The Situation of Senior-High School Chemical Education in Tohoku District of Japan : From the Results of a Questionnaire to Chemistry Teachers in 1995

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The Situation of Senior-High School Chemical Education in Tohoku District of Japan
—— From the Results of a Questionnaire to Chemistry Teachers in 1995 ——

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高校教師からみた東北地区における高校化学教育の現状
——1995年に実施したアンケート調査の結果から——

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A questionnaire investigation on chemical education was carried out in 1995 in order to know the state of chemical education in high schools in Tohoku District (northeastern area) of Japan. The questionnaires were sent to all the senior-high schools in Tohoku District. We received answers from 237 schools (collection rate 42.7%) and 361 teachers in these schools. Some results of the investigation are described and are compared with those obtained in a similar investigation made in 1982. One of the distinct changes is the decrease of student experiments. Another pronounced change is the less active chemistry clubs. The causes of these changes are discussed with reference to the teachers' answers to various questions in the questionnaire.

I. Introduction

A questionnaire investigation on chemical education was carried out in 1995 in order to know the state of chemical education in high schools in Tohoku District (northeastern area) of Japan. The questionnaire consists of two parts: Part A (Questions to the schools) and Part B (Questions to the teachers). The questionnaires were sent to all the 555 senior-high schools in Tohoku District. We received answers from 237 schools (collection rate 42.7%) and 361 teachers in these schools. Some of us carried out a similar questionnaire investigation in 1982[1]. Since the new Course of Study for senior-high school curricula has been operating since 1993, and the social environment surrounding science and chemistry has changed in these thirteen years, we made this investigation to find the general trend of changes in chemical education of senior-high schools in Japan.

In this article, some of the results of the investigation[2] are described and are compared with those obtained in the previous investigation made in 1982.

II. Results

1. General Features of the Schools Replied

The answers are from 201 public schools (collection rate 42.9%) and 36 private schools (collection rate 41.4%). Among the schools, 30% have more than 1,000 students, 43% have 501 to 1,000, 25% 101 to 500, and 2% have less than 100 students. Types of the schools are shown in Table 1. The 218 schools involved in Table 1 accommodate 175,014 students, about one half of all senior high school students in Tohoku District. In the previous investigation in 1982, the 260 schools corresponded to the questionnaire accommodated 174,569 students; these numbers are close to those in the present investigation.

2. Study of Chemistry under New Course of Study

According to the new Course of Study, each subject in science (Physics, Chemistry, Biology and Earth Science) is divided into 3 courses: IA (minimum 2 credits), IB (4 credits) and II (2 credits). Each course of II should be taught to students who have studied the corresponding course of IB. Features of these courses and the number of students taking various courses of chemistry is shown in Table 2. It indicates that in many schools of regular course in Tohoku District, most students study Chemistry IB, and that Chemistry IA is taught mainly to students in vocational courses. Table 2 indicates that only few students were studying Chemistry II in 1995. The numbers, however, include estimated ones, because the third year students in 1995 were studying chemistry under the previous Course of Study, and Chemistry II is expected to be taught mainly to third year students.

Table 1. The Type of the Schools Replied

Type	Number of Schools	Number of Students	Average Number of Students in a School
Regular Course Only	128	99,197	775
Regular and Vocational Courses	45	45,166	1,004
Vocational Courses only	45	30,651	681
Total	218	175,014	803

Table 2. The New Chemistry Courses and the Number of Students Studying

Course	Feature	Number of Students Studying*	
Chemistry IA	Emphasis on daily human life, featuring phenomena, substances and industrial products observed and used in human life	R	7,078
		R+V	5,102
		V	7,849
		Total	20,029
Chemistry IB	A standard course of introductory and fundamental chemistry (Reformed from former Chemistry by eliminating equilibrium, reaction rate, and polymer chemistry)	R	29,654
		R+V	8,310
		V	2,118
		Total	40,082
Chemistry II	An advanced course for students interested in chemical science (Composed mainly from topics which were eliminated from former Chemistry in reforming it to Chemistry IB)	R	6,009
		R+V	1,226
		V	0
		Total	7,233

*R : High schools of Regular course ; R+V : High schools with Regular course and Vocational course
V : High schools of Vocational course

Table 3. The Change in Science and Chemistry Unit by the Change of the Course of Study

