Challenging in PBL Education on the Field of Chemistry, Machine and Mathematics

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Abstract

It's important for teacher to educate the skill to students. Fundamentally ability is also important, but in recent years companies are focus on the ability to solve problem in cooperation with others. The class so far were the style that the teacher talks unilaterally methods. Base on the method, students who can understand contents of the lesson are no problem, but students who cannot understand one has problems. To solve this problem, it has been attention to active learning. This method is defined as interactive learning. Therefore the students have to participate more actively. As a result, the students are able to obtain a skill solving a problem and to solve fundamental problem.

Herein, we described chemistry, mechanical and mathematics subjects. From student's comments, this method clarified a useful for problem-solving ability.

Keywords: *PBL education, Active Learning, NMR analysis, Open CAE, Group work*

1. Introduction

Up to now, Kosen education has been conducting in order to bring up technical engineers. Therefore, Alumnae and alumni play an active role as efficient worker in the industrial society. However, shift with change in academic development, educational method need to be changed. Most of the teaching centres, schools, colleges, universities and tuition have their teaching methods based on lectures where instructors would lead the whole learning environment and convey information to students via power point screen or notes written on boards. This teaching strategy would give effects when students are interested and passionate on the learning process or instructors able to give consecutive motivation on their means of teaching. However, with today's student, lecturing does not hold their attention long. Students today have grown up dealing with interactive tools like Internet, computers and smartphones and these gadgets and media allow students to enjoy the real-world problem solving and also give opportunity to express their own views and hear their own voices. Educational life should work the same. A very good example of this is the projective base learning (PBL) engaged in the robotics projects. Students get into group to seek solution to real challenging problems. This process creates a learning community where all participants take responsibility for learning and achieving understanding of concepts by themselves, also deepens the communication skills. With this supportive evidence, implementing PBL in teaching of chemistry has come to action, yet not a major influence in education. In our college, students are allowed to engage in practical tasks which give a complete different learning exposure to chemistry, mechanics, and mathematics. In fact, they learn better and understand deeper through operating experimental procedures and discussion with their friends. This paper provides an overview of the findings in our department education system and discusses the consequences of implicating PBL based syllabus on educational development.

1-1. Outline of this experimental lesson

Our department of chemistry afford students with complete experience in understanding chemistry by variety of experiments based on biology, physical chemistry and analytic chemistry according to their education grade. Particularly, students of the fourth grade has more intense experimental tasks of 3hours a week. They are offered with opportunities to enhance their knowledge in chemistry through class includes 10 practical themes ; NMR spectroscopy (^{1}H NMR, ^{13}C NMR) measurement, X-ray spectroscopy, density and

viscosity against water-alcohol system, measurement of heat of solution for sodium thiosulfate, measurement of boiling point for methanol-benzene system, electromotive force of Daniel-Volta battery, hydrolysis rate of methyl acetate, logic circuit, absorption spectrum and emission spectrum, computer simulations.

