性を説明するための教材を作成することが可能となると考えられる。この観点より、生物応用化学科 4 年次開講科目「創造工学」において、学生主導による「Scigress MO Compact」を利用した本科 2, 3 年生を対象とする有機化学の e-learning 教材の作成および、作成した教材を受講した学生によるアンケートの回答に基づく教育効果の検討を行った。

2. 教材の作成

e-learning 教材の作成には生物応用化学科の 4 年生 2 名が参加した。教材に取り上げるテーマを決定する際、教員から学生に対し、“Scigress MO Compact の特色をうまく利用できるテーマであること”, “自分たちが 2, 3 年次に履修した有機化学の授業内容で難しく感じたことを教材として取り上げること”を指示するとともに、平成 27 年度に生物応用化学科 2, 3 年生が有機化学の授業で使用している教科書²を提供した。これらを受けた学生主体の議論の結果、“シクロヘキサンの環反転”を取り上げた教材を作成することが決定された。つづいて、以下に述べる手順で e-learning 教材の作成を実行した。その際、作成に使用するソフトウェアの使用方法を教員が学生に示した後、実際の教材作製作業を学生が行った。

まず「Scigress MO Compact」を用いて、シクロヘキサンの立体配座変換過程とそれに伴う分子の生成熱変化を可視化するために、再安定な立体配座であるいす形配座を初期状態に設定し、骨格炭素の二面体角を 10° ずつ変化させ、3D モデルと生成熱を PM6 法により計算した。その結果、シクロヘキサンの立体配座はエネルギー最少の状態であるいす形配座 (図 1 (a), 生成熱の計算値: -27.3 kcal/mol) からエネルギー極大の状態である半いす形配座 (図 1 (b), 生成熱の計算値: -21.1 kcal/mol) を経て、エネルギー極小の状態であるねじれ舟形配座 (図 1 (c), 生成熱の計算値: -24.2 kcal/mol) に変化する過程を可視化することができた。つづいて、ねじれいす形配座を初期状態として上の操作とは 1 炭素だけずれた骨格炭素の二面体角を 10° ずつ変化させた際の 3D モデルと生成熱を

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計算することにより、ねじれ舟形配座からエネルギー極大の配座である舟形配座 (図 1 (d), 生成熱の計算値: -22.5kcal/mol) に変化する過程を可視化することができた。さらに、フリーソフトウェア「AG-デスクトップレコーダー」(© T. Ishii)³および「Windows Movie Live Movie Maker」(マイクロソフト社製)を用いて、いす形配座からねじれ舟形配座への変換過程および、ねじれ舟形配座から舟形配座への変換過程のアニメーション(WMV ファイル)をそれぞれ作成した。

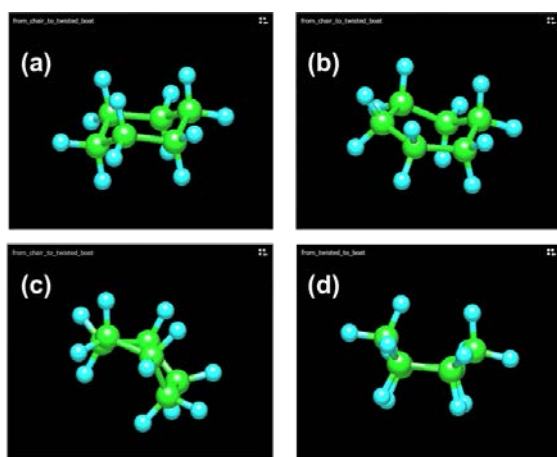


図 1 シクロヘキサンの配座変換におけるエネルギー極値をとる立体配座の 3D モデル。

- (a) いす形配座 (b) 半いす形配座
(c) ねじれ舟形配座 (d) 舟形配座

つづいて、骨格炭素の二面体角を変化させた際の生成熱の変化を配座変換の進行度に対してプロットすることにより、シクロヘキサンの環反転過程における反応座標を作成した (図 2)。得られた反応座標からは舟形配座が準安定な中間体ではなく遷移状態に相当しており、ねじれ舟形配座が準安定な配座であることが示される。この結果は実験的に得られたシクロヘキサンの環反転の反応座標にみられる挙動と一致した⁴。