		Number of Schools Replied	Decreased	Increased	Unchanged
Science	Non-Science Major Classes	107	48(44.9%)	9(8.4%)	50(46.7%)
	Science Major Classes	110	46(41.8%)	21(19.1%)	43(39.1%)
	Classes of Various Majors	160	71(44.3%)	14(8.8%)	81(50.6%)
Chemistry	Non-Science Major Classes	103	36(34.9%)	19(18.4%)	48(46.6%)
	Science Major Classes	107	30(28.0%)	34(31.8%)	43(40.2%)
	Classes of Various Majors	164	50(30.5%)	43(26.2%)	71(43.2%)

The number of credits in science which each student takes depends on his/her major. We expected that the number of credits (units) in Science and Chemistry had changed accompanying the change of the Course of Study. The change of credits in Science is given in Table 3. It is seen that the number of science credits has decreased considerably for all students. The number of credits of Chemistry has decreased for non-science majors in many schools.

3. Chemistry Experiments

Questions on experiments adopted in Chemistry IA, Chemistry IB and Chemistry II were made in this investigation. Experiments adopted in Chemistry IB are shown in Figure 1. The Percentage of Adoption of each experiment is obtained by

$$\frac{\text{Number of Schools Adopting the Experiment}}{\text{Total Number of Schools Replied to the Questionnaire } (=237)} \times 100$$