授業要目（シラバス）［物質工学科 - 必修得］

対象学科	物質工学科	担当教員	青木 薫, 綾関由幸		
授業科目名	物質工学実験II	科目コード			
学年	4学年	開講学期	通年	単位数	3単位
区分	必修得	授業の形態	実験	単位種別	履修
授業概要	物理化学・無機化学・生物学・機械工学・電気工学に関連する各種の実験を通して、実験計画の立案、データの取得と整理、データの妥当性に関する検討、関連知識・情報の調査を総合的に行う訓練を行う。				
関連する本校の学習教育目標	「複合PRG」:B-1	関連するJABEE学習教育目標	「複合PRG」:d-2		
到達目標	テーマに合致した実験計画の立案、データの取得と整理、データの妥当性に関する検討、関連知識・情報の調査をチームで分担して行うことができる。				
授業の進め方とアドバイス	提示された実験テーマとそのテーマに関する実験を行うための基本的な実験器具等に基づき、計画を立案し実行に移す。調査・研究をチームの構成員が分担して実験を行うこと。 物質工学の基礎を実践に生かすための幅広い知識・技術を習得するために、臨海実習、ものづくり実習を行なう。実験テーマ・実習に関する基礎知識を問う試験を後期期末試験で行う。				
授業内容・スケジュール	回数	授業内容			
	前期: (1)下記7テーマについて実験し、レポートを提出する。 ○テーマ1 「NMR測定と解析」 ○テーマ2 「単結晶X線回折測定と解析」 ○テーマ3 「ホーアルコール混合系の密度変化と粘度」 ○テーマ4 「ギ酸銅ナトリウムの溶解熱測定」 ○テーマ5 「メタノール-ベンゼン混合系の沸点測定」 ○テーマ6 「ダニエル・ボルタ電池の起電力」 ○テーマ7 「酢酸メチルの加水分解速度」 ○テーマ8 「論理回路」 ○テーマ9 「吸収スペクトルと発光スペクトル」 ○テーマ10 「コンピュータシミュレーション」 (2)臨海実習(広島大学臨海実習施設) 21時間 後期:ものづくり実習 後期期末試験				
教科書	特に定めない				
参考書	後藤廉平編「物理化学実験法」共立出版、小寺明編「物理化学実験法」朝倉書店ほか実験書				
関連教科	物理化学、情報科学I、生物、生化学、機械工学				
基礎知識	化学、無機化学、物理化学、有機化学、生物、生化学、機械工学				
成績の評価方法	総合評価割合		各テーマのレポート:28点。 臨海実習レポート:12点 ものづくり実習レポート:20点		
	定期試験	40%			
	レポート	60%	試験は行った実験・実習に対する基礎知識を問う。		
	演習・小テスト	%			
	その他	%			
		100 %			
備考	オフィスアワー:毎週金曜日16時20分以降				

Figure 1. Syllabus of Experimental lesson (Japanese ver.)

The students are grouped and time is provided for students to do some research on their experiment, in they are assigned to design the own experiential procedures that aim to explain and describe the hypothesis of each task. This enable personalized learning. Participants set their own learning pace and concepts by merging the gap between theory and practice which play a crucial role retaining ideas gained from classroom learning. This journey also imparts high focus on collaboration and valuable discussion among members which increase students' engagement in chemistry Of course, teachers confirm the pre preparation by checking their notes and instructing them the safety alerts before they are allowed to carry out the experiment.

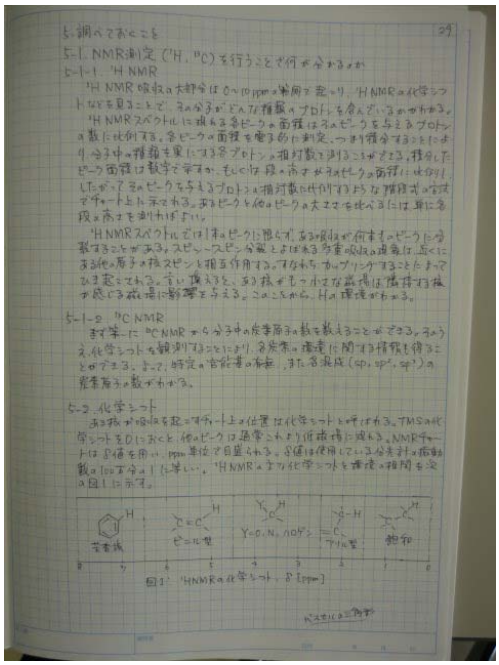

Figure 2. Experimental notebook

1-2. Details of this experimental lesson

~ NMR Measurement of Unknown Organic Compounds~

NMR analysis is the most common and powerful tool used nowadays which provides scientists with substance or chemicals information of both stoichiometry and stereometry (Figure 3). Students are provided an unknown sample with known element constituents. The NMR data was measured by students. The data have to analyze until next lesson.