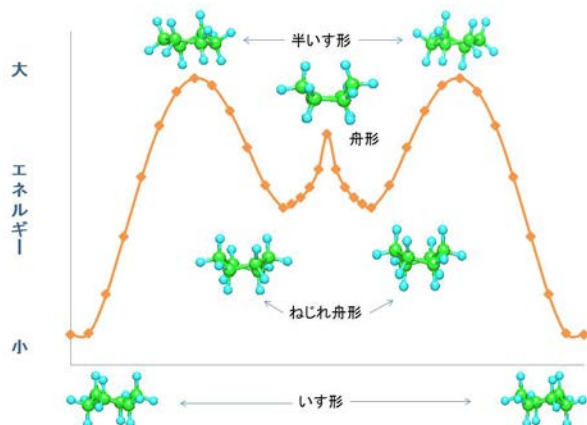


図 2 シクロヘキサンの環反転過程における反応座標。

さらに、シクロヘキサンの安定性が水素原子間に生じる立体障害に依存することを視覚的に説明するために、原子の Van der Waals 半径を反映した space fill 表示による配座変換過程のアニメーションも別途作成した (図 3)。いす形配座では炭素-アキシャル水素結合が同じ方に向いている一方 (図 3 a), 半いす形配座ではいす形配座よりも水素原子間の立体障害が大きくなっていることがわかるようにモデルの角度を調整し、注目すべき部分を赤丸で囲んだ (図 3 b)。また、舟形配座とねじれ舟形配座との比較においても、ねじれ舟形配座では水素原子間どうしのぶつかりが緩和されていることを強調した角度でモデルを表示した。

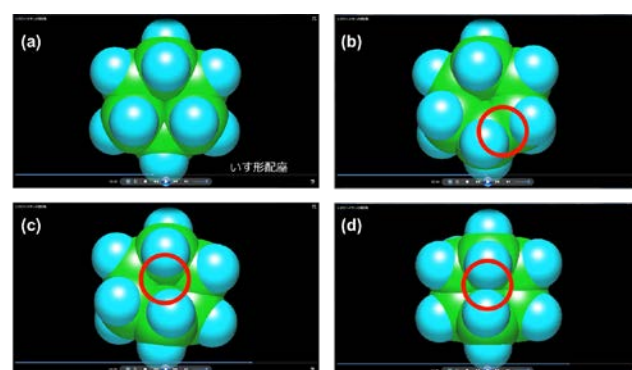


図 3 space fill 表示によるシクロヘキサンの立体配座の 3D モデル。

- (a) いす形配座 (b) 半いす形配座
(c) ねじれ舟形配座 (d) 舟形配座

このようにして作成した各動画を Windows Live Movie Maker を用いて統合し、全体として約 5 分間の動画に編集した。最後に、作成した動画に対するナレーションの原稿を作成し、実際の動画の進行に合わせて学生が読み上げ、サウンドレコーダーを用いて録音して得た音声ファイルを Windows Live Movie Maker により動画と同期させて、受講用教材の作成を完了した。

3. 教育効果

作成した教材を MOODLE 上に保存し、生物応用化学科 3 年生 (平成 25 年度入学) に受講させたうえでこの教材に関するアンケート調査を行った。アンケートの有効回答者数は 18 人であった。受講者が有機化合物の立体化学について予め知っていた知識に関する項目に対する回答の集計を表 1 に示す。設問 (1) と (2) はシクロヘキサンの立体配座に関する知識の程度を確認するためのものであり、回答の分布からはシクロヘキサンのいす形配座と舟形配座の存在についてはすべての回答者が知っていたのに対し、半いす形配座とねじれ舟形配座については回答者の半数以上が知らなかったことが示唆された。ま

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た、設問 (3) と (4) は有機化合物の立体配座・立体障害とエネルギーの関係について問うものであったが、これらについては受講前の時点ではほとんどの受講者に対して定着していることがうかがえた。

つぎに、e-learning 受講による学習効果に関する項目に対する回答の集計を表 2 に示す。どの項目についても回答者の約三分の二が肯定的な回答を与えた。設問 (5) ～ (7) は、今回作成した教材の中で説明されている内容に関係しており、e-learning の受講がポジティブな教育効果を与えたことを示している。一方で約三分の一の回答者には効果が感じられなかった。別途に実施した記述式アンケートにみられた意見として“立体障害の違いを理解させたい配座を並べて表示するべきである”、“ナレーションに間がなかったのを、自分で考えながら受講する余裕がなかった”という内容が挙げられる。今後教育効果をさらに向上させるためにはアニメーションをみせることだけでなくインターバルや静止画の配置にも留意した教材の設計が必要と考えられる。