The most popular experiments are similar to

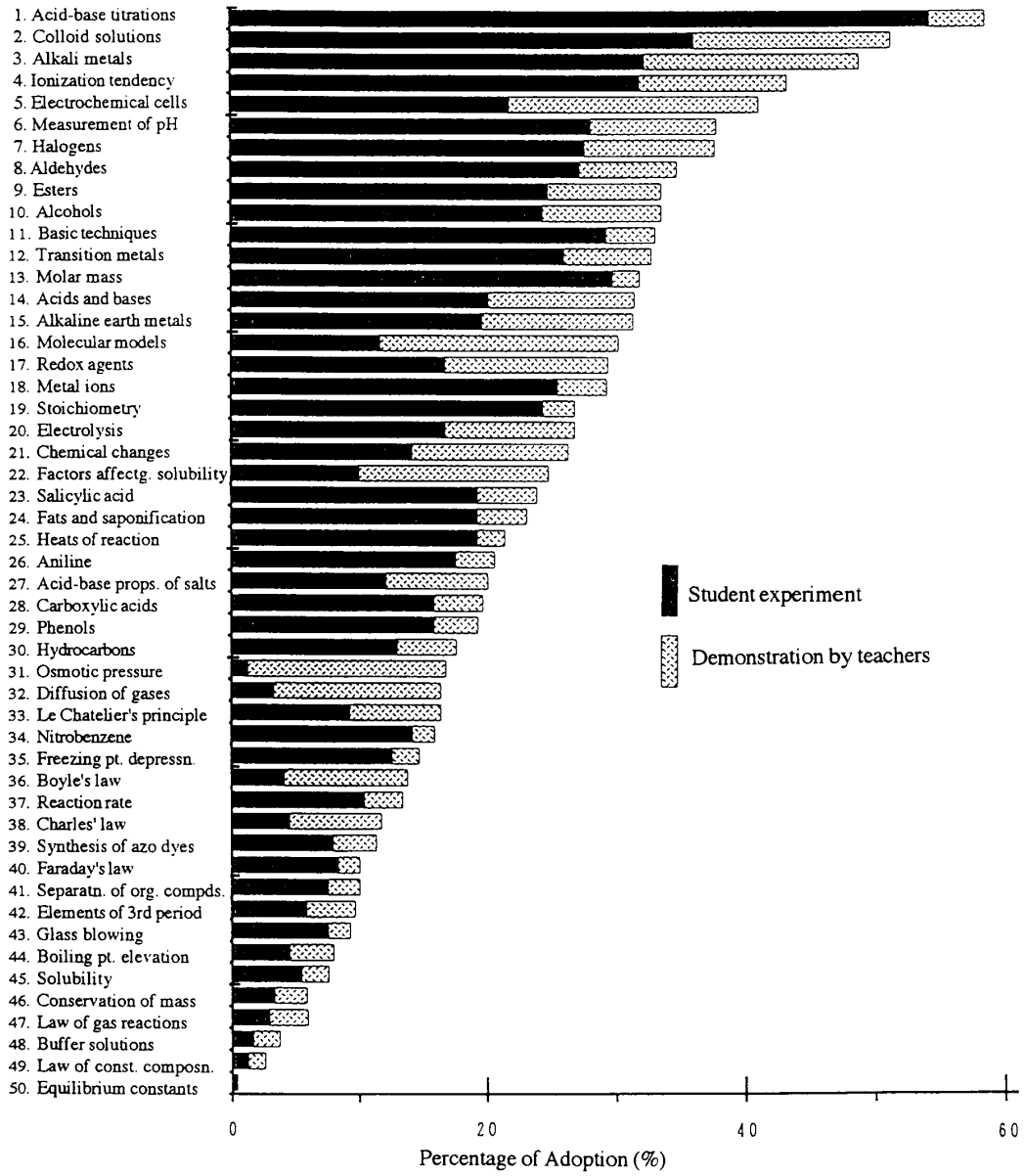

Fig. 1. Experiments Adopted in Chemistry IB

those in the previous investigation in 1982.

Some other questions on experiments were asked to chemistry teachers. One question is: 'How often are student experiments carried out yearly?' Answers from 261 teachers in 1995 are summarized in Table 4 together with those obtained in 1982. In 1982, 38.6% teachers carried out more than 11 experiments, while in 1995, only 6.5% teachers did more than 11 experiments. It is clear from Table 4, that

Table 4. The Number of Experments Carried out in a Year

The Number of Experments in a Year	Number of Teachers in 1995	[Number of Teachers in 1982]
0-5	111(42.5%)	86(24.8%)
6-10	133(51.0%)	127(36.6%)
11-15	16(6.1%)	92(27.1%)
16-	1(0.4%)	40(11.5%)

much less student experiments were carried out in chemistry in 1995 than in 1982.

The following question was made to teachers: 'Though many students like to carry out chemistry experiments, why experiments are not carried out very often?' Answers from 341 teachers are shown in Figure 2. Many teachers thought that experiments tend to retard the progress of study, and the time for teaching chemistry is not enough to introduce many experiments. All teachers who wrote comments as the 'Others' in Figure 2, referred to their busyness: They have many miscellaneous duties in addition to teaching chemistry as shown in **5.** and **7.** of this section.

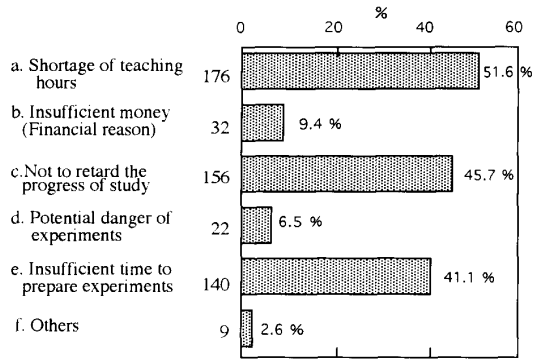

Fig. 2. The Reasons for the Scarcity of Experiments

4. Chemistry (Science) Club Activities

There are two types of clubs in many high schools: compulsory clubs ('Hisshu Kurabu') and extracurricular clubs ('Bu-Katsudou'). The activities of the former clubs are usually limited within the class hours (1 hour a week), while those of the latter are extended beyond class hours. In 233 high schools, there are 294 clubs related to chemistry. Examples of the names of such clubs are Chemisty Club (45), Science Club (28), Natural Science Club (24), *etc*. Table 5 shows numbers of Chemistry/Science clubs and the number of students who belong to such clubs. It is seen from Table 5, that extracurricular chemistry clubs have decreased considerably in these 13 years, though compulsory chemistry clubs have increased. It is also seen that the average number of students in one Chemistry/Science club has decreased dramatically since the previous investigation in 1982.