Figure 3. NMR equipment

Teacher taught a meaning chemical shift and split of signals (singlet, doublet and triplet). In the case of ethanol, the chemical composition formula weight is C2H6O1. Firstly Degree of unsaturated (D. U.) was calculated from chemical composition formula weight. D. U. shows a number of unsaturated bond and existence of cyclic structure in the molecule. As a result, a candidate molecular structure were easily obtained

(Figure 4). In this case this value show 0; unsaturated bond not involved in the molecule. From this knowledge, students can write two kinds of candidate structures (Figure 4).

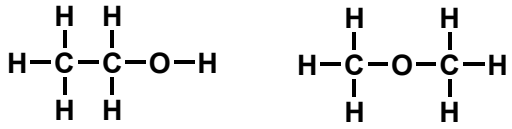

Figure 4. Candidate structure for C2H6O1
Left: ethanol Light: diethyl ether

One out of these compounds determined by ^{1}H NMR and ^{13}C NMR analysis.

1-3. Results and Discussion

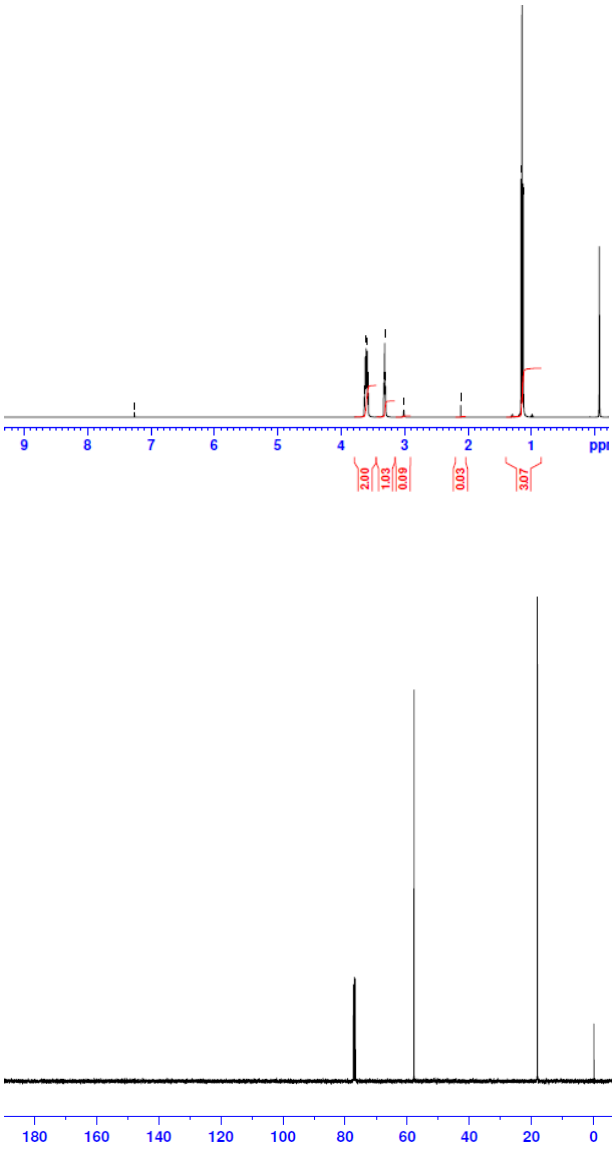

Figure 5. NMR spectra of ^{1}H NMR and ^{13}C NMR

In the case of C2H6O1, it has two candidate structures (Figure 4). On the other hand a molecule has ethyl group and methoxy group. According to ^{1}H NMR data, δ 1.11 ppm indicated triplet signal (3H) and δ 3.57 ppm also indicated quartet signal (2H). And ^{13}C NMR spectrum shows two signals in the chart. As a result, there are two kinds of carbon atoms in the molecule. Finally it has been conclude an unknown sample as ethanol.

By thinking for a candidated structure and analyzing NMR data, students are going to have important skill.

The objective of this lesson is to be having ability for solving problem by discussing their friends.

How do students think about this lesson? I have been interested in student's thought. For some students, this experimental lesson may be pretty hard to write a report. However, a written report is good one. The NMR assignments of unknown samples were also written very well. I carried out the survey about how to proceed the experimental curriculum for the student. The survey includes following listed questions.