設問	選択項目				
	良く知っていた	まあまあ知っていた	少し知っていた	あまり知らなかった	全然知らなかった
(1) シクロヘキサンの立体配座に「いす形」「舟形」があることを知っていましたか。	13人	6人	0人	0人	0人
(2) シクロヘキサンの立体配座には「いす形」「舟形」以外に「半いす形」「ねじれ舟形」があることを知っていましたか。	1人	2人	5人	5人	6人
(3) 同じ分子であっても立体配座が変わるとそのエネルギーが変わることを知っていましたか。	5人	9人	2人	3人	0人
(4) 構成原子間の立体障害が大きくなる立体配座では分子の持つエネルギーが大きくなることを知っていましたか。	5人	8人	3人	3人	0人

表 1 受講前の立体配座の知識に関するアンケート回答。

設問	選択項目				
	良く理解できた	まあまあ理解できた	どちらともいえない	あまり理解できなかった	全く理解できなかった
(1) 今回の動画を見て、シクロヘキサンのいす形配座がエネルギー極小の状態であるのに対し、舟形配座がエネルギー極大の状態であることが理解できましたか。	3人	11人	5人	0人	0人
(2) 今回の動画を見て、シクロヘキサンが環反転するときの立体配座の移り変わりとそのに伴うエネルギーの変化について理解できましたか。	1人	11人	4人	3人	0人
(3) 今回の動画を見て、立体障害が大きくなる立体配座では分子の持つエネルギーが大きくなることが理解できましたか。	4人	9人	4人	1人	0人
(4) 今回の動画のように分子の構造変化をアニメーションで表すと、分子のエネルギー(安定性)と立体障害との関係性を理解しやすかったですか。	3人	10人	3人	2人	1人

表 2 受講後の立体配座の知識に関するアンケート回答。

つづいて、教材を作成した側の学生 (平成 24 年度入学) に対する教育効果について述べる。シクロヘキサンの立体配座は 2 年次履修科目「有機化学」の授業内容に含まれており、当該学生がこの科目を履修した平成 25 年度に使用された教科書にはシクロヘキサンの立体化学について次のように記述されている⁵。

- ① シクロヘキサンはいす形配座と舟形配座の 2 種の形で存在する。
- ② いす形配座と舟形配座はすみやかな平衡状態にある。
- ③ 常温では約 1000 倍いす形配座が舟形配座より多く存在している。

以上の記述からは、いす形配座と舟形配座はともにエネルギー極小の状態をとっていると学生が解釈する可能性があり、実際教材の作成に携わった 2 名の学生もそのように解釈していた。これに対し、Sigress MO Compact を用いた計算結果からは、図 2 に表されるように舟形配座はエネルギー極大の遷移状態であることが示唆された。これを受けて、学生は自発的に有機化学の書籍⁴を調査し、シクロヘキサンの準安定な立体配座がねじれ舟形とよばれる配座であること、さらに最安定ないす形からねじれ舟形配座に変換される途中の遷移状態が半いす形配座であることを学習することができた。下級生に対する自己学習用の教材を作成する中で、図らずも自分たちが授業で学んできたものよりも厳密な知識を自発的に学習できたことは、教材作成の作業が、作成者自身に対してもアクティブラーニングを促す効果があったことを示している。

3. 結言

半経験的分子軌道計算ソフトウェアを利用して作成した e-learning 教材が、原子間に生じる立体障害が有機化合物の安定性に影響を与えることを、受講者に視覚的に理解させることにおいて一定の効果を持つことが示唆された。さらに、教材を作成した学生に対しても自発的により深い知識を学ぶことを促す効果がみられた。

4. 謝辞

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(教育論文)

Preparation of E-learning Material by Using Semi-empirical Molecular Orbital Calculation Software “Scigress MO Compact” and its Educational Effects

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An e-learning material to instruct the conformational change in cyclohexane was prepared by using the semi-empirical molecular orbital calculation software “Scigress MO Compact”. The result of questionnaire showed that the material helped considerable students to understand the steric conformations of cyclohexane. Moreover, the molecular orbital calculation software encouraged the students who prepared the e-learning material to study the conformational change in cyclohexane deeply.

Key Words : *Semi-empirical Molecular Orbital Calculation Software, Organic Chemistry, e-learning material*

半経験的分子軌道計算ソフトウェア「Scigress MO Compact」を利用し、シクロヘキサンの立体配変換に伴うエネルギーの変化が分子内に生じる立体障害に起因することを説明するための e-learning 教材を作成した。受講者に対するアンケートの結果より、作成した教材にはポジティブな教育効果が認められた。また、教材の作成に携わった学生に対しても、授業で学んだものよりも深い知識を自発的に学ぶことを促す効果が見出された。

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