Some clubs carry out public activities. Examples of such activities are: Presentation of papers on the investigation in or outside the school, demonstration as part of School Festivals, entry in the competition of Student Sci-

Table 5. Numbers of Chemistry/Science Clubs and Students in these Clubs (Figures in [ ] are those in the investigation in 1982)

Type of High School	Number of Schools	Number of Clubs*				Number of Students in Clubs (n)	n/m**	Schools without Clubs
		Compulsory (C)	Extracurricular (E)	C-E*	Total (m)			
Regular(R)	131 [133]	50[8]	39[51]	44[20]	138[79]	1201[1349]	9.1[25.3]	74[54]
R+V	49[56]	26[5]	19[15]	22[8]	67[28]	371[490]	5.5[16.4]	21[27]
Vocational(V)	49[66]	29[4]	27[9]	29[9]	85[20]	211[335]	2.5[16.8]	18[35]
Other	4[23]	3[0]	3[2]	3[0]	9[2]	4[5]	0.4[2.5]	1[22]
Total	233[269]	108[17]	88[77]	98[37]	294[128]	1787[2149]	6.1[16.8]	114[138]

*There are two types of clubs in many high schools: Compulsory clubs (C, 'Hisshu Kurabu') and Extracurricular clubs (E, 'Bu-Katsudou'). In some schools such classification is not distinct as denoted by 'C-E'.
**Average number of students in one Chemistry/Science Club

ence Prize, *etc*. A question was made on such public activities. The number of schools which made such public activities are 117 (49.4%) in the present investigation, while it was 93.8% in the investigation in 1982.

Among 240 teachers who answered to question on chemistry clubs, 50% recognized chemistry club in his/her school had become less active, and only 10% recognized more active.

5. Teachers' Teaching Load

There are 561 chemistry teachers in 227 schools. Among them, 55.8% teach only chemistry, 38.5% teach other subjects in addition to chemisty, and 5.7% are part-timers. The ratio of teachers who teach other subjects in addition to chemistry was 29.5% in the investigation in 1982. The ratio have increased by 9 points.

A question was made on the teaching time of chemistry teachers. It was found that teachers who teach 10-15 hours decreased from 57% in 1982 to 44% in 1995, and teachers who teach 16-20 hours increased from 33% in 1982 to 45% in 1995.

The teaching hours of subjects other than chemistry were 1-5 hours for 46% of the teacher who answered the question, 6-10 hours for 42%, and 11-15 hours for 12% teachers.

6. Chemistry Teachers' Opinions and Perceptions on Recent Social Trend Surrounding Science and Chemistry

Figure 3 shows teachers' answers to the question: 'It is said that there is science-shunning (Rika-Banare, the tendency science is disliked) among the younger generation. How do you think about it?' Some teachers pointed out that many students think science is difficult. Some pointed out that it is related to the study of mathematics. Many teachers referred to the lowering of ability of calculation. Some

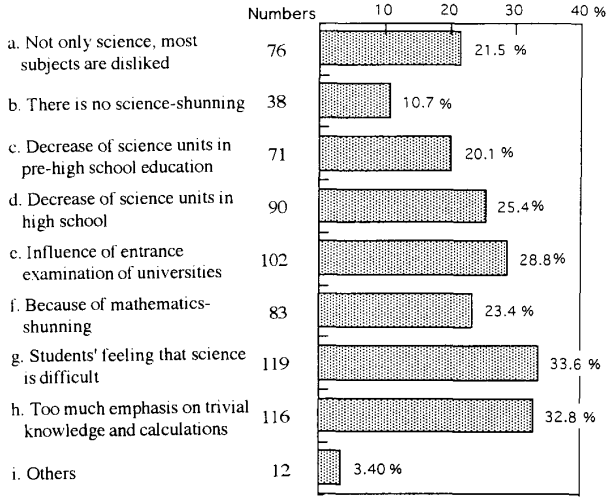

Fig. 3. Teachers' Opinions on 'Science-Shunning' (Answers from 354 Teachers)

teachers thought there are influences of entrance examinations of universities.

Similar answers were obtained to the question: 'What do you think are the reasons that chemistry is not popular to students?' In addition to similar opinions to those in Figure 3, some teachers pointed out the formation of negative images of chemistry through mass media.

7. Chemistry Teachers' Opinions and Feelings on Teaching Chemistry

Several questions were made to teachers on teaching chemistry. 357 Teachers answered to the question 'What points do you regard as important in teaching chemistry in class?' Among them, 43% [36% in the investigation in 1982] chose 'To teach theories systematically', 39% chose 'Introduction of many experiments, to let students observe and experience actual reactions and changes', 30% [53%] chose 'Emphasis on teaching chemistry through substances and phenomena encountered in daily human life'.