1) What grade are you in college?
2) How feel about this experimental curriculum?
3) If you feel good, please fill in your comment.
4) If you feel nothing or no good, please fill in your comment.
5) Please teach me about skills you are learning into the experiment.

These answers are below. The answer for question 2 shows much good feelings. Therefore answers for the question 3 are collecting a lot answers. Mainly answers are to be discussed with the student about not understanding problems and to be understood importance of team work. Answer for the question 4 is not answered. This is meaning that all students feel satisfactory. From the student's comments, they has been discussed with their friends about analysis of NMR data. According to discussion, students have an ability to solve problems for unknown matter and communication skills.

2-1. Introduction of OpenCAE software to experiments.

Recently, manufacturing development by CAE application is indispensable in research and development at companies.

Even at Kosen, there are few opportunities for students to learn numerical analysis while studying. I thought that experiencing numerical analysis at school was effective, and I took it into the class of student experiment.

On accounting to all the facts, the department of mechanical engineering in National Institute of Technology,Yonago College has offered a subject of "Mechanical Engineering Experiment Practicum" to 1st grade to 5th grade. In each grade, subjects that can

acquire 3 credits in 140 weeks per week, 3 weeks in all 30 weeks . In this subject, unique and high-tech contents (WHAT KNID OF UNIQUE AND HIGH_TECH CONTENT) are built in, so that students able to learn mechanical engineering thoroughly. For lower grade students (first to third grade), machining at the manufacturing center (practical factory) is the main practical task offered, and the experiment is conducted using materials such as metallographic observation and metallic materials test which are the fundamental chapters in dynamics system. For higher grades students (fourth to fifth grade), experiments about strength of materials, thermodynamics, hydrodynamics and mechanical mechanics are offered. For 5th grade student, we introduced the opportunity to set up "numerical simulation by finite element method" as a theme of strength of materials.

We decided to use ready-made software.

· Experiments must be 280 minutes lessons per theme. (140 minutes per session, 1 theme setting in 2 weeks.)

· Computer proficiency for each students differ.

From the above, we decided to adopt "ADVENTURE on Windows (Windows version)" by the University of Tokyo ADVENTURE project in this theme. Figure 1 shows the basic screen of "ADVENTURE on Windows".

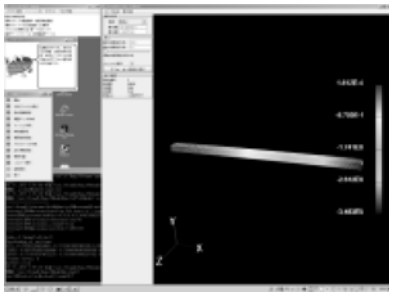

Figure 6 ADVENTURE on Windows

During the first class, we decided to introduce "ADVENTURE" for the following merit.

· It is open-source software and does not require expenses for purchasing software.

· The Windows version is much easier to set up than the Linux version.

· Since it runs on Windows, virtual software etc is unnecessary.

· Since "ADVENTURE" itself can be operated easily, it is easy to administrate in a short time.

2-2. How to use the software

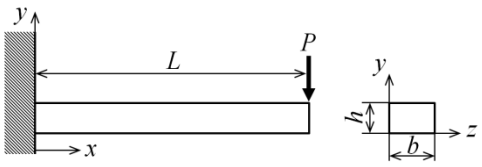

Figure 7 Numerical Example (Cantilever beam)

In the numerical analysis of the example at the first week, everyone worked on the cantilever problem receiving the concentrated load as shown in Fig. 7, and the stress of the beams for the comparison of the numerical analysis result and the theoretical value of the flexural bending. In the second week, I focused on numerical analysis of tasks and report preparation.

The assignment was divided into 3 questions according to the degree of difficulty, and the students select one from those and answer in the report.

In this lesson, considering the difficulty level in numerical analysis, tasks 1 to 3 have the following contents.

Problem 1: When the H-shaped steel of Fig. 8 has a sectional shape in which the load is applied as the cantilevered beam of Fig.9.

Problem 2: When the H-shaped steel of Fig. 8 has a sectional shape in which the load is applied as the both-end supported beam in Fig. 10.

Problem 3: Stress analysis of a flat plate having a circular hole as shown in Fig. 11.

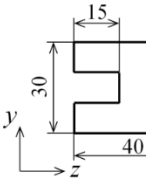

Figure 8 Shape of section

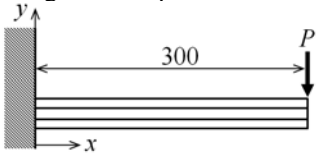

Figure 9 Exercises 1 (Cantilever beam)

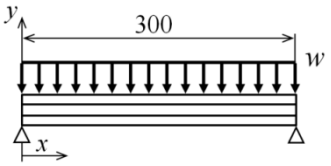

Figure 10 Exercises 2 (Simply supported beam)

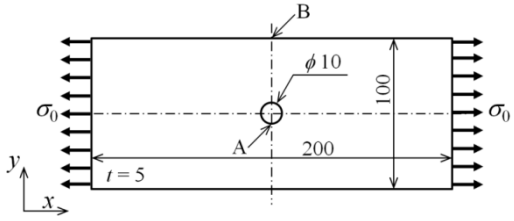

Figure 11 Exercises 3 (Flat plate with circular hole)

This class was introduced since 2017 and the deta of classes for two years has been accumulated.

Table1. Selectivity in exercise

Task No.	Selectivity	
	2015	2016
1	57 %	79 %
2	0 %	0 %
3	43 %	21 %

3. Attempt of active learning in applied mathematics

In the 4th grade, we offer subjects aimed at applying mathematical knowledge such as vector analysis, complex analysis, Fourier analysis, Laplace transform, and probability statistics to other fields such as engineering.
In the active learning conducted this time, each question of periodic examination is allocated for each group, and each group learns and discusses so that other students can explain the allocated problems centered on leaders so that they can easily understand. After that, the leader carried out a board book and commentary on the blackboard and carried out at the class content such that teachers complemented and provided guidance at the appropriate time.

3-1. Assembling a lesson

The composition of the lesson is as follows.

Each group, the leader will explain in front of the students an easy-to-understand answer to the questions assigned by the leader.

Table 2　Contents of time table

Time(min)	Context
0 ～20	Introduction
20 ～ 35	Exercise(Group)
35 ～ 80	Presentation(Group)
80 ～ 90	Questionnaire

3-2. Exercise by group work

I asked the reader to create an example solution that other students could easily understand. I distributed A4 paper for each group and let me write the contents of the model answer and commentary on this paper.

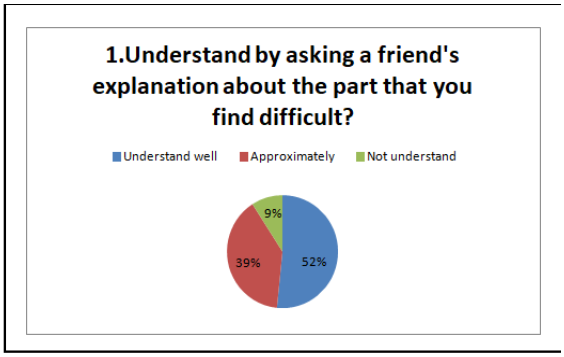

Figure 12

Conclusions

In this paper, students carried out by the discussion with group member a structure analysis of organic compound. As a result, students are able to have the ability for solving the problem. This ability facilitate solution difficult problem and to create newly technology. In mechanics, although we have sampled few years. It can be confirmed that there is a large difference in the selectivity of problems. In both grade students, there is no student who chose task 2. From this result, task 3 has higher points and tips for the similar problem by using the Internet. Applied mathematics conducted group work by using active learing methods. From this result, the half students of this class answered 'it can be understood well'(Figure 12).

Acknowledgements

I gratefully acknowledge Prof. Takenaka for his valuable suggestion and discussions.

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