Figure 4 shows answers of 354 teachers to the question 'What is your anxieties in teaching

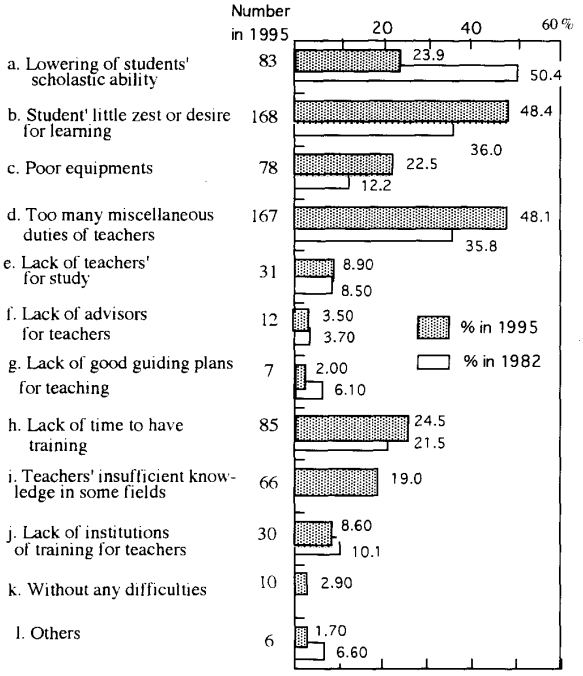

Fig. 4. Anxieties which Teachers are Feeling (Answers from 354 teachers. Figures in [ ] are those in the investigation in 1982)

chemistry?' together with those in 1982. The big difference in Figure 4 between the results of 1995 and those of 1982, is the reversal of the order of a. and b. Young generations who have grown up in the economic prosperity of Japan, are satisfied without working hard, and some students have little interests in studying any subjects. Many teachers felt that many students lack good attitude toward learning.

More teachers felt that they are busy with miscellaneous duties outside teaching chemistry in 1995 than in 1982. About 40% chemistry teachers teach subjects other than chemistry. To teach such subjects often make chemistry teachers busy because it requires extra time for preparation. Teachers also have miscellaneous work in addition to teach classes within the curriculum. Many chemistry teachers have extracurricular lessons to prepare for the university entrance examinations and supplementary lessons to slow learners. Some teachers are asked to take care of clubs other than chemistry clubs: Brass band, baseball clubs, tennis clubs, *etc*. They are especially busy when there are competitions or official games. Some teachers are busy with PTA or Alumni associations. Teachers have to attend various meetings on guidance of students life (in and outside school), students' selection of universities, and on scholarships, *etc*.

Similar answers were obtained to the question 'What is your difficulties in teaching chemistry?' Some teachers felt that there are too many topics in the textbook. It may correspond to the reason of scarcity of experiments indicated in Figure 2: It is thought that experiments tend to retard the progress of teaching.

Questions were made on the chemistry textbooks. 351 teachers answered to the question. Among them, 44.1% were satisfied with the textbooks they use, and others were not much satisfied with their textbooks. 21% teachers thought that there are too many topics in the textbook, 20% thought that the textbook is too difficult for students.

Most students study Chemistry IB (*cf*. Table 4), in which the topic 'Chemical equilibrium' is excluded. Equilibrium was an important part in Chemistry in the previous curriculum which most students studied. A question was made: 'Do you teach Equilibrium in your class of Chemistry IB?' More than half teachers answered that they were teaching Equilibrium in Chemistry IB. It seems that many teachers think that the concept of chemical equilibrium might have been included in Chemistry IB which most students study. Chemical equilibrium consists an important part of Chemistry II, but the number of students who study Chemistry II is small.

Several questions were made on 15 main

Table 6. Teachers' Answers to Questions on Various Topics in Chemistry

Topics which students complain to be difficult to understand		Topics which teachers feel difficulty in teaching	
1. Atomic mass, molcular mass, mole & Avogadro's number	244	1. Transition elements, metal complexes	151
2. Chemical equilibrium	113	2. Chemical equilibrium	110
3. Redox reactions	101	3. Atomic mass, molecular mass, mole & Avogadro's number	109
4. Transition elements, metal complexes	96	4. Polymer chemistry	100
5. Reaction rate and heat of reaction	77	5. Reaction rate and heat of reaction	81
6. Gas laws	63	6. Redox reactions	56
7. Organic compounds	54	7. Gas laws	54
8. Electrolysis, electrochemical cells	54	8. Chemical bonds	47
9. Polymer chemistry	50	9. Organic compounds	44
10. Chemical equation	35	10. Separation of metal ions from mixtures	28
11. Chemical bonds	29	11. Structure of atoms & molecules	27
12. Separation of metal ions from mixtures	24	12. Electrolysis, electrochemical cells	25
13. Acids and bases	23	13. Chemical equation	24
14. Structure of atoms & molecules	11	14. Elements, periodic table	23
15. Elements, periodic table	10	15. Acids and bases	10
Topics which students are willing to study		**Topics which teachers do not feel difficulty in teaching**	
1. Acids and bases	211	1. Structure of atoms & molecules	155
2. Electrolysis, electrochemical cells	166	2. Acids and bases	131
3. Separation of metal ions from mixtures	104	3. Chemical equations	103
4. Organic compounds	82	4. Electrolysis, electrochemical cells	91
5. Structure of atoms & molecules	81	5. Organic compounds	84
6. Elements, periodic table	71	6. Elements, periodic table	62
7. Gas laws	35	7. Chemical bonds	57
8. Redox reactions	28	8. Atomic mass, molecular mass, mole & Avogadro's number	56
9. Chemical equations	26	9. Gas laws	54
10. Chemical bonds	23	10. Redox reactions	46
11. Polymer chemistry	20	11. Separation of metal ions from mixtures	30
12. Reaction rate and heat of reaction	18	12. Reaction rate and heat of reaction	13
13. Transition elements, metal complexes	14	13. Polymer chemistry	13

topics of chemistry: 'List three topics which students complain that they are difficult to understand', 'List three topics which students like to study', 'List three topics which you feel easy to teach', and 'List three topics you feel difficult to teach.' Answers from 361 teachers are shown in Table 6. Topics are listed with the number of teachers who listed the topics in decreasing orders. Topics which were listed by less than ten teachers are omitted.

It is seen from Table 6 that teachers do not feel difficulty in teaching topics which are popular to students, and *vice versa*.

III. Discussion

Chemical education in Japanese high schools reflects various factors surrounding it: the Course of Study, entrance examination of universities, the education in primary and lower secondary schools, public opinions on science

and chemistry, *etc*. Changes of these factors in recent decades, seem to have changed high school chemical education to some extent.

One of the pronounced changes is the decrease of Science credits which students take (see Table 3). It may be considered to be the reflection of 'Science shunning.' It may also be due to the influence of entrance examination of universities. Recently many universities tend to reduce the number of subjects required at the entrance examination, to attract more students. Only one science subject is required for science-majors, and no subject on science to non-science majors. It is normal for high school students to focus on subjects required at the entrance examinations, and to neglect subjects which are not required.

The less frequent student experiments are also distinct (see Table 4), although teachers think that experiments are important. The new Course of Study also puts a strong emphasis on student experiments. Teachers answered that experiments tend to retard the progress of study. It is believed that experiments take time and are not efficient for the preparation of entrance examinations of universities, and that lectures or problem-solving exercises are more efficient. Because the success in the examination justifies everything, the number of experiments has thus been decreasing. Another cause may be that teachers are too busy. More teachers felt busyness in 1995 than in 1982. It is concerned that chemistry without experiments may make chemistry less attractive.

Another pronounced change is the less active Chemistry/Science club activities (see Table 5). This may also be a reflection of Science shunning, the entrance examinations and busy teachers.

In Table 6, the topic 'Atomic mass, molar mass, mole and Avogadro's number' was at the top of the list of topics which students complain that it is difficult to understand. As this topic is given at the beginning of the textbooks, students who cannot understand it may feel frustrated in chemistry. This topic includes numerical calculations, and the difficulty may be related to poor ability of calculation of some students, which was pointed out by many teachers. It is seen topics popular to students are those in which experiments are done in many schools (*cf*. Figure 1). Such examples are 'Acids and bases' and 'Redox reactions including ionization tendency'. It implies the importance of experiments in studying chemistry.

There seem to be various factors in the recent trend that science, especially chemistry is not attracting many students.

The present investigation has substantiated some descriptions on the state of high school chemistry in the report *Chemical Education in Japan, 2nd Version.*[3].

Acknowledgment

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